3D APPLICATION EFFECTIVENESS ON NURSING STUDENTS' LEVEL OF ELECTROCARDIOGRAM KNOWLEDGE

by

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A DISSERTATION

Submitted in partial fulfillment of the requirements
for the degree of Doctor of Education
in the Department of Educational Leadership,
Policy, and Technology Studies
in the Graduate School of
The University of Alabama

TUSCALOOSA, ALABAMA

2014

ABSTRACT

Nursing students have difficulty interpreting ECG rhythms. The current classroom environment often lacks application and practice opportunities, and as a result, students struggle with identification of ECG rhythms at the patient's bedside. The purpose of this study was to determine the effectiveness of a 3D app on nursing student's ECG level of knowledge as evidenced by exam performance. A gap in the literature exists examining 3D app technology used as a teaching methodology for nursing students learning ECG interpretation. A quasi-experimental research design consisting of one experimental group and one control group was implemented. The instrument used in this study included an identical 10-item pretest and posttest. Paired or dependent *t*-tests and an independent *t*-test were used for the statistical analysis. The pretest and posttest allowed the researcher to identify the differences in learning outcomes between these two groups. The statistical significance was set at $p < .05$. The findings from this study did not show a statistical difference in learning from 3D app technology for ECG knowledge. Both the experimental and control groups posttest mean scores increased.

DEDICATION

This dissertation is dedicated to my husband, Brad, the love of my life! God has blessed me with you, and I thank Him everyday. Without you I would have never been able to accomplish anything in this life. You have always been there supporting me and encouraging me. I am thankful for our three beautiful children, Hayden, Brock, and Kate and dedicate this dissertation to them as well. For my kids, always remember you really can do anything that you set your mind to. The sky is the limit. I love you Hayden! I love you Brock! I love you Kate! I truly believe that nursing is a calling and you guys have all helped me continue to answer the call that God has chosen for me to pursue.

LIST OF ABBREVIATIONS AND SYMBOLS

AACN	American Association of Colleges of Nursing
ADHD	Attention Deficit Hyperactivity Disorder
ALM	Army Learning Model
CCNE	Commission on College Nursing Education
CDC	Centers for Disease Control and Prevention
CI	Confidence Interval
CNE	Certified Nurse Educator
CPR	Cardiopulmonary Resuscitation
CSDA	Connecting Soldiers to Digital Applications
ECG	Electrocardiogram
IOM	Institute of Medicine
IRB	Institutional Review Board
LMS	Learning Management System
M	Sample Mean
n	Number of Participants in a group
NLN	National League for Nursing
PDA	Personal Digital Assistant
VSC	Virtual Construction Simulator
SD	Sample Standard Deviation
SPSS	Statistical Package for the Social Sciences

ACKNOWLEDGMENTS

I wish to acknowledge all of my committee members, Dr. Vivian Wright, Dr. Susan Gaskins, Dr. Doug McKnight, Dr. Kay Sackett, and Dr. Marietta Stanton. Thank you for being a part of this amazing journey.

I wish to acknowledge my committee chair, Dr. Vivian Wright, for being patient with me and for your support and encouragement. I could have never accomplished this without your guidance, dedication, professionalism, and compassion. You were an excellent chair and I look up to you and your dedication to educating others.

I wish to acknowledge my fellow members of Cohort 4 from the University of Alabama. What a journey? This accomplishment would have never taken place without all of you, especially my friends Mrs. Tammi Tanner and Mr. John Lundeen! Without you guys I would have never made it.

I wish to acknowledge my newly found family at Samford University's Ida Vines Moffett School of Nursing. What a blessing! Each and every person I have met has continuously encouraged me and supported me along this journey. God has put me at Ida Vines Moffett School of Nursing for a reason and I am so very thankful. I especially want to thank my buddy, Mrs. Lisa Gurley, co-teacher and friend. You are an unbelievable nurse educator and I want to grow up to be just like you. I love you friend! I wish to acknowledge my entire family. I could have never accomplished this without your love and understanding. Thanks for understanding when I wasn't there at times (I may have temporarily tuned out), but now I am back. I love you!

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CHAPTER I

INTRODUCTION

Current literature reveals that although nursing students must correctly interpret ECG rhythms in order to provide safe, competent care, they often have difficulty grasping electrocardiogram (ECG) identification and have minimal clinical practice opportunity for applying this knowledge (Jang, Hwang, Park, Kim, & Kim, 2005). According to Celikkan, Senuzun, Sari, and Sahin (2013), nursing students' knowledge retention of ECG identification from classroom lecture gradually decreases when students leave the classroom. Although nursing students may be comfortable learning theoretical knowledge from classroom lectures, they can become apprehensive when applying this knowledge during the clinical experience (Celikkan et al., 2013). Nursing students typically have not seen this procedure performed on a patient, and therefore, lack clinical experience. This lack of clinical experience may result in difficulty in identifying ECG rhythms, which directly affects patient care (Celikkan et al., 2013). The gap between nursing knowledge and applying knowledge at the bedside is reflective of the disconnect between the skills and knowledge learned under supervision in an academic environment and those skills needed for safe, independent function at the patient's bedside (Benner, Sutphen, Leonard, & Day 2010; Burns & Poster, 2008).

According to the Center for Disease Control (CDC) (2011) heart disease is the number one cause of death in the United States. Heart disease can result in dysrhythmias. Dysrhythmias are visible on an ECG, and an ECG is the current daily diagnostic tool for detecting various cardiovascular diseases (Akgun et al., 2014; Lewis, Dirksen, Heitkemper, Bucher, & Camera, 2011). Correctly interpreting the information on an ECG takes significant amounts of training and practice, and nurses must act under pressure to detect life-threatening dysrhythmias (Akgun et al., 2014; Zhou et al., 2012). Therefore, the importance of skilled ECG interpretation is vital in nurse education. Innovative technologies, such as three-dimensional applications (3D apps) via mobile devices, provide immediate interactive content with ample practice opportunity for learning ECG interpretation.

There is rapid growth in the smartphone market, and this growth includes 3D app technology (Mouza, Yoo, & Sheets, 2012). The 3D app technology increases student engagement by including richer experiences through high-definition audio, high-definition video, quality multimedia options, interface responsiveness (interactivity), access to web content, and 3D graphics (Brenton et al., 2007; Gutierrez, Abud, Vera, & Sanchez, 2013; Montserrat, Belén, Rodríguez, Jorge, & Rodríguez, 2013). McDonough and Marks (2002) point out that face-to-face tutorials in small groups compared to individual tutorials via computers for medical students learning exposure therapy for phobias had improved learning outcomes with the computer learning strategy. Chih-Fu and Ming-Chin (2013) note that when comparing two-dimensional (2D) static pictures to 3D animations, the 3D animations allowed for better visual comprehension and provide better understandings of appearances for orthographic views in a graphical course.

Current nursing classrooms utilize 2D static pictures via lecture for the majority of teaching content, and innovative technologies for teaching and learning practices are rarely used within the nursing classroom (Benner et al., 2010; Berry, Lundeen, & Hightower, 2014). When nursing practice is introduced to mobile devices at the point of patient care, errors are reduced, effort is saved, and immediate feedback takes place (Doran et al., 2010; Wu, 2014). The technology of the 3D app can offer interactivity for learning ECG content and provide plentiful practice opportunities on mobile devices within current classroom pedagogy. This study researched 3D app technology and how it affected nursing students' ability to learn ECG rhythm interpretation via the mobile device the iPad.

History of Mobile Apps

Mobile apps are a relatively new technology closely tied to the recent development of mobile devices. A mobile device is a device that can access the Internet anytime or anywhere (Prensky, 2011). Personal digital assistants (PDAs), smartphones, and tablet computers such as the iPad are all considered mobile devices, and all offer consumers the option of downloading apps. Introduced in 1993, the IBM Simon Personal Communicator was considered one of the first smartphone devices and included cell phone, pager, fax machine, and computer app features (Sager, 2012). The touchscreen on Simon included icons set up like an app that could be tapped with a stylus. The touchscreen technology also featured an e-mail function, calculator, calendar, clock, and a game called Scramble. Simon also delivered additional app features such as a camera function, maps, and music, but these options were only accessible by plugging a memory card into the phone (Sager, 2012).

Since Simon's inception, the mobile device market has exploded. According to International Telecommunication (2013), mobile subscriptions increased from 268 million users in 2007 to 2.1 billion users in 2013, and with this ubiquity of smartphones and tablets, the term *app* (for application) became popular. Sarasohn-Kahn (2010) point out that most users can download apps onto a mobile device without any training or computer knowledge. Apps are being used throughout the general population, as well as in healthcare. Liu, Zhu, Holroyd, & Seng, (2011) state that mobile health apps are a recent phenomenon and note that mobile apps include options for networking, medical sensors, and mobile computing, as well as other communication technologies within healthcare. Mobile devices allow users to accomplish tasks anywhere, at anytime, are intuitive and user friendly (Liu et al., 2011).

Liu et al. (2011) document that Apple Incorporated had the greatest number of mobile health apps by the end of 2009 and led the app market in 2010. However, most apps do not offer content using 3D options and mainly consist of 2D options within the app. Liu et al. (2011) reviewed 1,056 medical applications and only two apps claimed to be 3D. The company behind these two apps, 3D4Medical Images, has developed programs that allow learners to interact with 3D views, videos, and content to order to learn body systems (Liu et al., 2011). The 3D visualization utilized with 3D4Medical Images software presents unique future opportunities in mobile health apps for learning.

Purpose of the Study

The purpose of this study was to determine the effectiveness of 3D apps on nursing students' ECG identification knowledge. Gagné's conceptual perspective called the Nine Events of Instruction guided the instructional sequence of this study. This study sought to determine if the teaching strategy of 3D app technology, as compared to the teaching strategy of a traditional lecture covering the same ECG content, affects nursing students' ECG examination performance at one private Christian southeastern university.

Research Question

Do nursing students who receive ECG identification knowledge via a 3D app have greater learning outcomes (evidenced by higher posttest scores) compared to nursing students who receive the same content via traditional lecture? The 3D app functions as the independent variable of this research study, while the dependent variable for this study is the nursing student's level of knowledge as evidenced by examination performance.

Why Try 3D App Technology in Nurse Education?

The National League of Nursing (NLN) research priorities for nursing education 2012-2015 point out the necessity for nurse educators to identify and evaluate effective emerging technologies that teach decision-making skills to nursing students. Kucirkava, Messer, Sheehy, and Panadero (2014) note that little empirical research has been done to review the educational value of apps or the impact of apps. Apps used in education are a relatively new concept, and many studies recognize the underutilized potential for learning experiences in mobile technology. Apps that are 3D engage students in active learning by allowing the student the opportunity to spin true-to-life pictures and drag and cut pictures into sections. This can assist students in visualizing content, meeting individual learning needs (Steinback, 2011). The mobile device used in this study, the iPad, shares many of the same components for learning as smartphones and laptops, but the iPad's increased level of interactivity, portability, and computing power set it apart (Melhuish & Falloon, 2010; Steinbach, 2011).

The American Association of Colleges of Nursing (AACN) (2008) state that nurse educators should provide opportunities in the education experience that utilize a range of technologies that focus on supporting patient care, using simulations, and analyzing patient situation data. The AACN's goals can be explored with research that utilizes 3D app technology on mobile devices in order to determine the pedagogical possibilities for learning. Melhuish and Falloon (2010) suggest that a mobile device can offer a vast number of apps that can easily be selected to meet themes and learning topics for individual learning needs. The authors also state that individuals can tailor apps to suit specific goals in the same way that an educator can for meeting student learning needs.

The use of mobile technologies can improve the quality of nursing practice and should be utilized in nursing curriculum, since clinical experiences are complex and traditional didactic education is limited in providing real experiences and opportunities for student-patient interaction (Cibulka & Crane-Wider, 2010; Feng et al., 2013). Feng et al. (2013) further state that clinical experiences are often unpredictable and might create stress for the beginning learner; stress can reduce critical thinking and competent functioning. The focus of teaching and learning must remain on the way mobile learning can be integrated into effective, evidence-driven, innovative practices that empower learners and enrich their learning experience (Melhuish & Falloon, 2010). The Institute of Medicine's (IOM) (2010) report "The Future of Nursing" stress that the opportunity to transform practice through the use of technology has never been greater.

Conceptual Framework

Billings (2000) notes that when students are engaged and interact with content within a course, the student assumes responsibility for his or her learning. In addition, Hewson and Hughes (2005) discuss that most classroom methods can be usefully categorized by incorporating Gagné's Nine Events of Instruction. Gagné's model of instructional design provided the conceptual perspective for this study. This framework will be implemented for guiding the sequence of instruction in order to provide consistent structure for both teaching strategies in both learning environments.

Gagné focuses on learning outcomes and how to design instructional events in order to achieve such learning outcomes (Gagné, Briggs, & Wagner, 1992). These nine events mirror the cognitive stages for the learning process of adults and can be used as a guideline for creating external conditions that promote learning (Gagné et al., 1992; Zhu & St. Amant, 2010). Gagné's Nine Events of Instruction summarizes key milestones related to instruction which include the following: 1) gaining attention, 2) informing learner of objectives, 3) retrieval, 4) presenting content, 5) learning guidance, 6) performance, 7) feedback, 8) assessing performance, and 9) retention and transfer. Each phase of instruction provide specific pedagogical purpose and instructional strategies will vary according to the type of learning tasks.

Definitions

Application (App): An app can contain a variety of content and is downloaded by users onto a mobile device. Apps can be accessed anytime or anywhere, in order to accomplish tasks (Liu et al., 2011; Sarasohn-Kahn, 2010).

Electrocardiogram (ECG): An ECG is a recording of the electrical conductivity or activity of the heart and is a non-invasive assessment utilized by healthcare professionals for early detection of dysrhythmia, or abnormal activity of the heart (Bond, Finlay, Nugent, Moore, & Guldenring, 2013).

Generation Z: A Generation Z student is an individual born in the 1990's, raised in the 2000's,and driven by social media. Characteristics of these individuals include being highly connected, lifelong use of the Internet, instant messaging, text messaging, and these individuals have not known a day without a mobile device (Tulgan, 2013).

3D app: A 3D app is downloaded to a mobile device and involves three dimensions, including depth, in which interactivity takes place by the user on a mobile device (Prensky, 2006; Prensky, 2011).

Millennial student: A millennial student is an individual born between 1983 and 1991. These individuals do not know a day without the Internet. Millennial students are considered technologically savvy, and they use multimedia daily and collaborate with peers (Werth & Werth, 2011).

Mobile device: A mobile device, such as a smartphone, tablet, or laptop, is a device that can access the Internet anytime or anywhere (Prensky, 2011).

Objective test: This is a method of evaluation where there is only one correct answer. One 10-question multiple-choice test will be used in this study. The same test will be given as a pretest and posttest (Benner, 2001).

Traditional lecture: A traditional lecture is an instructional method in which an individual who has expertise in an area presents new information to any sized group of students. This is an educational program that is delivered via face-to-face didactic lectures, handouts, textbooks, and verbal or paper interactions, as well as any combination of these methods (Feng et al., 2013).

Assumptions of the Study

For the purpose of this research study, the following assumptions were made:

1. The researcher has the knowledge and ability to teach content via the 3D app.
2. The participants have the computer skills necessary to interact with this technology.
3. The participants' pretest and posttest examination responses are representative of their knowledge.

Significance of the Study

This research study is the first to look at 3D app technology's effectiveness on nursing knowledge of ECG interpretation as evidenced by examination performance. The results of this study contribute to the body of knowledge for 3D apps and effectiveness of 3D apps for nursing students learning ECG interpretation; thereby adding to the nursing literature. Due to the seriousness of patient outcomes that can be altered by correctly or incorrectly interpreting ECG rhythms, additional teaching strategies need to be researched and evaluated. The ability to identify normal versus abnormal or life-threatening ECG rhythms can enhance a nurses' ability to provide safe, effective care and even save lives.

Summary

This study's purpose was to determine the effectiveness of 3D apps on nursing students' ECG identification knowledge. The research question was stated, and Gagné's Nine Events of Learning, which guided the instructional sequence of this study, was elucidated. Appropriate term definitions for this research were provided. The assumptions of this research were described and the chapter closed with an explanation of the significance of the research study.

CHAPTER II

REVIEW OF LITERATURE

This chapter contains a review of literature related to the research study. Active learning and Gagné's conceptual perspective is discussed and will guide the methodology of this study. The impact of 3D technology versus 2D technology on teaching and learning is included. Millennial and Generation Z nursing students that make up the current traditional classroom, as well as current use of technology in nurse education is discussed in this chapter. Outcomes from pedagogical approaches that utilize 3D apps for teaching and learning in various populations such as the military, K-12, individuals who fall on the autism spectrum, individuals with special needs, higher education, construction science, and medical education are all reviewed. This literature review closes with a discussion of the benefits, barriers, and student perceptions of mobile devices (namely, the iPad). Current research does not reflect studies that examine 3D apps effectiveness on nursing students' ECG identification knowledge and this research may reflect pedagogical possibilities in nurse education.

Active Learning

Active learning is a term that encompasses an umbrella of several instructional strategies where the focus of learning is to place the responsibility of learning on the learner (Chickering & Gamson, 1987). Gagné's instructional theory adaptation can serve as a guide to help nurse educators make decisions for utilizing technologically driven teaching methodologies for learning that focus on active learning and interactivity. Chi (2008) defines active learning as physically doing something and these activities need to include engaging activities, such as gazing, fixating, underlining, pointing, or manipulating objects. These active learning characteristics engage the learner’s cognitive process by activating and searching existing knowledge. This can take many forms, as there are visual, auditory, and kinesthetic types of learners (Notarianni, Curry-Laurenco, Barham, & Palmar, 2009). Nursing itself is an interactive profession; nurses must see, listen to, and touch patients. Nursing requires all three components to provide quality, safe nursing care, and nurse educators can utilize technologies with their pedagogical approach that engage all of these components.

Gagné et al. (1992) stress that learning takes place by the learner interacting with his or her external environment. Therefore, for complex content, nurse educators should be innovative with their teaching strategies and consider incorporating technology within the learning environment (Benner et al., 2010). Nurse educators could choose technology for teaching and learning that require students to interact with content. The 3D app technology is an instructional strategy that requires interactivity with the user to display needed education content. An alternative or supplement to classroom lecture could be incorporating 3D app technology that encourages an active and interactive learning environment. For example, as a student learns ECG content via 3D app technology, the educator can facilitate learning by encouraging practice opportunities and visualize cardiac rhythms via videos and animations. Such practice opportunities take place by interacting with the 3D app while reading text that describes what is taking place in the heart. As the student asks questions in regard to the content, the educator can provide feedback and reinforcement, internally motivating the student. As students correctly identify ECG rhythms and move forward in the app, the educator can observe increased engagement and student learning. The use of 3D technology can offer options for grasping the attention of the student, motivating the student, and engaging the student in the learning process.

Gagné's Nine Events of Instruction

Gagné's Nine Events of Instruction guided this research study, which examined knowledge development of ECG rhythm interpretation through use of a 3D app on a mobile device (specifically, the iPad). Accessing the app required the learner to be active with the functionality of the device in order to interact with the components and content of the app. Additionally, the 3D app offers ample practice sessions and this practice is determined through the choice of the user and by the needs of the learner. Therefore, the student is individually challenged. The visual, auditory, and kinesthetic components of this app may motivate students, gain attention, and promote the process of learning ECG rhythm interpretation, since the learner interacted with their external environment.

According to Gagné et al. (1992) the teacher designing instruction can create situations that include conditions of learning for both internal and external processes. Richey (1996) writes that Gagné's work focuses on the internal process of learning and includes external events that stimulate and control learning, which are dependent on past learning. Depending on the desired learning outcome, instruction will vary and the need to include strategies that motivate, direct, guide practice, provide feedback, and reinforce learning should all be included in instructional sequencing.

After discovering internal and external stimuli during the learning process, Gagné's Nine Events of Instruction correspond to cognitive processes that take place during learning and can be utilized in order to ensure effective learning takes place. These necessary learning conditions serve as the basis of instruction design, as well as selection of appropriate media for nursing students learning ECG rhythm interpretation via a 3D app (Gagné et al., 1992). If nurse educators incorporate Gagné's Nine Events of Instruction in planning the instructional design of ECG interpretation learning, effective instruction should take place and learning outcomes should increase (Gagné et al., 1992; Richey, 1996; Zhu & St. Amant, 2010). The investigator incorporated Gagné's Nine Events of Instruction as the instructional guide for this research study. The components of this conceptual framework provided the investigator tools that assessed students utilizing 3D app technology via a mobile device in the nursing classroom. Gagné's Nine Events of Instruction are discussed below.

1. Gain Attention

Gagné et al. (1992) provided an instructional sequence for organizing and facilitating effective learning options that lead to learner achievement. The first instructional event is gaining attention. Gagné et al. (1992) acknowledge that a variety of events can be employed in order to gain the learner's attention. If an event appeals to a learner's interest, attention can be gained. Gaining attention can involve visual, auditory, or kinesthetic stimuli, or any combination of these three. In order to gain a student's attention, the educator can show 3D graphics of the heart, text, videos, PowerPoint slides, and animations (Gagné et al., 1992). Orientation to the 3D app can also gain the attention of students.

2. Inform Students of Learning Objectives

Informing students of learning objectives is the second event of instruction. When educators inform learners of the objectives in a clear, concise manner, expectancy is captured and students understand what they should obtain from the learning experience. Clearly stating learning objectives and not assuming that the student knows what the learning objectives are, provides an environment for learning to take place (Gagné et al., 1992).

3. Stimulate Recall

Stimulating recall of prior learning is the third event of instruction. In order for learning to take place, stimulating recall of prior learning is associated with new learning. Stimulating prior recall retrieves and places information in the student's working memory, creating an opportunity for combining ideas that are essential for learning (Gagné et al., 1992). Prior knowledge of ECG interpretation will be assessed by a 10-item pretest during the beginning of the traditional lecture. This prior knowledge can then be associated with the instruction that takes place via the ECG traditional lecture and 3D app learning session.

4. Present Content

The presentation of the content is the fourth event of instruction. Presentation of the content or presenting a stimulus, is when selective perception takes place and proper stimuli needs to be included as part of instructional events in order for learning to take place (Gagné et al., 1992). According to Gagné et al. (1992) content should be provided in an organized manner, and if possible utilizing multi-media. Presenting content can be visual, auditory, kinesthetic, or any combination of the three. For this study, traditional lecture and the 3D app session provided content in an organized manner and both environments used multi-media tools.

5. Provide Guidance

Providing learning guidance is the fifth event of instruction and should include examples that increase student learning. Guidance provides events that adapt to learner differences and provides instructional support (Gagné et al., 1992). When learning guidance is given, in this study by providing ECG rhythm examples, semantic encoding takes place for long term memory. Directions and student content guides were provided to students for both learning environments. This was to ensure that guidance was available for both environments. In addition, examples were provided by faculty that cued and prompted learners throughout both the traditional lecture and 3D app learning sessions.

6. Elicit Performance

Eliciting performance is the sixth event of instruction and should require the student to verify that content has been committed to memory. If the educator elicits performance, then the learner responds, and verification takes place. This could include the student correctly identifying an ECG rhythm, practicing this knowledge throughout the learning experience, and revisiting rhythms as needed. As the student practices content and moves forward within the app, this illustrates that learning is taking place (Kronke, Muller, Friederici, & Obrig, 2012). This part of the study's instruction sequence provided opportunity for active learning, as well as giving the student opportunity to show evidence of learning the content. Advancing through the app's levels of education convinces the instructor that learning is taking place, and perhaps more importantly, convinces the student that learning is taking place (Gagné et al., 1992).

7. Provide Feedback

Providing feedback is the seventh event of instruction. The educator needs to provide information immediately that allows the student to see where they should improve learning. Feedback creates reinforcement for student learning and provides opportunities to correct any incorrect learner performance (Gagné et al., 1992). Opportunity within the instructional sequence for providing feedback may be delivered in different ways. For example, a head nod or a verbal response, would be ways of providing both verbal and nonverbal learning reinforcement. For this study, such feedback was provided throughout both teaching methodologies.

8. Assess Performance

Assessing performance is the eighth event of instruction and could include a posttest. A posttest allows assessment of student knowledge and learning. A posttest assessment was completed as part of this study for all participants. By assessing performance, the desired learning outcome will be measured, and knowledge retrieval will be activated (Gagné et al., 1992).

9. Enhance Retention and Transfer

Enhancing retention and transfer is the ninth event of instruction. The educator could require an examination that has questions in regards to student knowledge and retrieval of long-term memory of the content. In order to transfer knowledge, the student should be able to apply previously learned content to a new set of questions as a means of enhancing knowledge retention. These necessary learning conditions serve for the basis of instruction design, as well as selection of appropriate media for nursing students learning ECG rhythm interpretation via a 3D app (Gagné et al., 1992). These learning conditions were implemented in this study and guided the methodology of this study. The components are listed in Table 1 below.

Table 1

Gagné's Nine Events of Instruction with Process of Learning

Event 1: Gain attention • Investigator provides stimulus • For learning to take place student attention needs to be captured
Event 2: Learning objectives • Expectation of learning is created by providing learning objectives • Inform participants of expectations
Event 3: Stimulate recall of prior knowledge • Retrieval of information takes place and moves from short-term memory • Learning takes place if new information is associated with prior knowledge
Event 4: Present content • Selective perception of content in participant's mind takes place
Event 5: Provide learning guidance • Semantic encoding takes place by moving information to long-term memory
Event 6: Eliciting performance • Participants response encodes and verifies content to memory • Practicing the content is a way to elicit performance
Event 7: Providing feedback • Reinforcement takes place from participant performance and how the participant applies information • Specific and immediate feedback of learners performance
Event 8: Assess performance • Retrieval of information is prompted • Reinforcement of final understanding of content • A pretest or posttest can be utilized
Event 9: Enhance retention and transfer • Participant retrieves information • Generalizes learning that allows participants to apply learning to new situations.

Note. Adapted from Gagné, R. M., Briggs, L. J., & Wagner, W. W. (1992). *Principles of Instructional Design (4th ed.).* Fort Worth, TX: Harcourt Brace Jovanovich College Publishers.

When each of Gagné's Nine Events of Instruction is embedded in the instructional sequence learning will be facilitated. These Nine Events of Instruction were incorporated in this study for nursing students' learning ECG interpretation.

3D Technology's Impact on Learning

Interpretation of ECGs in the current nursing classroom is taught via lecture by showing 2D pictures of rhythms. In 2D app technology, a 2D computer-assisted program allows objects to be drawn on an X-Y scale, as if they were drawn on paper. This 2D option is referred as static. These 2D images can be scaled larger or smaller, but cannot be rotated to different angles, which explains why such objects are considered static. The term *3D image* is derived from the use of three axes in a medium that includes dimensions of height, width, and depth. Images can be displayed and users are able to manipulate in all three dimensions. This manipulation includes images and content that can be rotated, scaled smaller or larger, and viewed from all angles, even spliced and spanned, by the user via the touchscreen. These three dimensions provide complexities that have been previously unavailable. These 3D options are usually created through a series of photographs taken at various increments. This process includes a 360-degree turn around of the content that is placed into a Quick-Time movie, or Flash video, which is what the user interacts with via the 3D app (Steinbach, 2011).

The 3D app for this study allowed the nursing student to view ECG rhythms and to interact with the content. This 3D app engaged the student in active learning by allowing the student to spin accurate pictures of the heart, vessels, conduction system, and ECG rhythms or drag and cut the pictures into sections thereby helping visualize the inside of the heart. This is all done within the 3D view of the human body and at the student's individual pace. Silen, Wirell, Kvist, Nylander, and Smedby (2008) found that 3D images assist medical students to better understand spatial anatomy and that students need time for introduction to the content in order to be interested in using the new media, which adds educational value to the student's learning process. Silen et al. (2008) investigated questionnaires for 62 medical and physiotherapy students' opinions about the different formats of visualizations and their learning experiences and found these students had a deeper knowledge of content when interpreting 3D images compared to 2D images. Hilbelink (2009) found that 124 volunteer undergraduate students learning skull anatomy through 3D images had significantly higher scores for spatial relationships than students learning the same content through 2D images.

The Millennial and Generation Z Nursing Student

The current nursing classroom is made up of a majority of millennial students and Generation Z students. Characteristics of millennial learners and Generation Z learners differ from their predecessors and are worth discussion. The millennial student, born between 1983-1991, have been exposed to immersive, interactive, virtual worlds, 3D technology, and interactive games, since they were born, and these millennial learners now make up the current 18 to 24 year old college student population (Pardue & Morgan 2008; Werth & Werth, 2011). Millennial students are competent with technology, need immediate feedback, engage in multi-tasking, and depend heavily on visual cues to process what they are learning (Pardue & Morgan 2008; Werth & Werth, 2011). Millennial students have always had the Internet available to them and their main form of communication consists of social networking and text messaging (Werth & Werth, 2011). These students are techno savvy and the nursing discipline should utilize innovative technologies that build on such attributes (Lynch-Sauer et al., 2011; Werth & Werth, 2011).

Millennial students learn differently and enter the classroom with different learning expectations. Howe and Strauss (2003) write that higher education needs to prepare to adjust to the Millennial Generation and strategies are needed in the classroom to engage millennials. Seven core traits of the Millennial Generation include: (1) sheltered, (2) confident, (3) team-oriented, (4) conventional, (5) pressured, (6) achieving, and (7) special. Numerous sources acknowledge that a unique feature for millennial learners is that they pay attention in bursts while multitasking, and piece together information through interaction (Juke, McCain, & Crockett, 2010; Prensky, 2011). Millennial students make up a large portion of the current nursing classroom.

Generation Z are individuals who have been born after the millennial generation and their characteristics include being highly connected, lifelong use of the Internet, instant messaging, text messaging, and this generation has not known a day without a mobile device (Tulgan, 2013). Generation Z have been born in the 1990's and raised in the 2000's and are driven by social media (Tulgan, 2013). Generation Z students make up a large portion of the current nursing classroom. The nursing discipline should utilize innovative technologies that build on both millennial and Generation Z characteristics.

Current Use of Technology in Nurse Education

The relationship between theory and clinical application is a struggle for nursing students, and they primarily receive content through traditional lecture via slide presentations, which may not engage the student in understanding or visualizing the content (Benner et al., 2010). Technology that enables interactive learning activities, such as 3D apps, may be an interactive platform for learning ECG interpretation in nursing education. Billings (2000) stresses that educators must focus on pedagogy first, and not on the technology, so that technology enables learning. Gedik, Hanci-Karademirci, Kursun, and Cagiltay (2012) point out that the type of software and hardware used with mobile learning greatly affects pedagogical approaches.

Lynch et al. (2011) found from a survey of 218 nursing students, that nursing students welcome the use of interactive media and are comfortable with technology. When compared to traditional lecture method for learning ECG interpretation, studies found that with Web-based teaching methods and interactive videoconferencing in teaching methods, students had higher levels of ECG interpretation with these technologies as evidenced by higher posttest scores (Jang et al., 2005; Celikkan et al., 2013). Celikkan et al. (2013) looked at pretest and posttest scores of nursing students (13 males and 57 females) and found that significant improvement for learning ECG skills with the interactive videoconferencing took place. Additionally, Celikkan et al. (2013) obtained results from a questionnaire, and these nursing students were overwhelmingly satisfied with the interactive videoconference based lecture compared to the traditional lecture. Jang et al. (2005) developed a four-week, self-directed, Web-based learning program for interpreting ECG recordings and looked at a group of 105 nursing students. The ability to interpret ECG recordings, by comparing pretest and posttest scores, were higher significantly among the students in the Web-based group than the traditional lecture group. Further, both technologies shifted the student from learning in a passive manner to learning in a more active manner. Additionally, learning outcomes for forty-six nursing students studying the respiratory system through mobile learning systems were improved compared to a traditional learning option (Wu, Hwang, Su, & Haung, 2012).

Nurse educators must engage students in active learning if nursing students are going to be able to apply what is learned in the classroom to the patient at the bedside. Active learning includes techniques where students actively process and apply knowledge cognitively, and point out that passively acquiring knowledge is often what takes place (Nelson & Hauck 2008; Notarianni et al., 2009). For active learning to take place, students need to actively process the content that they are learning, and then have an opportunity to apply that knowledge (Nelson & Huack, 2008). Jeng, Wu, Huang, Tan, and Yang (2010) completed a review study of nurse educators that looked at nursing students who use mobile devices to facilitate learning. These authors described the situated learning environment as one that consisted of a mobile learner (nursing student) and the mobile coach (educator) who completed interactive learning activities by allowing the student to explore knowledge through these mobile learning tools. The coach guided the learner, monitored the needs of the student, and provided appropriate assistance, while the nursing students' knowledge was increased with the use of mobile devices (Jeng et al., 2010). Thus, technology that enables more interactive learning activities, such as the use of a 3D app, can be an interactive platform for learning ECG interpretation in nursing education.

Current Nursing Classroom Learning Objectives

The ECG content is offered as early as the first fundamental nursing course for some universities, while others provide ECG interpretation as late as the last semester or a critical care course. Each individual nursing university determines this sequence. A nursing student may never actually set foot on a cardiac or telemetry unit or experience opportunities for applying ECG rhythm interpretation. Often, when nursing students start clinical experience, ECG interpretation opportunities have only been from 2D slides in traditional lecture. The gap between nursing students' knowledge and skills learned in a classroom, and the student's independent application of knowledge and skills, has been an ongoing challenge for nurse education, and introducing new innovative technologies into the didactic phase should take place. (Benner 2001; Benner et al., 2010; Sampaio, Ferreira, Rosario, & Martins 2010).

Nursing students currently learn ECG rhythm interpretation by analyzing a three-second strip in the classroom, and interpreting a 12-lead ECG is considered a more advanced nursing skill. The three-second ECG strip was used in this study. The nursing objectives for learning ECG interpretation include: to gain a basic knowledge of cardiac electrophysiology, to understand the representations of the cardiac cycle on the ECG, to understand the conduction system of the heart, to master techniques used for learning the characteristic of the different dysrhythmias, and to identify three lethal rhythms (Berry et al., 2014). The nursing objectives were embedded in the traditional lecture and 3D app learning sessions for this research study.

3D Apps Used Today

3D Apps in the US Military

The military has utilized 3D app technology for years and is continuously researching the learning and teaching opportunities inherent in technology. Sostak (2012) stressed that mobile apps are beginning to gain acceptance in the military as effective training products, and the future advancement for better learning must be considered. The Connecting Soldiers to Digital Applications (CSDA) program strives to explore smartphone technologies that can access army functions and support through mobile devices. In addition, pilot programs for CSDA are evaluating applications developed by the military and commercially for tactical purposes such as identifying location, identification reporting, and battlefield situations (Gammell 2011; Vane, 2011). The MEDEVAC app offers practice with requisitions, calls for fire, situational awareness, and other mission command task features for the military (Vane, 2011). Smartphone technology also saves time and money for the military. Soldiers are using apps for self-paced individual training programs, distance learning options, language translation, education, administrative functions, identification purposes, operations, and tactical functions (Moffett, 2011). Apps help candidates prepare for basic military training in the US Air Force and guide these candidates in obtaining better physical condition (Gammell, 2011).

Stafford and Thornhill (2012) discuss the Army Learning Model (ALM), which advocates the need for expanding the role of blended learning for Army education. This model suggests combining face-to-face instruction with online learning and improving production of technology that enhances production for training support, education support, and job performance. Interactive multimedia, including apps for use on mobile devices is beneficial, and the US Army is currently developing more of these types of technologies. Due to the benefits of mobile apps, slide presentation lectures need to be reduced, allowing multisensory interactive media methods to provide more realistic training for the military (Stafford & Thornhill, 2012). The Army has even launched their own marketplace for downloading apps in order to reduce time in delivering apps across the Army. The military app marketplace includes valuable training aids and planning tools, which are changing the way soldiers are being educated and trained (Stafford & Thornhill, 2012).

Martin and Lin (2011) discuss how smartphones provide soldier content at the point of need, since the soldiers have smartphones with them at all times. These authors further note the current soldier’s training involves sitting in a classroom for forty-five minutes watching PowerPoint presentations. Spain, Priest, and Murphy (2012) discuss that as the US military training requirements grow in scope and complexity, the resources of manpower, time, and money are limited, and there is a need for less instructor-led training. The US military is pushing to move from traditional lecture to collaborative, problem-solving learning experiences that are technology based training experiences tailored to individual learning needs.

Schulman et al. (2012) evaluated 113 US Army Forward Surgical Team members in a study that looked specifically at trauma and critical care education by using a pretest and posttest design for a scenario assessment looking at the medical condition of shock. The study found that these areas of study faced increased time constraints for teaching and learning, limited options for clinical hours, large amounts of content for retention, and the necessity of being able to access information in trauma and critical care situations. These authors proposed that mobile learning could mitigate these challenges and found that traditional lecture and mobile learning were equally effective with no statistically significant difference between the experimental (n = 53) and control (n = 60) groups. Both groups performed better on the posttest than the pretest, which suggests mobile learning utilizing apps is an effective means for providing the same content knowledge. The savings in time with mobile learning was an important benefit of this study. The authors found that the app content used in this study took participants 10 minutes to complete, compared to 60 minutes for participants to complete with traditional lecture content (Schulman et al., 2012).

3D Apps in K-12

Many pedagogical uses of 3D apps exist in the literature for K-12 learning environments and show implementation and effectiveness of using such technology. For example, 30 fifth graders in Taiwan, used a mobile tablet for learning math and were able to better connect mathematical concepts and improved mathematic knowledge and skills compared to a paperpencil option (Hwang, Wu & Ke, 2011). Bai, Pan, Hirumic, and Kebritchi (2012) found that using a 3D instructional math game for 437 eighth graders had significant effect on mathematical knowledge of algebra, and maintained student learning motivation. Kucirkara et al. (2014) reported that 41 children learning Spanish via an iPad, had higher individual engagement with the 3D app, in contrast to individual engagement with a 2D app. These authors also found the 3D app allowed the individuals to create audio and visual texts, from the mobile device's camera by recording audio and taking pictures, whereas the 2D app only allowed the individuals to color and draw for activities while learning Spanish.

3D Apps in the Autistic Population

Pedagogical implementation of 3D apps for autistic populations is available in the literature. When using a virtual learning environment with a 3D avatar, individuals on the autism spectrum had positive effects for social interaction performance and learning through the use of 3D expressive avatars and animated social situations (Cheng & Ye, 2010). Cheng, Chiang, Ye, and Cheng (2010) looked at collaborative 3D virtual interactive learning environments using the iPad for instructional delivery and found for children who fell on the autistic spectrum, empathy was enhanced, escape-maintenance behavior was reduced, and academic engagement was increased. Kagohara et al. (2013) looked at 15 studies that involved the use of iPods and iPads as teaching aids for individuals with developmental disability studies covering academic, communication, employment, leisure, and school setting transitions. These authors looked at 47 participants ranging from 4 to 27 years of age with autism spectrum diagnosis, an intellectual disability, or both, and found these mobile devices to be viable technological aids for these individuals. Kagohara et al. (2013) discussed that from the data collected from these 15 studies, the results were positive, suggesting that mobile devices are viable technological aids for individuals with developmental disabilities.

3D Apps in Special Needs Population

Using the iPad, Fernandez-Lopez, Rodriguez-Fortiz, Rodriguez-Almendros, and Martinz-Segura (2013) utilized the mobile app Picaa to study learning outcomes in special needs populations. Picaa is a 3D app that is specifically designed for teaching special needs individuals. Fernandez-Lopez et al. (2013) found with the accessibility of the images and text on the mobile device, such applications helped special need students better develop skills in perception, attention, memory, reading, writing, motor skills, and reasoning. Kagohara, Sigafoos, Achmadi, O'Reilly, and Lancioni (2012) found that based on specific instructional procedures, or pedagogy, students performed better using the spell check tool on mobile devices, such as the iPad. These two students were provided an iPad, with a downloaded video illustrating how to using the spell check tool and both participants reached 100% in correct performance. McClanahan, Williams, Kennedy, and Tate (2012) found that the iPad helped fifth grade readers with Attention Deficit Hyperactive Disorder (ADHD) focus their attention and discussed that from pretest and posttest scores, one student gained one year's growth in reading within a six week time period. Hayden, Hawkins, Denune, Kimener, and McCoy (2012) found that three high school students with emotional disturbances solved more math problems correctly and in less time on the iPad condition of the study, compared to the worksheet condition of the study. These authors further point out that these students demonstrated higher levels of active engagement, felt in control of learning, and expressed a preference for multimedia contents with the iPad condition, compared with the worksheet condition. Falloon (2013) found that the use of mobile devices provides practice opportunity for early childhood education, offers skill refinement for students with poor fine motor skills, and multi-media learning environments enhanced the learning process. Skiada, Soroniati, Gardeli, and Zissis (2014) designed a mobile app interactive experience for five children who were diagnosed with dyslexia and found that these students had higher performance in overall scores from the interactive experience.

3D Apps in Higher Education

Pedagogy that utilizes 3D app technology in higher education has been discussed in the literature. There were multiple studies found in the literature that illustrate 3D application technology in higher education. Moreno, Ozogul, and Reisslein (2011) point out that problem solving was better when students had concrete visual representation experiences when learning electrical circuit analysis and that prior knowledge connects with such visual representation. Vogel, Vogel, Cannon-Bowers, Muse, and Wright (2006) describe *interactive* as an option for the user to make a choice and found that interactive simulations for learning with computer gaming had more dominant cognitive gain outcomes compared to lecture. Noguera, Jimenez, and Osuna-Perez (2013) found that using a 3D mobile learning tool via a hand held device for 70 university students in Spain learning physiotherapy of the ankle and knee, showed that the students using the 3D tool answered 100% posttest questions correctly, compared to students in the traditional method.

Brenton et al. (2005) discuss how teaching anatomy is moving toward the use of 3D modeling and computer-assisted learning. These authors further discuss that since technological developments are available, while the field suffers from to time constraints, as well as limited availability of cadavers, other options for learning anatomy is needed. These authors state that the obvious benefit of 3D models is that users view spatial relationships from multiple viewpoints and 3D models are very different from textbooks, since textbooks do not show spatial relationships. Hahn and Bussell (2012) examined curricular uses of the iPad, and found that the iPad was useful for chemistry, specifically a 3D molecule app. These studies suggest that if apps are developed with fully productive functions for courses, the iPad, will become a valuable tool for curricular uses (Hahn & Bussell, 2012). In reviewing the positive outcomes of the previously discussed studies, educators need to utilize pedagogical approaches that include 3D app technology and implement innovative technologies that engage student learning.

3D Apps in Construction Science

Many studies found that using 3D technology with virtual environment technology adds value to the learning experience for construction sciences. This discipline can benefit from utilizing 3D technology in teaching and learning complex concepts; however, Goedert, Cho, Subramaniam, Guo, and Xiao (2011) point out that the construction industry has not taken advantage of new technologies that exist in simulations, modeling, and software engineering education. Thomas et al. (2013) looked at learning complex geometries for construction and engineering students and at the potential for 3D graphics as effective supplementation within virtual environments for learning. These authors discussed that visualization leads to changes in physical forms through 3D computer graphics (Thomas et al., 2013).

Sampaio et al. (2010) state that 3D models can assist in making decisions based on visual analysis and are important monitoring tools for structural anomalies in civil engineering. Sampaio et al. (2010) assert that architects develop 3D models in order to show clients a clearer understanding of what a house will look like when it is built. Current methods for data acquisition in construction are manual and time consuming, and methods that use color and 3D data for monitoring construction progress are beneficial at the construction site (Son & Kim, 2010).

3D Apps in Medical Education

Important pedagogical offerings in the literature include 3D apps in medical education and should be discussed. In medical education, 3D visualization advancements provide authentic images that help medical students understand spatial anatomy. Medical schools often teach in 2D imagery, but De Ribaupierre and Wilson (2012) assert that 3D spatial abilities are crucial for surgeons in learning temporal lobectomy. De Ribaupierre and Wilson (2012) created a 3D interactive model for medical students learning temporal lobectomy and compared the applications to 2D images. When 3D applications were utilized, medical residents indicated a better understanding of temporal lobectomy compared to using 2D images (De Ribaupierre & Wilson, 2012). Nicholson, Chalk, Funnell, and Daniel (2006) discuss a 3D interactive anatomical model that was computer-generated for learning middle and inner ear content in an anatomy course and found that the 3D intervention group's(*n*=28) mean quiz score was 83%, compared to the control group's (*n*=29) mean quiz score of 65%, for learning middle and inner ear content.

The iPad may push physicians away from desktops and toward tablets for patient education, viewing radiographs, and viewing ECGs (Berger, 2010). Cloud computing and mobile devices mean the ECG rhythm will be able to be visualized utilizing such software technology by medical professionals. Semeraro et al. (2011) found that the cardiopulmonary resuscitation (CPR), or the iCPR app for learning CPR was successful, by looking at a sample of 50 users (4 doctors, 22 nurses and 24 lay people) and found chest compression performance significantly improved by all users in terms of the compression rate. Additionally, participants stated that the iCPR app assisted them in achieving the correct chest compression rate (Semeraro et al., 2011). Ringle (2011) discussed a small iPad pilot study at Duke University School of Nursing where clinical nurse educators found the iPad ideal for clinical instruction. The nursing students could use the iPad to look up medication, procedure information, and patient education materials at the bedside. The nursing student could share content visually, and clinical nurse educators reported they were completely supportive for using the iPad in the clinical setting (Ringle, 2011).

Prober and Heath (2012) stress that current medical educators need to make lessons more memorable by capturing student curiosity through active learning, which increases student engagement. Stanford Medical School redesigned a core biochemistry course and replaced traditional lecture format with short on line presentations and set aside class time for discussions and interactive learning. Although students were not required to participate in class and attendance was optional, class attendance rose from 30% to 80% (Prober & Heath, 2012). Classroom time was utilized to boost engagement and retention by creating learning spaces that were comfortable, required only low-stake quizzes, and offered participation in discussion, giving all the potential to improve learning retention (Prober & Heath, 2012).

John (2007) provided a survey from 1995 to 2005 that reviewed medical apps that utilized app technologies and found that if the app offered an interactivity level, this interactivity provided value to medical education and training tools for students. Models that offer 3D animation and visualization of cross-sectional components brought extra dimensions to learning, enhancing the educational process, and suggesting that such 3D models need to include options such as video clips, text, and self-assessment tools (John, 2007). Davis et al. (2012) found that a three minute video on a mobile device covering chest tube insertion for surgical residents was an effective medium for teaching chest tube insertion. There were 128 participants with 50% in the experimental group, which performed significantly higher on quiz scores than the control group that did not view the three minute video on the mobile device (Davis et al., 2012). Davis et al. (2012) point out that embedding the video on the mobile device allowed participants to access the content immediately before chest tube insertion took place enhancing the learning process. The utilization of 3D app technology in medical education has multiple benefits to teaching and learning.

iPad Learning

This current study used 3D technology via the iPad for its research, so the benefits, barriers, and student perceptions of iPad are discussed.

Benefits of the iPad for Learning

Walsh and Simpson (2013) point out that the use of touch pads is in its infancy and the impact on learning and teaching is undiscovered. According to Jukes et al. (2010) technology empowers students to master content at their own pace, and this mastery takes place when learning is convenient and practical. Educators need to be creative when embracing pedagogy that drives students to want to learn through discovery via mobile learning.

Versility. Bansavich and Yoshioka (2011) discuss the iPad's versatile uses in the classroom, including actions such as accessing websites, audio, video, presentations, learning management systems, ample document formats, as well as being portable, mobile, and small. The iPad's design and graphics, ease of use, speed of apps, touchscreen function, electronic book (eBook) downloads, and the battery life, are all benefits for learning. Additionally, the iPad offers the increased power of a computer with video and camera options, which can be used as a tool for a variety of teaching strategies that target active learning and link simulation options to real world situations (Bansavich & Yoshioka, 2011; Robinson, 2011). Annotating, note taking, multimedia, viewing, interacting, mobility of learning inside and outside the classroom, language learning, science learning, and interactivity are all benefits for learning experiences with the iPad. The iPad can be used by one student to annotate and tag a photo for evidence for a project, while another student can write a synthesis of the evidence on a class blog, meeting the needs of various learning styles (Bansavich & Yoshioka, 2011; Melhuish & Falloon, 2010).

Clinic Experience. For clinical experiences, the iPad can be used for teaching patients, students, and staff, while interactive applications, entertainment, social networking, productivity tasks, service work, research, and meetings are also valuable use for teaching and learning (Ringle, 2011). The iPad allows small group exploration opportunity and interactive platforms (Bansavich & Yoshioka, 2011; Ringle, 2011).

Mobility. Johnson, Levine, Smith, and Stone (2010) stress that the idea of books on mobile devices move the textbook content to an interactive option and can create interactive activities that obtain, store, read, and annotate along with gaming, animation, and video components. The eBook option creates opportunity for interactive simulations at the user's fingertips with the ability to annotate within the eBook, collaborate on note taking, quickly reference during class, keyword search, and tag, all while learning the content from the eBook.

For students carrying the iPad, the weight is minimal compared to that of a textbook's weight. Additionally, eBooks are not tied to having Internet access so they can be used anywhere. Because of the lack of printing costs, eBooks can usually offer better pricing than traditional textbooks. When the iPad is online, hyper-links to other sources, embedded assessments, and interactive activities are all available to the learner (Johnson et al., 2010).

Other Uses. Other beneficial uses of the iPad include lab setting, fieldwork, research tool, student advising, and tutorial viewing and such benefits can be wireless, convenient, productive, and offer auxiliary apps, which all assist student learning in courses (Goral, 2011; Hahn & Bussell, 2012). Ciampia (2012) found that touch pads were useful, engaging applications that motivated students and increased student interaction in the classroom. Goral (2011) points out that using tablet technology may enhance creativity, enhance critical thinking, lead to cost savings for students since tablets use digital reading, and encourage interaction between student and faculty. The iPad can offer implications for found learning or discovery, and its use in education may facilitate teachers as coaches for learning (Johnston et al., 2010; Mouza, 2008). Greater student learning autonomy allows enhancement of metacognition, and complex content or problems can be addressed in this mobile learning or real time environments. The iPad is a mobile device that can be used for individual learning with a huge number of app choices, offering great potential for learning (Herrington, Montei, Herrington, Olney, & Ferry, 2008; Melhuish & Falloon, 2010). The flexibility and engagement options from apps, allow multiple options for student learning experiences. There are ample benefits in using the iPad for teaching and learning.

Barriers of the iPad for Learning

There are some potential barriers of the iPad. These include keyboard issues, lack of student access to an iPad, cost, functionality or lack of familiarity to apps, lack of productivity, and limited ability to create content. Entertainment, social networking, productivity tasks, service work, research, meetings and other interesting apps could be considered barriers, since these options may distract the student from learning (Bansavich & Yoshioka, 2011; Robinson, 2011). For eBooks issues of copying, highlighting, challenge of annotating, size of the keyboard, as well as potential copyright issues could all be barriers of the iPad. Potential copyright issues could include rightful ownership and use when it comes to audiovisual materials, web pages, work saved, or electronic email messaging. Gaining access to a secure network, difficulty typing on the touchscreen, issues with researching and writing due to the size of keyboard and compatibility issues may prevent students from accessing some course content, such as loading online quizzes (Bansavich & Yoshioka 2011; Hahn & Bussell, 2012; Robinson, 2011). Supplemental apps, such as downloading a Flash Player Browser could alleviate such issues for the iPad. These barriers can influence the use of the iPad for teaching and learning.

Student Perceptions of the iPad

Robinson (2011) studied iPad app use among radiography students and stated that the app was chosen for its high-definition graphics and quality of visualization. Robinson (2011) surveyed 68 radiography students and found that the iPad and app were convenient to use, motivated the student to participate in activities, enhanced learning, brought greater student attention to their task, and overall, these students preferred the iPad over paper worksheets and 2D pictures. These students also requested that the iPad be used in other courses. Saorin, Torre, Martin, and Carbonell (2013) conducted a study among 41 engineering students and found that students preferred the workshop in a digital tablet format, rather than the paper format, and 83% of students preferred using large screen devices (tablets) over small screen devices (smartphones). Saorin et al. (2013) explained that the experimental group consisted of students who had obtained the lowest pretest scores for spatial skills, and after the spatial training workshop was completed using digital tablets, these participants performed correctly on admission exams for technical drawing. Hesser and Schwartz (2013) utilized the iPad in creating a paperless chemistry lab and the students rated overall experiences as positive.

The 3D4Medical Heart Pro III in Nurse Education

The investigator was introduced to the 3D4Medical Heart Pro III app by a nursing colleague who conveyed that a pediatric cardiovascular surgeon used this app daily for educational purposes. This physician chose this app due to its realistic and accurate visualizations of cardiac anatomy and her ability to write on the screen for educating patients and family members about pediatric cardiac surgical procedures. The 3D4Medical Heart Pro III app also offers ample options for learning ECG interpretation and includes videos, animations, audio pronunciations, sound, media for pin labeling, quiz options, ability to write on the screen, interaction with the app's content, pivot cardiac positions within the body as well as slice, drag, drop, zoom in and out for cardiac content. This 3D app is anatomically accurate and allows the user to rotate and view the heart from any angle. Additionally, this 3D app is user friendly with greater functionality of learning ECG interpretation for nursing, compared to other apps that exist to date (Lewis, 2012; Miles, 2010). This 3D app was used at Stanford University School of Medicine and was chosen by faculty for its use and functionality specifically because the 3D app allows the users to rotate, cut, and label different components of a realistic 3D heart; it was positively received by medical educators and medical students (Ringle 2011; Rath 2012). There is limited availability of 3D apps involving the cardiovascular system and ECG interpretation content. This 3D app consists of a visual, kinesthetic, and auditory (normal beating heart) option for the cardiac system. There are many apps that do not offer interactivity or have the functionality of reaching all three of the learning styles (Miles 2010).

The 3D4Medical Heart Pro III app has won numerous awards. This app was picked from over 300,000 apps to be featured first in 2012 in the Apple commercial for the iPad 4 and is still featured today. This app was developed by 3D4Medical Images. This app also received gold and silver awards from the Web Health Awards in the Mobile Applications in 2012 for the patient communication category. Additionally, 3D4 Medical Heart Pro III was featured by Hospital Corporation of America (HCA) and is currently rated as one of the top 10 best iPad apps, by

Apple users, and as one of the top 10 best iPhone apps, by doctors and medical students (Miles, 2010).

Falloon (2013) discussed several components that are essential for app selection: (a) learning objectives should be communicated in accessible and understandable ways, (b) distraction-free pathways should be provided towards achieving goals, (c) understandable instructions and teaching components should be included, (d) formative, corrective feedback should be included, (e) a combination of games, practice and learning components should be utilized, and (f) interactive components targeting characteristics of the student learners should be provided. Falloon (2013) stressed that careful attention to the design and content of apps needs to be done in order to utilize iPads for thoughtful engagement and productive learning. This investigator chose the app based on professional judgment of how the app would support ECG interpretation teaching and learning goals, online reviews of the app, availability of the appropriate content, ratings for the app, cost of the app, convenience, 3D visualizations, user-friendliness of the software and touchscreen interface for interactivity and functionality. As mentioned previously, Gagné's Nine Events of Instruction assisted the investigator in developing the pedagogical approach enabled by the 3D app technology.

Summary

Gagné's Nine Events of Instruction was discussed in this review of literature and each event was described. The 3D app, via the iPad, can be an avenue that enables the learning process, especially if designed from a pedagogical approach based on Gagné's Nine Events of Instruction. The Millennial Generation and Generation Z technological expectations within the classroom was reviewed and reinforced that these students anticipate interactive learning experiences. The various types of learners were revealed from the literature and exist in the current nursing classroom today. Many studies reviewed the use of 3D app technology on mobile devices for various military, K-12, autistic individuals, special needs individuals, higher education, construction science, and medical education populations, which were discussed throughout this chapter.

CHAPTER III

RESEARCH METHODOLOGY

The purpose of this research study was to investigate the effectiveness of 3D app technology on nursing students' ECG interpretation knowledge as evidenced by examination performance. Due to the seriousness of patient outcomes that can be altered by correctly or incorrectly interpreting ECG rhythms, new teaching strategies need to be evaluated. This chapter outlines the research study process used by the investigator to determine if a difference existed between nursing students who were taught ECG rhythm interpretation using a 3D app versus nursing students who were taught the same content via traditional lecture. This chapter includes the research design, setting, population and sample, sampling procedures, sample size, recruitment, procedures, data collection, data analysis, and chapter summary.

Research Design

This research study was a quasi-experimental research design consisting of one experimental group and one control group. The 3D app functioned as the independent variable of this research study, while the dependent variable for this study was the nursing student's level of knowledge as evidenced by examination performance. This study explored the effect of 3D app technology as a teaching strategy compared to the traditional lecture teaching strategy on nursing students' level of knowledge of ECG interpretation as evidenced by examination performance. The same 10-item test was the instrument used in this study. An instrument threat for this research study did not exist, since the pretest and posttests were identical tests (Polit & Beck, 2010). The pretest was given to all participants to determine current level of ECG knowledge.

The posttest was utilized to determine whether a difference in nursing students' knowledge level of ECG interpretation existed between the two groups.

Setting

The setting for this research study was a nursing program in a private Christian university located in a large metropolitan southeastern area in the US. This university contained a population of approximately 4,900 undergraduate and graduate students, approximately 300 were undergraduate nursing students. The university community had 301 full-time faculty members at the time of the study. The school has been accredited by the Commission on College Nursing Education (CCNE) and was ranked as the third regional southern university for the annual college ranking by *U.S. News & World Report* (2013). This school of nursing offers baccalaureate degrees in nursing, master degrees in nursing, and doctoral nurse practice degrees that are all accredited by CCNE. Qualifications of the investigator for implementing this research study include a Master's of Science in Nursing, 7 years of teaching in nurse education, and 17 years of nursing experience that included critical care experience. For this study, the investigator worked with the faculty member responsible for teaching the ECG interpretation content within the university setting to implement the research process. This study was conducted in a critical care class during the fall 2014 semester. The investigator did not have any role within the critical care class. At the time of the study, the investigator was employed by this institution as an Assistant Professor.

Population and Sample

The population for this study was 50 undergraduate nursing students who were pursuing a baccalaureate nursing degree. Each student was given the opportunity to participate in the research study. A convenience sample was used for this study. Convenience samples are often utilized for nursing research studies (Polit & Beck, 2010). The sample was randomized to have equal participants in the experimental and control groups. Randomization consists of each individual participant having equal probability of being selected (Creswell, 2009). A power analysis for this study was performed to determine how large of a sample was needed to enable accurate and reliable statistical judgments. According to a pre-data-collection power analysis, a sample size of 70 was needed. The power was set at 0.95 for this analysis and the alpha was set at 0.05, but the sample size of 70 was not met, only a sample size of 50 was obtained. The sample size of 50 resulted in 50 students being enrolled in the critical care course.

Inclusion criteria included undergraduate nursing students enrolled in the critical care course during fall 2014. Exclusion criteria included students who had purchased or utilized the 3D Heart Pro Series III app prior to this study, due to the effect of prior knowledge on test performance. Exclusion criteria included students who were repeating the critical care course. There were not any students repeating the critical care course. The majority of these students were Caucasian, female, and in their early twenties. All participants spoke English and resided in the same city as the university setting. This population was homogenous due to similarities in degree, sex, age, and residence at the time of this study.

Recruitment

The participants of this study were recruited during the fall 2014 semester from the critical care class after Institutional Review Board (IRB) approval was granted. The investigator was granted approval from the IRB at the university where the investigator was enrolled in a doctoral program. The investigator was then granted reciprocal approval from the IRB at the university where the study took place. The investigator also received permission from the Dean of the College of Nursing and the critical care course coordinator where the study took place.

In order to enroll participants in this study, prior to consent, potential participants were provided a description of the study (see Recruitment Script, Appendix A). The investigator discussed the research study face-to-face with the potential participants at the start of the ECG traditional class lecture. The investigator informed the students of the details of the study, including purpose, participation, time required, potential risks and benefits, and the informed consent process. The investigator then invited all students to voluntarily participate in the research study. The informed consent form (see Appendix B) was distributed to all students, and the investigator provided time for review. After questions were answered, the investigator collected all the informed consent forms. After voluntary consent was obtained, participants completed a demographic questionnaire (see Appendix C) before the beginning of the ECG traditional lecture. There were no participants that declined enrollment in this study.

Informed Consent Form

Informed consent was obtained in class from participants prior to the ECG traditional lecture. Participation was strictly voluntary, and all nursing students taking the critical care class were eligible for the proposed study. The informed consent included (a) the name of the researcher conducting the study, (b) the time commitment, (c) the benefits and potential risks, (d) an explanation of the proposed study with time to answer questions, and (e) a note that participation was strictly voluntary. The rights and welfare of all subjects were protected, in accordance with both universities' protocols for human research, throughout this research study. The pretest and posttest (see Appendix D) collected did not have any effect on nursing students' course grades. There were no direct benefits to pariticpants. The study did not affect the participants' physical well-being, psychological well-being, political well-being, economic well-being, or social well-being and did not include any type of study medication. No risks were accociated with participating in this study. In addition, participants who agreed to participate were provided a copy of the consent form and confidentiality was explained.

Instrumentation

Data collection was accomplished by using identical pretest and posttest instruments. All participants took a pretest prior to the start of the ECG traditional lecture. The test consisted of 10 multiple-choice questions that evaluated learning outcomes of ECG interpretation knowledge. Participants randomized into the control group took the posttest at the close of the ECG traditional lecture. Participants randomized into the experimental group took the posttest at the close of the 3D app learning session. A valid tool for evaluating learning outcomes for 3D app ECG interpretation for undergraduate nursing education did not exist in the literature, so the investigator created the 10-item pretest and posttest.

Test Item Analysis

Test Questions

The 10-item pretest and posttest provided data regarding students' ECG knowledge level. The statistics in the learning management system (LMS) were used to determine reliability and validity of test items, but statistics available with this LMS were limited. These 10 items had not been used for testing before, as this test was created for purposes of this research study. According to McDonald (2009), a test that is well constructed should include portions of the course objectives for concepts tested. Therefore, the course objectives were evaluated, and items were written based on course objectives. The pretest and posttest items were aligned with the learning objectives. These 10 items were set to randomly shuffle within the LMS as participants completed the computerized exam. The school of nursing required all students to have a laptop for the classroom and testing. The posttest was utilized to determine whether a difference in nursing students' knowledge level of ECG interpretation existed between the two groups.

Question Reliability

Reliability is the degree to which an assessment tool produces stable and consistent results (Phelan & Wren, 2006). Looking at inter-rater reliability, or the degree as to which different judges agree on assessment decisions, can be useful since individual observers may not interpret answers the same way as other individuals (Phelan & Wren, 2006). With inter-rater reliability, these individuals may disagree as to how well certain responses demonstrate knowledge of the skill being assessed (Polit & Beck, 2010). For the pretest and posttest items, the investigator had a certified nurse educator (CNE) assess these multiple-choice questions, and the CNE found these questions to be appropriate for evaluating ECG rhythm interpretation. The qualifications of the faculty member teaching ECG interpretation included a Master of Science in

Nursing degree with a focus in nursing education, as well as being a CNE with over 10 years of experience within the classroom setting. This faculty member has taught the traditional ECG content in this critical care class for the past five years and is a full-time student pursuing a Doctorate of Education. This CNE also found these questions to meet the learning objectives for this content, thereby assisting with inter-reliability.

Question Validity

Validity is how well a test measures what it is supposed to measure and refers to ways the results are interpreted and used. Ways to improve validity include making sure objectives are clearly defined, expectations are written out, assessment measures match learning objectives, tests are reviewed by faculty for feedback, and assessment measures are compared to other measures that are available (Oermann & Gaberson, 2006; Phelan & Wren, 2006; Polit & Beck, 2010). Validity for teacher-created exams needs to be based on course objectives. The same CNE that assessed the 10-test items, also assessed the study objectives and found the objectives to be clearly defined, expectations clearly stated, and the pretest and posttest items measures matching learning objectives of the course. Participants were provided a student guide (see Appendix E) with all the previously mentioned information for improving validity. In regard to face validity, the investigator assessed if the test items measured what they were intended to measure (Polit & Beck, 2010). Face validity of a test looks at the test appearance and if this appearance matches the intended use of the test (Oermann & Gaberson, 2006; Polit & Beck, 2010). The pretest and posttest items did cover ECG rhythm content and therefore was consistent with the material covered in class. Content validity ensures that the test items measure the content that the instructor wants measured (Oermann & Gaberson, 2006). Construct validity looks at the extent to which the resulting test scores from the construct of interest are meaningful and accurate

(Oermann & Gaberson, 2006). In order to have face validity, content validity, and construct validity, the investigator asked the same CNE to assess the relationship between the test items chosen, objectives for learning ECG interpretation content and verification that the test items did measure what the items intended to measure. This CNE was in agreement.

Study Internal Consistency

The discrimination ability of test items can measure internal consistency within a test. The internal consistency looks at the parts of the instrument to see if it measures what it is supposed to measures (Polit & Beck, 2010). A Cronbach's alpha is a statistical test that measures the internal consistency of the instrument (Polit & Beck, 2010). The 10-item test was the instrument in this study and was very small. Additionally, the test and re-test option that strengthens internal consistency of an instrument was beyond the scope of this study and the test statistics from this study will contribute to further developing validity and reliability for each test item.

Sampling Procedures

Anonymity of pretest and posttest scores was guaranteed by number and letter assignments aligned with pretest and posttest scores. There was no other identifying information. The investigator utilized an alphabetized master class roster with the last three digits of the students' university identification number. This list of the last three digits of the student number was printed out on a spreadsheet. The investigator assigned a number of 1 through 50 to each participant. Odd numbers were assigned to the control group and even numbers were assigned to the experimental group. After each participant was assigned a number, the identification for that participant (their name) was removed from the alphabetical list so that the researcher could not identify any of the participants individually or to which group each participant was assigned. In order to identify the difference between the pretest and posttest a letter was assigned to each number. Thus, a participant labeled with the number 1 had a pretest classified with the designation 1A and a posttest classified with the designation 1B. Table 2 and Table 3 show examples of the experimental and control group number assignments for pretest and posttest scores.

Table 2

Example for Experimental Group Number Assignment for Pretest and Posttest

Student number	Pretest	Posttest
Student 2	2A	2B
Student 4	4A	4B
Student 6	6A	6B

Table 3

Example of the Control Group Number Assignment for Pretest and Posttest

Student number	Pretest	Posttest
Student 1	1A	1B
Student 3	3A	3B
Student 5	5A	5B

The original participant number and letter identification list was only seen and accessed by the investigator and was stored in a locked cabinet at the university.

Sample Size

Effect sizes of new areas of research can either be small, medium or large, and if research has not been completed, the investigator estimates the size (Polit & Beck, 2010). In regard to effect size, an effect size of .20 is weighed as small, an effect size of .50 is weighed as medium, and an effect size of .80 is weighed as large (Polit & Beck, 2010). Since there had not been any research done in the area of 3D app effectiveness for teaching ECG content, an effect size of .80 was used. The power analysis prior to this research was calculated with an effect size of 0.80, alpha of .05, and power .95 resulting in a needed sample size of 70 with 35 subjects in the control group and 35 subjects in the experimental group. Only 50 participants were enrolled in the critical care course, with 25 subjects in the control group and 25 subjects in the experimental group. The needed sample size of 70 was not met.

ECG Traditional Lecture Session

After consent was obtained, participants who consented were asked to (1) complete a demographic questionnaire and (2) complete a computerized 10-item pretest prior to the presentation of the ECG traditional lecture content within the university's LMS. During the approximately one-hour lecture on ECG interpretation, the investigator randomized the participants in order to ensure participants had equal opportunity for participation. Everyone who participated was randomized into one of two groups. One group was considered the control group and the other group was considered the experimental group.

After the 10-item pretest was completed, the ECG traditional lecture was provided to all students. The experimental group and control group were taught the same ECG content by the same faculty member via traditional lecture. Both groups had the traditional lecture in order to have identical content provided by the faculty member responsible for this content and to avoid influencing course exams or grades. At the end of the ECG traditional lecture, the control group completed a 10-item posttest that contained the same items as the pretest. The investigator allowed review of the test items rationales for learning content after the posttest was completed.

The traditional lecture content covering these objectives was provided by a PowerPoint presentation (see Appendix F), and a traditional lecture script guided this learning experience (see Appendix G). Table 4 below illustrates the events of instruction that took place during the ECG traditional lecture.

Table 4

ECG Traditional Lecture

Event 1: Gain attention • For learning to take place, student attention will be captured • Welcome and introduce to study • PowerPoint slide presentation via audiovisual equipment
Event 2: Learning objectives • Inform participants of expectations • Inform participants of learning objectives • Describe required performance
Event 3: Stimulate recall of prior knowledge • Pretest assessment
Event 4: Present content • Use clear, concise language • Present objectives matched with lecture objectives • Content will be presented via PowerPoint slides and traditional lecture for content • Present ECG rhythm examples
Event 5: Provide learning guidance • Teacher facilitating learning by guiding instructions • Provide instructional support times • Provide examples
Event 6: Eliciting performance • The learning activities will be aligned with learning objectives • Repetitive exploration • Hands-on opportunity by working through ECG interpretation via slides • Give learners opportunity to practice by seeing various ECG strips via PowerPoint slides
Event 7: Providing feedback • Specific and immediate feedback of learners' performance • Any questions or responses from students will be immediately provided feedback by faculty member • Faculty member easily accessible in room for entire session for feedback and guidance • Provide confirmatory feedback, corrective and remedial feedback
Event 8: Assess performance • Posttest at completion of lecture
Event 9: Enhance retention and transfer • Investigator will provide posttest answers with rationales at the close of the control group's 3D session.

Note. Adapted from Gagné, R. M., Briggs, L. J., & Wagner, W. W. (1992). *Principles of Instructional Design (4th ed.).* Fort Worth, TX: Harcourt Brace Jovanovich College Publishers.

The 3D App Learning Session

The experimental group's 3D app learning session was split into two sessions due to particpants' time constrainsts, scheduling of courses, availability, and cost of the iPads and the 3D app. The first 3D app learning session took place the day following the ECG traditional lecture. The second 3D app learning session took place the second day after the ECG traditional lecture. The investigator reserved a room and provided iPads that already had the 3D app downloaded and ready for participant use. Due to the expense of the iPad (approximately $500) and the expense of the app ($29.99) and in order to provide the same opportunity to all participants, the investigator provided the mobile device, as well as the app, during all 3D app learning sessions.

The first 10 minutes of the 3D app session included an orientation, which was provided by the investigator (see 3D App Learning Script, Appendix H). This orientation consisted of utilizing an overhead screen that was connected to the investigator's iPad. This was done in order to provide a demonstration of the interactive components of the 3D app. The investigator introduced herself, the study, the iPad, and the 3D app. The investigator demonstrated the amenities of the 3D app and how to access animations, videos, sound, and content. The participants then had time to familiarize themselves with the iPad, the 3D app, and the interactivity components of the app. The investigator stayed in the room for the entire session and answered questions. After the orientation was completed and the participants verbalized that they felt comfortable with the iPad and 3D app, the investigator provide a student outline to each participant. This outline's purpose was also to promote efficient use of the participant's time. The investigator developed this outline after aligning classroom lecture objectives in order to ensure the same objectives were taught by both teaching methodologies.

The experimental group was asked to complete the posttest at the close of their 3D app learning session. This was the same posttest as the control group posttest. The control group were polled via email for interest in particpation interest in the 3D app learning session. Only 6 of the 25 participants from the control group opted for reviewing the 3D app. This review was held during the following day of class lecture for the critical care course. The investigator taught all 3D app sessions. The investigator allowed review of the test items rationales for learning content after the posttest was completed. Also, both groups completed the 3D app learning session prior to the scheduled course examination of this content.

The investigator reserved 10 laptops with the appropriate security settings from the university for completing the computerized posttest after the 3D app session. Students brought personal computers and the investigator reserved laptops from the university for backup if any technical difficulties arose. The investigator stayed in the reserved room for the entire session and facilitated individual learning. The investigator was also available for any technology issues that arose and also had university information technology (IT) personnel available if needed. After all participants had completed the outline and practiced with the content, the experimental group then completed the 10-item computerized posttest. After the experimental group completed the posttest, the investigator allowed review of the test items with rationales for learning the content.

The experimental group was presented with the 3D app as the stimulus and had their attention directed and external prompts via the iPad as well as experienced guided learning and transfer of knowledge. Learning attainment assessments and feedback were provided. The pretest and posttest items included identifying ECG interpretation concepts such as blood flow, the conduction system of the heart, dysrhythmias, and three lethal rhythms (ventricular tachycardia, ventricular fibrillation, and asystole) were covered in both learning experiences. The experimental group was presented the same material via the 3D app as a supplemental teaching strategy. For the control group, the faculty member provided a stimulus, traditional lecture, directed attention, external prompts via PowerPoint slides, guided learning, transfer of knowledge, learning attainment, assessment, and feedback. Table 5 below illustrates the events of instruction that took place during the 3D app learning session.

Table *5*

3D App Session

Event 1: Gain attention • For learning to take place, student attention will be captured • Welcome and introduce to study • Orientation to iPad and to app • Demonstrate 3D app
Event 2: Learning objectives • Inform participants of expectations • Provide student outline with learning objectives • Inform participants of learning objectives • Describe required performance
Event 3: Stimulate recall of prior knowledge • Learning takes place if new information is associated with prior knowledge • Prior knowledge of iPad use • Prior knowledge of ECG interpretation • Pretest assessment will be completed during gaining attention
Event 4: Present content • Use clear and concise language • Content will be presented via app utilizing images, sound, video, animations, and text • Study outline with guidelines of content • Present examples • Present multiple methods of same content via app to address different learning preferences
Event 5: Provide learning guidance • Teacher facilitating learning by guiding instructions • Provide instructional support • Directions will be provided for students to explore app at own pace • Student outline will guide time on task for each learning objective. • Instructions include ability to move backward, forward and review content multiple times • Provide examples
Event 6: Eliciting performance • The learning activities are aligned with learning objectives • Repetitive exploration • Hands-on opportunity working through ECG rhythm and practicing • Give learners opportunity to practice • Elicit student activities
Event 7: Providing feedback • Specific and immediate feedback of learners performance • Any questions or responses from students will be provided feedback from the investigator

• Investigator accessible in room entire session for feedback and guidance • Provide confirmatory feedback • Provide corrective and remedial feedback
Event 8: Assess performance • Posttest at completion of learning session
Event 9: Enhance retention and transfer • Feedback of posttest given (correct answers) • Question and answer session will be held in regards to posttest items

Note. Adapted from Gagné, R. M., Briggs, L. J., & Wagner, W. W. (1992). *Principles of Instructional Design (4th ed.).* Fort Worth, TX: Harcourt Brace Jovanovich College Publishers.

Data Analysis

Pretest and posttest scores for each group were compared. Demographics were also analyzed. A paired (dependent) *t*-test and an independent *t*-test were used for the statistical analysis. The pretest and posttest allowed the researcher to identify the differences in learning outcomes between these two groups. These *t*-tests determined if there were any statistically significant differences between the experimental and control groups, and the mean scores were the outcome measure. The *t*-test is appropriate for this use because it compares the means of these two groups (Field, 2009). Upon completion of data collection, information was entered into the Statistical Package for the Social Science (SPSS) software for analysis. The pretest scores were compared to the posttest scores of both groups using a dependent sample in order to determine if there was a statistically significant difference. The posttest scores of the experimental and control groups were compared using an independent sample *t*-test. The independent sample *t*-test was conducted to determine whether there were differences between the groups in terms of the level of knowledge. The statistical significance was set at $p < .05$ for the independent and dependent test. Finally, the demographic data from both groups was used to determine any statistically significant differences between the groups.

Summary

In summary, this chapter discussed the research design of this study as well as the setting, population and sample, sampling procedures, sample size, recruitment, procedures, data collection, and data analysis. This study compared nursing students learning ECG interpretation, with the experimental group exposed to 3D app technology and the control group not exposed to 3D app technology for ECG interpretation content. The methodology was described in detail, and Gagné’s Nine Events of Instruction was embedded in the instructional sequence of this proposed study.

CHAPTER IV

RESULTS

This chapter will provide a description of the sample, including the number of participants per pretest and the number of participants per posttest for the experimental and control groups. This chapter presents the results and the analysis of data obtained. A description of the demographic characteristics of all participants is presented, followed by an explanation of the research question with the data analysis.

Demographic Data

The sample for this study utilized a convenience sample of nursing students enrolled in the critical care course of a baccalaureate nursing program at a small private Christian university in the southeastern area of the US. Only 50 students were enrolled in this course, and all 50 voluntarily consented. Of the 50 participants, none of the participants were excluded from this study, since no one was repeating the critical care course and no one had previously worked with the 3D app. Random assignment to either the experimental group or the control group was done to eliminate any possibility of bias.

The demographics of this sample consisted of 47 (94%) females and 3 (6%) males. Thirty-five students (70%) were between the ages of 19 and 24, 11 (22%) students were between the ages of 25 and 31, 3 (6%) students were between the ages of 32 and 40, and 1 (2%) student was between the ages of 41 and 49. The majority, 44 (88%) students were Caucasian, 3 (6%) were African American, and 3 (6%) were Hispanic American. Forty-two (84%) students were single, 7 (14%) were married, and 1 (2%) was divorced. All (100%) students answered “no” to the question on prior use of the 3D4Medical Heart Pro app, and all (100%) students completed all questions on the demographic questionnaire. This sample consisted of traditional and non-traditional undergraduate nursing students. Students enrolled in the critical care course were following four different university tracks: 11 traditional undergraduate nursing students, 18 undergraduate transfer students that follow the traditional track, 11 second-degree students that follow traditional track, and 10 accelerated students.

Data Analyses

The experimental and control groups of students were given a pretest to examine nursing students' knowledge level of ECG interpretation before the nursing intervention. Of the 25 participants randomized to the control group, 22 participants immediately completed the same posttest following the ECG traditional lecture intervention. Of the 25 participants in the control group, 3 participants left at the end of the ECG traditional lecture without completing the posttest. Of the 25 participants randomized to the experimental group, all 25 participants completed the same posttest immediately after their assigned 3D app learning session intervention. Data were entered into SPSS for statistical analyses. An independent *t*-test was used in order to analyze statistics on any differences between the posttest control scores and posttest experimental scores to determine if there was a statistical difference between the groups in terms of the level of knowledge. Paired *t*-tests were completed on the pretest scores with the posttest control scores and the posttest experimental scores to determine if there were any statistical differences.

At the .05 level of significance, an independent *t*-test showed that there was no statistically significant difference between posttest scores for the control group and the posttest scores for the experimental group, t (45) = -1.17, p = .248, d = -0.35, 95% CI [-1.26, .34]. Therefore, the 3D app technology did not have any significant effect (p = .248) on nursing students' level of ECG knowledge as evidenced by exam performance. The results are indicated below in Table 6.

Table 6

Independent t-*test for Posttest Control and Posttest Experimental Groups*

Group	n	M	SD	T	*p*
Control	22	7.45	1.22	-1.17	*.248
Experimental	25	7.92	1.47		

*p <.05

Paired (dependent) *t*-tests of the pretest with the posttest control and posttest experimental groups were conducted in order to compare the means for the same groups of participants at two different points in time. There was found to be no statistically significant difference between the pretest and the posttest scores of all participants. The mean of the posttest scores control (M = 7.45; SD 1.22) and the mean of the posttest scores experimental (M = 7.92; SD 1.47) did increase from the mean of the pretest scores control (M = 4.90; SD1.66) and the mean of the pretest scores experimental (M = 5.52; SD 1.44). The results indicate that the traditional learning session does not have any statistical effect (p = < .05) on nursing students' ECG level of knowledge as evidenced by examination performance. The paired *t*-test results are listed below in Table 7.

Table 7

Paired t*-test Statistics for Control and Experimental Groups*

Groups/Test	*N*	M	SD	T	*P*
Control					
Group	22	4.9091	1.65929	-	*.910
	22	7.4545	1.22386		
Posttest					
				-	
Experimental	25	5.200	1.44684	5.367	*.401
Group	25	7.9200	1.469.69		
**p* <.05					

Test Item Analysis Results

There was no valid and reliable tool in the existing literature that could be used to discuss test item statistics. This research study was the first measurement of these statistics. In order to find conclusive results, this test would need to be repeated multiple times. In the development of this 10-item test created for this research study, appropriate steps for reliability and validity were taken and analyzed upon completion of tests via the university's LMS.

In analyzing test items, one should understand central tendency (mean, median, and mode). Test item difficulty should be reviewed, as well as the percent of correct responses to individual questions. Test item discrimination values determine whether the participant taking the test knew the content or did not know the content. Test item discrimination is measured by two values: item discrimination ratio (IDR) and point biserial correlation coefficient (PBCC) (Caputi, 2010). This was the very first time these test items for evaluating ECG interpretation were used and the results, therefore, were limited. Reliability for internal consistency of the test scores was calculated by the LMS, which only calculates the coefficient of internal consistency for the entire test for the highest graded attempted. Since this test was a first-time test, it is important to test and retest over time in order to strengthen the meaning of the data, accumulate data and determine each test item's worth. This was beyond the scope of this study. The statistics from this study will be the first to introduce this data, which will assist future studies in building and strengthening test validity and reliability. Best practices for test item analysis would include accumulation of test statistics to examine the validity and reliability of these items and would help determine if the items should be used or not used.

Summary

The researcher addressed the research question in this study and examined the effectiveness of a 3D app technology for nursing students learning ECG interpretation. This research looked at nursing student posttest scores to see if such scores were increased after a 3D app learning session versus a traditional lecture. Both teaching interventions resulted in higher mean posttest scores compared to the pretest scores for both the control and experimental groups, but this increase in means was not statistically significant. The test item analysis was limited due to small group size, small question bank, homogenous sample, and first-time testing. Discussion of these findings, implications, limitations, and recommendations for future studies will be discussed in Chapter V.

CHAPTER V

DISCUSSION

Nursing students have difficulty interpreting ECG rhythms, and the current classroom environment often lacks application and practice opportunities for this skill. As a result, students struggle with identification of ECG rhythms at the patient's bedside. The purpose of this study was to determine the effectiveness of a 3D app on nursing student's ECG level of knowledge as evidenced by exam performance. A gap exists in literature that examines 3D app technology used as a teaching methodology for nursing students learning ECG interpretation. A quasi-experimental research design was used to test the effect of 3D app technology on nursing students' ECG level of knowledge. An independent *t*-test and paired *t*-tests were used for statistical analysis. Major findings, limitations, discussion of the findings, implications for nursing education, recommendations, and conclusions for research are presented.

Major Findings

Research Question: Do nursing students who receive ECG identification knowledge via a 3D app have greater learning outcomes (evidenced by higher posttest scores) compared to nursing students who receive the same content via traditional lecture?

The use of 3D app technology on an iPad created an active learning environment for nursing students learning ECG interpretation for this study. The review of literature indicated that when nurse educators used technologies, such as interactive videoconferencing for learning ECG interpretation, Web-based teaching methods for learning ECG interpretation, and mobile devices for learning respiratory systems, higher learning outcomes resulted (Celikkan et al., 2013; Jang et al., 2005; Wu, Hwang, Su, & Huang, 2012). However, in this current study, when a *t*-test statistical analysis was performed to determine the effectiveness of 3D app technology with a student's ECG knowledge level, the results did not indicate higher learning outcomes. There were no statistically significant differences between traditional lecture and the 3D app technology when learning ECG interpretation, which is not consistent with findings that have been reported in the literature. Importantly, both posttest means increased, therefore, according to these measures learning did take place. However, the nursing discipline is a relatively homogenous population that is not representative of the wider population, and many different variables among these studies may explain inconsistencies. The studies reported in the literature looked at different disciplines and different populations, all with different learning needs. The nursing studies that reported positive learning outcomes included different technologies and not 3D app technology for learning ECG interpretation. The inconsistency between the results of this study performed in the field of nursing compared to other disciplines and populations reinforce the need for nurse educators to further research 3D app technology via the iPad for learning ECG interpretation.

The studies found throughout the literature that looked at teaching methodologies using 3D apps consisted of different disciplines with different individual learning needs. Studies have not looked at 3D app technology over time, and the level of evidence for the studies found throughout the literature did not result in any meta-analysis or randomized controlled studies. This research study was the first to study 3D app technology in nurse education for learning ECG interpretation, which all may help explain such inconsistencies. These inconsistencies help reinforce the need for systematic reproduction of larger samples over time in order to generalize to nursing education.

Schulman et al. (2012) noted that surgical team members who taught via traditional lecture compared to mobile learning using apps were equally effective and had no statistical significance between the experimental and control groups for learning the same content. In that experiment, both groups performed better on the posttest than the pretest when learning about the medical condition of shock. Schulman et al. (2012) concluded that mobile learning utilizing apps are an effective means for providing the same content knowledge. For this current nursing research study, both groups did perform better on the posttest than the pretest when learning ECG interpretation via a 3D app. Both teaching methodologies may be equally effective for learning the same content, which is consistent with Schulman et al. (2012). This increase in posttest means for learning same content knowledge was an interesting finding and warrants further exploration and research.

In the literature, students learning via 3D apps on mobile devices at the K-12 and higher education levels (specifically construction science and medical education) as well as autistic and special needs individuals reported positive experiences or improved learning outcomes (Brenton et al., 2005; Cheng & Ye, 2010; De Ribaupierre & Wilson, 2012; Kagohara et al., 2013; Kucirkova et al., 2014; McClanahan et al., 2012; Nicholson et al., 2006; Noguera et al., 2013; Sampaio et al., 2010; Schmidt et al., 2012; Silen et al., 2008). The findings discussed in the literature may not represent the wider population, or the relatively homogenous nursing population. The technology of 3D apps assisted with learners that had different learning needs. These findings cannot be generalized to nursing education or make predictions about the entire nursing population due to the studies discussed consisted of relatively small sample sizes.

Limitations

Generalizations of the results of this study are limited by many factors and are important to note for future study considerations. First, participants examined in this study consisted of only one nursing class within one university setting in the southeast US. Adding another nursing class or additional university settings might produce different results, as nursing student populations vary between individual classes and different universities. Second, demographic data revealed a relatively homogenous group of nursing students. The use of multiple classes of students from other universities could reveal different results. Third, as this study was conducted in only one critical care course at one southeastern private Christian university in the US, the sample was limited geographically and might not represent the overall population of a critical care course within other university settings. Fourth, a convenience sample was used and might not be representative of participants within the same geographical area or representative of participants nationally. Fifth, the total population of this study was small. Polit and Beck (2008) write that many nursing studies include populations that are small due to time constraints, limited resources, and subject availability. The small sample size in this study could have affected observation of meaningful differences of the data analysis, and therefore, a larger sample would be preferred to a small sample. The sample size was less than the number of participants necessary to maintain the desired power level as predetermined by the analysis of power. Sixth, when using paired *t*-tests, time lapse and learning effect could have potentially existed, and that might have influenced posttest results. There was a one-day and two-day time lapse between the experimental groups' 3D app learning sessions. The students could have taken that period of time to study and learn the material, resulting in higher means. Seventh, the 3D app used for this research study is only compatible with Apple devices, therefore limiting the options for mobile devices that use 3D app technology. Likewise, the company 3D4Medical is only one of several companies that currently exist and offer interactive 3D experiences for learning ECG content; as a result, some participants may not be familiar with the interactivity of the app or familiar with Apple products. Eighth, students might have not been academically motivated to take the 3D app learning session seriously, since individual course grades were not affected. The students also might not have utilized the time allocated for content review during the 3D app learning session and posttest time due to time constraints of current full-time course load. If students were academically motivated, the findings may have produced higher posttest scores. Ninth, the control group was the only group to complete the posttest following the ECG traditional lecture. If this experimental group completed the posttest following the ECG traditional lecture with the control group, then the mean results could have differed. Tenth, there was limited time for the use and practice of the 3D app by the experimental group. Students might need to use this technology for longer than one hour and possibly take it home for practice, which could influence learning outcomes. Finally, the researcher created the 10 test items because there was no existing tool that pertained specifically to this study. The results obtained were based on only one pretest and posttest design. The use of another posttest at a different point in time could yield different results and would strengthen the instrument's validity and reliability.

Conclusions

The goal of nurse education for ECG interpretation is to prepare future nurses to competently identify normal versus abnormal and life-threatening ECG rhythms. By correctly identifying ECG rhythms, the nurse is able to provide safe, effective care and save patient lives. Research using 3D app technology and the iPad was not found within nurse education literature.

In this study, the means of both the experimental and control groups' posttest scores did increase from the pretest, which may indicate to nurse educators that students are learning from both teaching methodologies. Gagné's instructional sequence was valuable in that it provided the basis for the instructional sequence of this entire study and guidance for the adult learning process. Due to the seriousness of patient outcomes that can be altered by correctly or incorrectly interpreting ECG rhythms, additional teaching strategies need to be evaluated and further research is required.

There is a need for nurse educators to put to use 3D app technologies in the classroom. This technology was found to be beneficial for different disciplines and populations throughout the literature. Since the 3D app improves learning outcomes for autistic individuals and special needs individuals, this technology can accommodate learner differences. This was not proven via this study, but what was found in the literature for these populations and warrants further research. The literature showed many positive outcomes from pedagogical approaches that utilize 3D apps for teaching and learning in the military, K-12, higher education, construction science, and medical education, but these positive outcomes are inconsistent with the findings of this study and cannot be generalized to nursing education. The findings from this study did provide quantitative evidence in regard to 3D app technology in nurse education, creating a starting point for further research.

Implications for Nursing Education

The findings of this research have several implications for nurse education. There is a limited body of knowledge in nursing education regarding 3D app technology in learning ECG identification. This study is the first to report 3D app technology for ECG interpretation implementation within nursing education to have a positive or negative effect on student examinations scores. Nurse educators have a new technology at their fingertips and should consider using 3D app technology for teaching ECG interpretation or supplementing the ECG traditional lecture. The importance of the ability to identify normal versus abnormal or life-threatening ECG rhythms cannot be overstated, and this skill enhances a nurse's ability to save lives.

The NLN's research priorities for nursing education for the years 2012 to 2015 calls for nurse educators to identify and evaluate effective emerging technologies that teach decision-making skills to nursing students. The 3D app on an iPad is an example of an emerging technology that can enhance student learning. This technology is appropriate as requested by NLN research priorities. The AACN's (2008) suggestion for using new technologies by nurse educators should provide opportunities in the education experience that utilize a range of technologies and focus on supporting patient care, using simulations, and analyzing patient situation data. This 3D app technology supports ECG interpretation or patient care, uses 3D videos and animations, and analyzes patient situation data or changing ECG rhythms. Evidence-based practice is necessary in nurse education to determine which technologies improve learning outcomes. This study does add to the body of knowledge in nursing education. In order to empower the current nursing student, nurse educators must stay current with content and clinical practice as well as with technology in order to enrich learning experiences and improve learning outcomes. The 3D app technology has the potential to meet millennials' learning needs and Generation Zs' learning needs by capturing the attention of this diverse body of learners. This 3D app technology offers a multimedia-rich format that provides spatial reasoning of ECG interpretation, demonstrates new ECG rhythm content, and allows ample practice opportunity.

Hands-on learning takes place via 3D app technology, which assists in bridging the knowledge application gap of ECG interpretation at the bedside. Nurse educators must be proactive and engaged in developing 3D apps for nurse education.

Recommendations

Based on the findings and discussion from this study, further research recommendations are proposed. First, replication of this study with a larger sample size and multiple sites would result in a more diverse sample and increase generalizability. Second, replication of this study with an extended design should be completed longitudinally in order to achieve cumulative data for analysis. There is statistical strength in larger numbers, and looking at more than one critical care course would be beneficial since this would increase cumulative data. Third, retesting the 10-item test needs to be done multiple times in order to accumulate data on each test item. Further research on the 10 items will determine the reliability of the test and if there is consistency over time. Fourth, an incentive may be considered in order to motivate students in learning ECG interpretation. Fifth, a qualitative study examining students' perceptions of learning using 3D app technology and their learning experience on the iPad should be completed for nurse education in order to see nursing student perceptions on iPad and 3D app technology. Finally, a future study emphasizing long-term knowledge retention for learning outcomes on ECG interpretation should be completed.

Study Summary

The ubiquity of mobile devices and the explosion of technological advances continue. Meanwhile, a gap exists between nursing knowledge and applying that knowledge at the bedside in ECG interpretation. Nurse educators must embrace current technology for learning ECG interpretation, because competent ECG interpretation saves human lives. Innovative technologies, such as 3D app technology, for learning ECG interpretation needs to be researched, since no research or data exists in the nursing literature. The review of literature did not reveal any peer-reviewed articles relating to 3D app technology in nursing education, or any articles in regard to ECG rhythm interpretation utilizing 3D technology as a teaching strategy in nursing education. Many articles included benefits of active learning through innovative teaching strategies for education, but none specific to nursing. This gap in the literature provides an opportunity for contributions to nurse education’s body of knowledge regarding ECG interpretation using a 3D app on the iPad. If nurse educators become creative in closing this gap by embracing 3D app technologies, nursing students’ learning outcomes can be improved and in turn, patient lives are saved.

Gagné’s instructional sequence as the conceptual framework may or may not be useful, as evidenced by no statistically significant findings, but it is worth repeating to build consistency and strengthen further results. The findings from this study did not show a statistical difference in learning from 3D app technology for ECG knowledge, but the findings provide a starting point for future research utilizing 3D app technology. The literature demonstrated positive results using this 3D app technology in other disciplines, which showed pedagogical potential. Both the experimental and control groups posttest mean scores increased, so students learned from both teaching strategies. Exploration and repetition of this type of study can look closer at these measures. The 3D app technology has the potential to meet the millennials’ learning needs and Generation Zs’ learning needs with this multimedia-rich format technology that provides 3D views of ECG rhythms, anatomy of the heart, and hands-on practice opportunities for ECG interpretation. These aspects of the 3D app technology can assist in bridging the knowledge application gap of ECG interpretation at the bedside. More research is warranted in order to validate 3D technology as an evidenced-based teaching methodology for nursing. The literature offered ample studies on 3D technologies and their impact on learning for different sample groups, which can be generalized to 3D app technology. The benefits of the interactivity of technology and how technology enables alternative teaching methods, compared to traditional lecture is important for nursing students learning ECG interpretation. Such benefits described in the literature should be considered in nurse education for teaching and learning ECG interpretation.

The selective nature of the populations of studies reviewed and minimal data available, limit the application of the results to nurse education. Since this review did not draw conclusions specific to 3D technology and its interactive properties in nursing education, the evidence is inconclusive in the attempt to determine if 3D technology is more effective for nurse education. The inability to generalize conclusions specific to nurse education emphasizes the need for research to study the effectiveness of 3D app technology in order to determine if increased learning outcomes are enabled by the 3D app technology, specifically for the nursing discipline. Nurse educators must be proactive and engaged with developing 3D apps for nurse education; by doing so, their actions will help meet the needs of generations to come. Nurse educators will always be challenged to meet the needs of new generations of students while staying abreast of the technological advantages in health care. By studying and utilizing relevant technological advancements such as 3D app technology, nurse educators can continue to hone their craft and prepare their students to effectively meet the challenges of learning ECG interpretation and the many challenges of twenty-first century nursing.

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APPENDIX A

Recruitment Script

Hello, my name is Abbey Holthaus and I am a graduate student at the University of Alabama under the direction of Professor Dr. Vivian Wright. I also am an Assistant Professor at the Ida Vines Moffett School of Nursing at Samford University. In order to complete my doctoral studies at the University of Alabama, I am conducting a research study to find out if a 3D application can increase ECG rhythm interpretation compared to lecture, for undergraduate nursing students. The 3D application market is vast, but nursing educators have not utilized this teaching methodology in their current classrooms.

You have been asked to participate in this study since you are a nursing student enrolled in the critical care class during the fall 2014 semester. Participation in this study is voluntary and if you agree to participate in the study you will be asked to complete a 10-item computerized multiple-choice test in the critical care class before you go over ECG interpretation via lecture. For everyone that has chosen to participate, you will be randomized, or placed, into two different groups. One group is considered the control group and the other group is considered the experimental group. If you are randomized into the control group and after you complete the ECG lecture. You will take a second 10-item computerized multiple-choice test. If you are randomized to the experimental group, you will attend a class of ECG interpretation that is taught using a 3D app on an iPad. The 3D app and iPad will be provided. After the 3D app class is completed, you will take a second 10-item computerized multiple-choice test, which is the same test that the control group took. The two tests will be the same and will not count toward any of your critical care class grade. Class time will be provided to complete each test. For those of you who did not get to attend the 3D app class, there will be an optional 3D app class offered. Again, the 3D app and iPad will be provided and the class will be conducted in the same manner as the experimental group. This study will not cost you anything to participate and you will not be compensated for being in this study. This study will help nurse educators use more effective teaching methodologies within the classroom for learning ECG rhythm interpretation.

Lastly, your participation in this research study is voluntary. If you have any questions concerning this research study, please contact me at (205)534-0227 or my dissertation chair, Dr. Vivian Wright, at (205) 348-1401.

APPENDIX B

Informed Consent
AAHRPP DOCUMENT #192

UNIVERSITY OF ALABAMA
HUMAN RESEARCH PROTECTION PROGRAM

Informed Consent for a Non-Medical Study

UNIVERSITY OF ALABAMA

Individual's Consent to be in a Research Study

You are being asked to take part in a research study. This study is called "3D Application Effectiveness on Nursing Student's Level of Electrocardiogram Knowledge as Evidenced by Exam Performance". The study is being done by Mrs. Abbey Holthaus who is a doctoral candidate at the University of Alabama under the supervision of Professor Dr. Vivian Wright at the University of Alabama. Abbey is also an Assistant Professor at Ida Vines Moffett School of Nursing at Samford University. This study will take place at Samford University. In order to complete my doctoral studies at the University of Alabama, I am conducting a research study to find out if a 3D application can increase ECG rhythm interpretation compared to lecture, for undergraduate nursing students. The 3D application market is vast, but nursing educators have not utilized this teaching methodology in their current classrooms. The researcher will not be paid for this study and no product will be sold, and the researcher will not profit from this study. There are no conflict of interest by the investigator for this study.

What is this study about?
This study will determine if the teaching strategy of 3D application (app) technology, compared to the teaching strategy of traditional lecture covering the same ECG content, affects nursing students' ECG exam performance. Do nursing students who receive ECG interpretation knowledge via a 3D app on a mobile device, an iPad, have greater learning outcomes, evidenced by higher posttest scores, compared to nursing students who receive the same content, via traditional lecture? The innovative 3D app technology has not been researched in the nursing classroom and this study will help nurse educators use effective teaching methodologies within the classroom for learning ECG rhythm interpretation.

Why is this study important or useful?
Current undergraduate nursing students have difficulty grasping ECG interpretation. Nursing students have minimal clinical practice opportunities with ECG interpretation (Jang, Hwang, Park, Kim, & Kim, 2005). The current nursing classroom utilizes traditional lecture as the teaching methodology for teaching ECG interpretation for undergraduate nursing students (Benner, Sutphe, Leonard, & Day 2010; Celikkan, Senuzun, Sari, & Sahin, 2013). Benner et al. 2010 and Burns and Poster (2008) stress that there is a gap or disconnect between learning theory in the classroom and applying this theory knowledge at the bedside for providing patient care. This 3D app has the potential to be useful for nurse educators in offering other ways for grasping

ECG interpretation, offering practice opportunities, and connecting theory to application at the bedside for ECG interpretation.

Why have I been asked to be in this study?
You have been asked to participate in this study since you are a senior level nursing student enrolled in the critical care class during the fall 2014 semester.

How many people will be in this study?
The population for this study will be approximately 67 full-time undergraduate nursing students who are pursuing a baccalaureate nursing degree, enrolled in a senior level critical care class during the fall 2014. Each participant will be given the opportunity to participate in the research study.

What will I be asked to do in this study?
Participation in this study is voluntary. It is your free choice to participate. If you agree to participate in the study you will be asked to complete a 10-item computerized multiple-choice test before you go over ECG interpretation via traditional lecture. For everyone that chooses to participate, all will be randomized, or placed, into two different groups. One group is considered the control group and the other group is considered the experimental group. If you are randomized into the control group and after you complete the ECG lecture, you will take a second 10-item computerized multiple-choice test. If you are randomized to the experimental group, you will attend a 3D app learning session on ECG interpretation that is taught using a 3D app on an iPad. The 3D app and iPad will be provided. After the 3D app learning session is completed, you will take a second 10-item computerized multiple-choice test, which is the same test that the control group took. The two tests will be the same and will not count toward any of your critical care class grade. Class time will be provided to complete each test. For those of you who did not get to attend the 3D app learning session, there will be an optional 3D app learning session offered. Again, the 3D app and iPad will be provided. The 3D learning session will be conducted in the same manner as the experimental group. This study will not cost you anything to participate and you will not be compensated for being in this study. If you start the study, you can stop at any time.

How much time will I spend being in this study?
The traditional lecture session including the informed consent process should take approximately 60 minutes. This time is your normal scheduled class time for ECG interpretation content. The 3D app session will take approximately 60 minutes for the experimental session. For the optional 3D session for the control group that session will take approximately 60 minutes for completion.

Will being in this study cost me anything?
The only cost to you from this study is your time.

Will I be compensated for being in this study?
You will not be compensated for being in this study.

What are the risks (dangers or harms) to me if I am in this study?

There are no risks foreseen for this study. This study does not affect your physical well-being, psychological well-being or political well- being. This study will not affect your critical care class grades.
The researcher will pull the class roster from the Learning Management System, Moodle, by using the last 3 digits of your student number. No name identification will be used. The researcher will number each 3 digit number (1 through 67) and this number assignment document will be stored in a locked file cabinet in IVMSON. Anonymity of pretest and posttest scores will be guaranteed by letter assignments. A letter designation will be assigned to each student number, in order to identify the difference between the pretest and posttest. Thus, a participant labeled with the number one will have a pretest classified with the letter A, or 1A and for the posttest classified with the letter B, or 1B. No one will have access to this data other than the investigator and the dissertation chair. This list will be kept for three years and then destroyed. There will be no other identifying information used.

What are the benefits (good things) that may happen if I am in this study? There are no direct benefits to you. You may complete the study with an additional learning experience of ECG interpretation that utilizes 3D app technology. This 3D app research study has the potential to add to scholarly literature as it will be the first in these type of research in nurse education.

What are the benefits to science or society?
This study has the potential to help nurse educators use more effective teaching methodologies within the classroom for learning ECG rhythm interpretation.

How will my privacy be protected?
If you agree to participate your name appears in connection with this study is on this informed consent. Also, the master list of the class roster, with the last 3 digits of student numbers and number assignment of each student, will be stored in a locked file cabinet in the IVMSON. No name identification will be used. No one will have access to this data other than the investigator and dissertation chair. This list will be kept for three years and then destroyed.

How will my confidentiality be protected?
Confidentiality is protected by transferring a number system to the last 3 digits of your student id number. Your name will not be used. The researcher will number each 3 digit number with the number 1 to 67. Students who agree to participate in the study, within the critical care class, will be randomly assigned to one of the two treatment groups. If your last 3 digits of your student id number is given an odd number you will be randomized to the control group. If your last 3 digits of your student id number is given an even number, you will be randomized to the experimental group. The document with this numbering and lettering system will be stored in a locked file cabinet in the IVMSON. This list will be kept for three years and then destroyed. No name identification will be used. No one will have access to this data other than the investigator and dissertation chair only.

What are the alternatives to being in this study? Do I have other choices? The alternative to being in this study is not to participate and participation is strictly voluntary. You may withdraw from the study at any time.

What are my rights as a participant in this study?
Taking part in this study is voluntary. It is your free choice. You can refuse to be in it at all. If you start the study, you can stop at any time. There will be no affect on your relations with faculty at Samford University and no parts of this study will affect your critical care course grades. The University of Alabama Institutional Review Board and Samford University Institutional Review Board ("the IRB") are committees that protects the rights of people in research studies. These IRBs may review study records from time to time to be sure that people in research studies are being treated fairly and that the study is being carried out as planned.

Who do I call if I have questions or problems?
If you have questions, concerns, or complaints about the study right now, please ask them. If you have questions, concerns, or complaints about the study later on, please call Abbey Holthaus at 205-726-4666. If you have questions about your rights as a person in a research study, call Ms. Tanta Myles, the Research Compliance Officer of the University, at 205-348-8461 or toll-free at 1-877-820-3066.

You may also ask questions, make suggestions, or file complaints and concerns through the IRB Outreach website at http://osp.ua.edu/site/PRCO_Welcome.html or email the Research Compliance office at participantoutreach@bama.ua.edu. After you participate, you are encouraged to complete the survey for research participants that is online at the outreach website or you may ask the investigator for a copy of it and mail it to the University Office for Research Compliance, Box 870127, 358 Rose Administration Building, Tuscaloosa, AL 35487-0127.

I have read this consent form. I have had a chance to ask questions. I agree to take part in it. I will receive a copy of this consent form to keep.

____

Signature of Research Participant Date

____

Signature of Investigator Date

APPENDIX C

Demographic Questionnaire

1. Age (in years) is

    a. 19-24
    b. 25-31
    c. 32-40
    d. 41-49
    e. 50 and above

2. Gender is

    a. Male
    b. Female

3. Race is

    a. Caucasian
    b. African-American
    c. Asian-American
    d. Hispanic-American
    e. Other

4. Marital status is

    a. Single
    b. Married
    c. Divorced
    d. Widowed

5. Have you ever used the 3D4Medical Heart Pro III app?

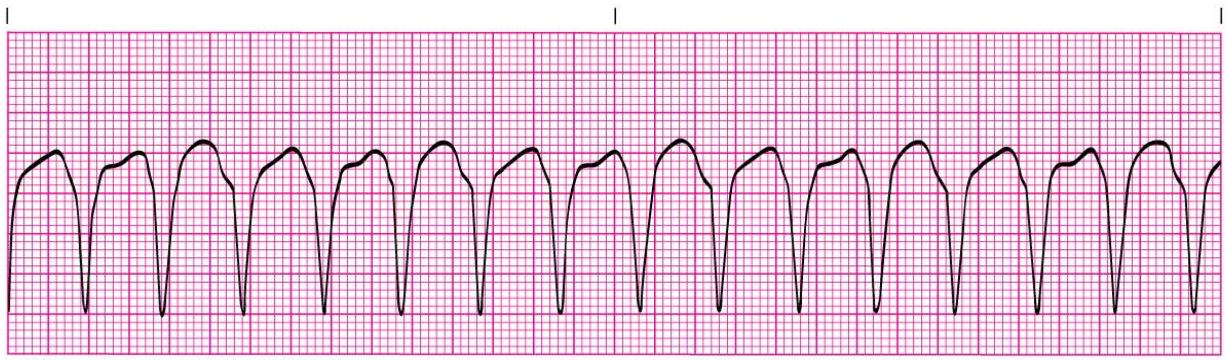
    a. Yes
    b. no

APPENDIX D

Pretest and Posttest

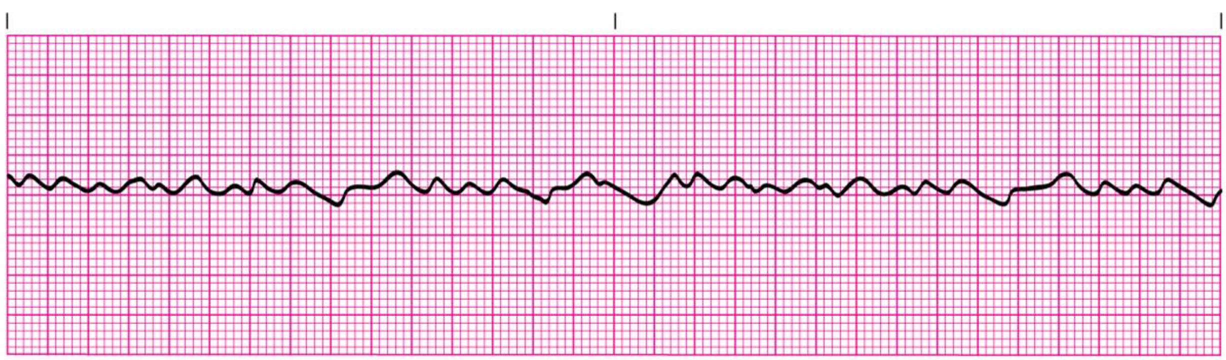
Pretest and Posttest 10 Item Quiz with Answers

1. The nurse interprets this heart rhythm as? *Select one:*



A. Sinus Tachycardia
B. Ventricular Tachycardia ***Correct***
C. Complete Heart Block
D. Ventricular Fibrillation

2. The nurse interprets this heart rhythm as? *Select one:*

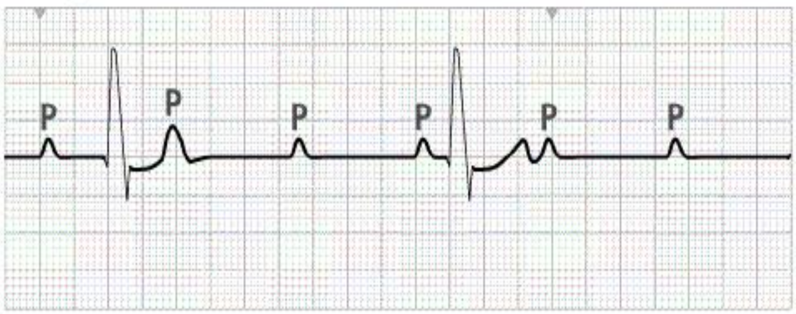


A. Atrial Fibrillation
B. Asystole
C. Ventricular Tachycardia
D. Ventricular Fibrillation ***Correct***

3. The nurse interprets this heart rhythm as? *Select one:*

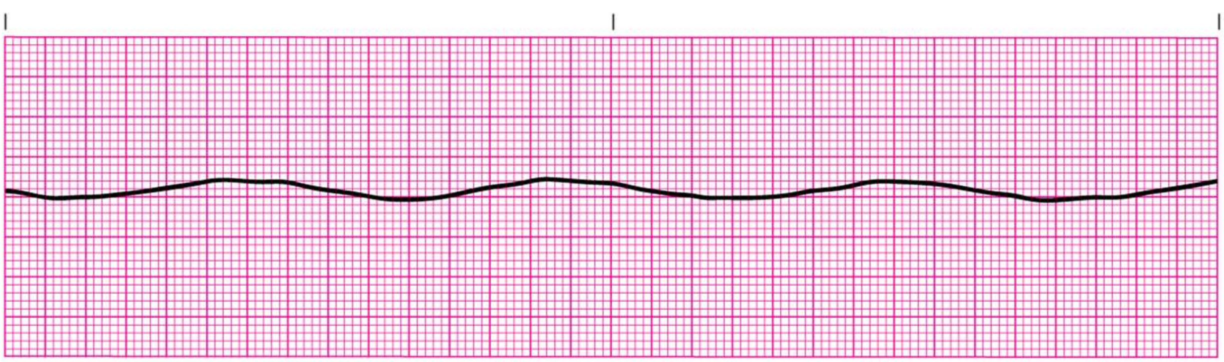
A. Ventricular Tachycardia
B. Ventricular Fibrillation
C. Bradycardia
D. Atrial Fibrillation ***Correct***

4. The nurse interprets this heart rhythm as? *Select one:*



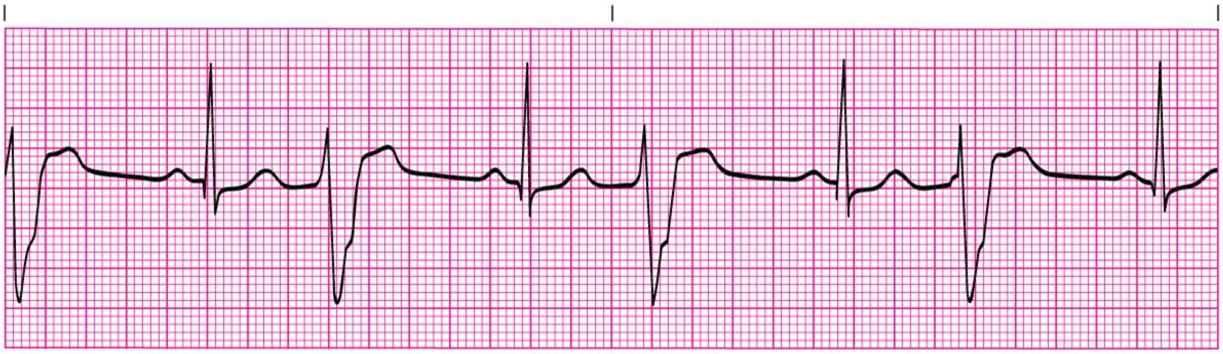
1. Bradycardia
2. First degree Heart Block
3. Complete Heart Block ***Correct***
4. Sinus Rhythm with Premature Atrial Contractions (PACs).

5. The nurse interprets this heart rhythm as? *Select one:*



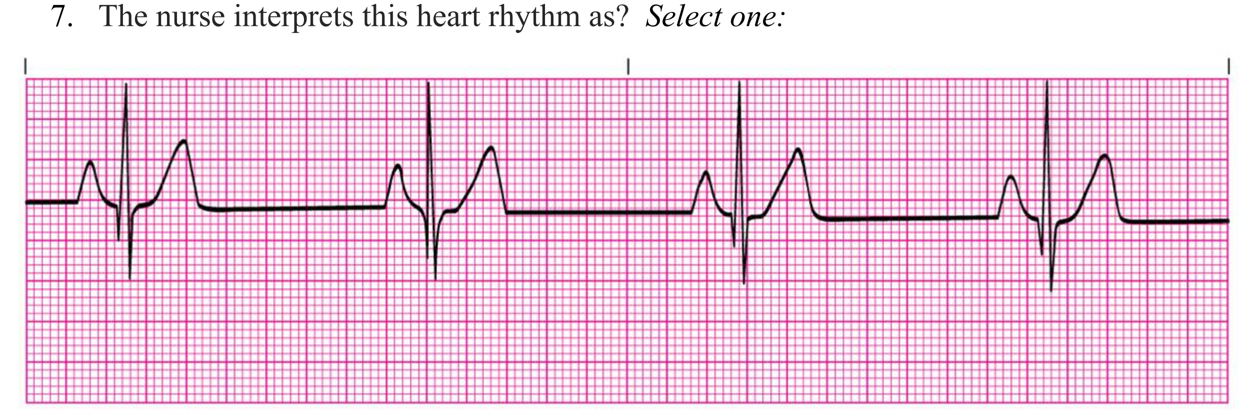
A. Asystole ***Correct***
B. Ventricular Fibrillation
C. Normal Sinus Rhythm
D. Bradycardia

6. The nurse interprets the beats in the strip below as? *Select one:*



A. Premature Ventricular Contractions (PVC's) ***Correct***
B. Premature Atrial Contractions (PAC's)
C. Normal Sinus Rhythm
D. Complete Heart Block

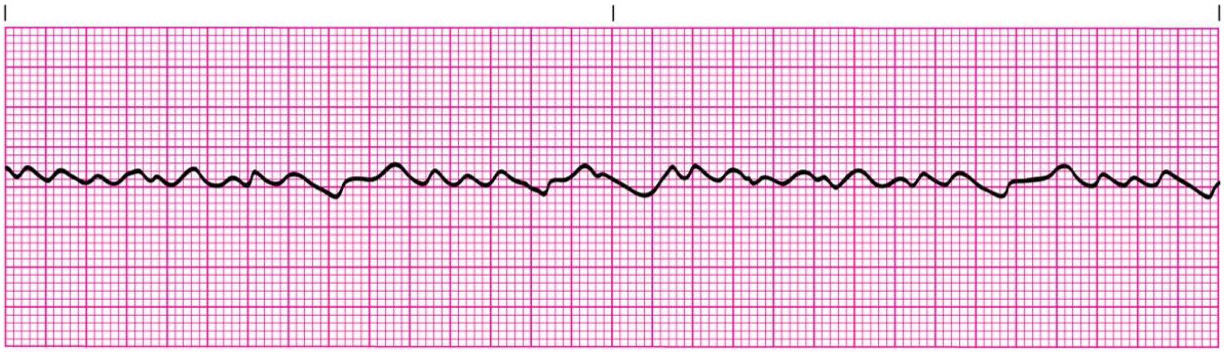
7. The nurse interprets this heart rhythm as? *Select one:*



A. Bradycardia ***Correct***
B. Sinus Tachycardia
C. Normal Sinus Rhythm
D. Atrial Fibrillation

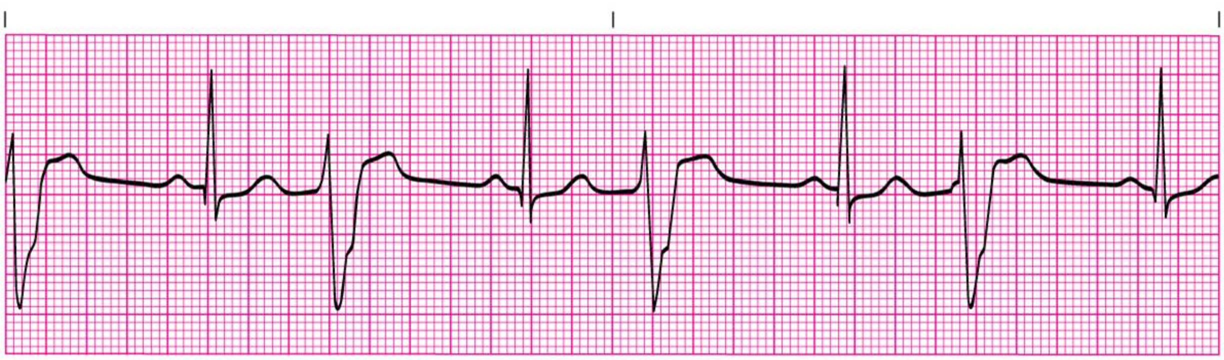
8. Which of the following ECG strips is interpreted as a lethal rhythm? *Select one:*

A. CORRECT

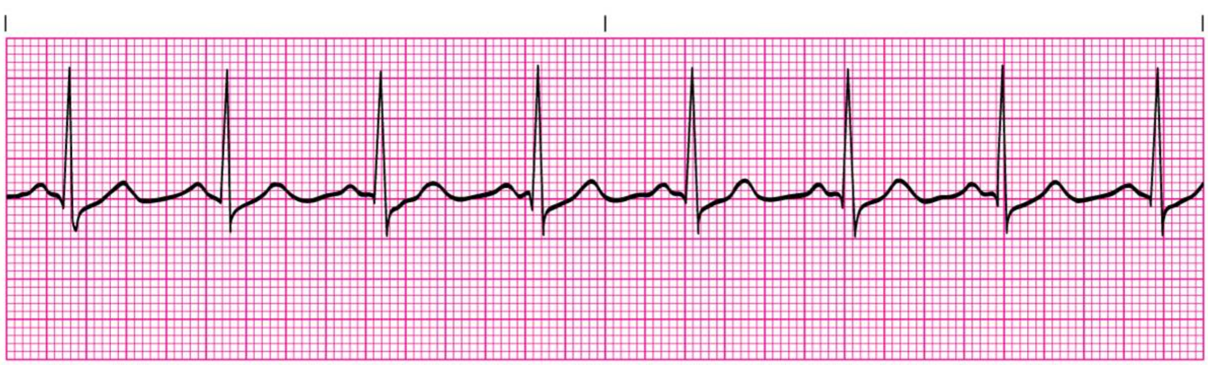


B.

C.

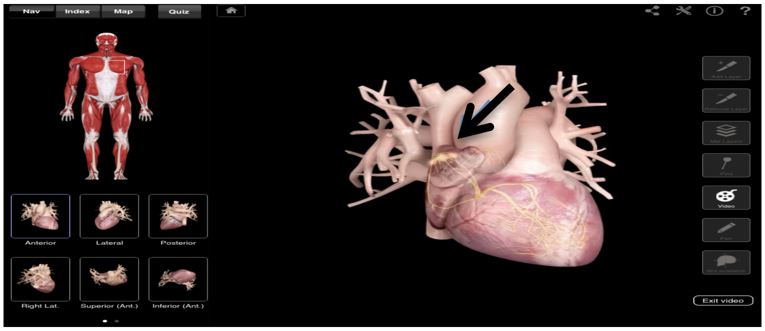


D. Normal Sinus Rhythm



9. The nurse interprets where electrical conduction begins in the heart, as?

The black arrow is pointing to this area in the image below? *Select one:*



A. SA node *Correct*
B. AV node
C. Purkinje Fibers
D. Bundle of his

10. Which of the following are considered lethal rhythms? *Select one:*

A. Atrial Fibrillation, PAC's, and Atrial Flutter
B. Ventricular Fibrillation, Ventricular Tachycardia, and Asystole **Correct**
C. First-degree Heart Block, Second-degree Heart Block, PVC's
D. Sinus Tachycardia, Sinus Bradycardia, and Sinus Rhythm

APPENDIX E

Student Content Guide

Student Content Guide

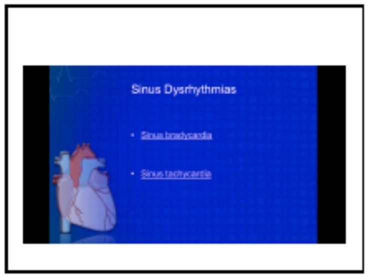
Orientation: 5 minutes • Research Study • iPad • 3D App Researcher will present each category above to the students and walk participants through the technological aspect of each component of the study
Step by step instructions: 10 minutes • Familiarize participants with iPad • Familiarize participants with 3D app • Familiarize participants with firs icons of 3D App • Practice manipulating images and content by rotating, scaling smaller, scaling lager, view angles, zoom, splice, spin, and span with the iPad's touch screen
Discuss prior knowledge of ECG interpretation: 5 minutes Multimedia presentation & Informal Discussion
Objectives: 2 minutes • to gain a basic knowledge of cardiac electrophysiology • to understand the representations of the cardiac cycle on the ECG • to understand the conduction system of the heart • to master techniques used for learning the characteristic of the different dysrhythmias • to understand what is going on in the heart when dysrhythmias take place • identify lethal rhythms
Individual review for each concept for 25-30 minutes: A. Video B. Animation C. Read Text View ECG rhythms, cardiac procedures and interact with the content by practicing ECG interpretation; Revisit ECG rhythms as needed 1. Heart Blood Flow 2. Conduction System 3. Heart Anatomy 4. Atrial Fibrillation 5. Atrial Tachycardia 6. Bradycardia 7. Heat Block 8. Normal Sinus Rhythm 9. Premature Atrial Contractions (PAC's) 10. Premature Ventricular Contractions (PVC's) 11. Sinus Tachycardia 12. Ventricular Tachycardia 13. Ventricular Fibrillation

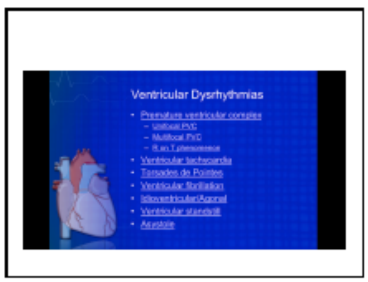
14. Pacemaker • Investigator will provide examples via the 3D app content • Point out reading explanation, watching videos, engagement with animations, interacting with the app, and reviewing the ECG strip change
Provide learning guidance: Ongoing Investigator will guide individual learning needs
Individual practice time: 10-15 minutes Review 3 lethal rhythms 1. Asystole 2. Ventricular Tachycardia 3. Ventricular Fibrillation Opportunity for practice and participant revisit content and practice content through the app
Provide ongoing feedback Investigator will provide ongoing feedback throughout the entire session as needed for both groups
Post test: 10 minutes
Review post test: 10 minutes Investigator will provide posttest answers with rationales at the close of the control group's 3D session.

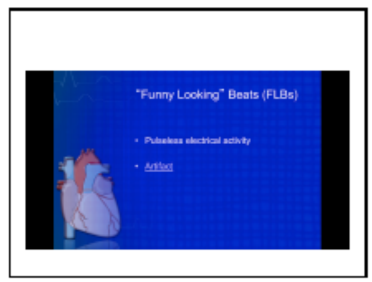
Note. Adapted from Gagné, R. M., Briggs, L. J., & Wagner, W. W. (1992). *Principles of Instructional Design (4th ed.).* Fort Worth, TX: Harcourt Brace Jovanovich College Publishers.

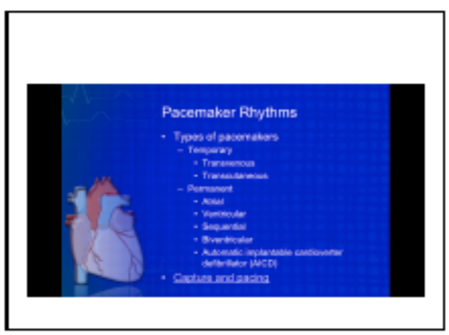
APPENDIX F

Traditional Lecture PowerPoint









APPENDIX G

Traditional Lecture Script

Traditional Lecture Script with Gagné's Nine Events of Instruction

Event 1: Gain attention • For learning to take place, student attention will be captured • Welcome and introduce to study • PowerPoint slide presentation via audiovisual equipment
Event 2: Learning objectives • Inform participants of expectations • Inform participants of learning objectives • Describe required performance
Event 3: Stimulate recall of prior knowledge • Pretest assessment
Event 4: Present content • Use clear, concise language • Present objectives matched with lecture objectives • Content will be presented via PowerPoint slides and traditional lecture for content • Present ECG rhythm examples
Event 5: Provide learning guidance • Teacher facilitating learning by guiding instructions • Provide instructional support times • Provide examples
Event 6: Eliciting performance • The learning activities will be aligned with learning objectives • Repetitive exploration • Hands-on opportunity by working through ECG interpretation via slides • Give learners opportunity to practice by seeing various ECG strips via PowerPoint slides
Event 7: Providing feedback • Specific and immediate feedback of learners' performance • Any questions or responses from students will be immediately provided feedback by faculty member • Faculty member easily accessible in room for entire session for feedback and guidance • Provide confirmatory feedback, corrective and remedial feedback
Event 8: Assess performance • Posttest at completion of lecture
Event 9: Enhance retention and transfer • Investigator will provide posttest answers with rationales at the close of the control group's 3D session.

Note. Adapted from Gagné, R. M., Briggs, L. J., & Wagner, W. W. (1992). *Principles of Instructional Design (4th ed.).* Fort Worth, TX: Harcourt Brace Jovanovich College Publishers.

APPENDIX H

3D App Script

3D App Script with Gagné's Nine Events of Instruction

Event 1: Gain attention • For learning to take place, student attention will be captured • Welcome and introduce to study • Orientation to iPad and to app • Demonstrate 3D app
Event 2: Learning objectives • Inform participants of expectations • Provide student outline with learning objectives • Inform participants of learning objectives • Describe required performance
Event 3: Stimulate recall of prior knowledge • Learning takes place if new information is associated with prior knowledge • Prior knowledge of iPad use • Prior knowledge of ECG interpretation • Pretest assessment will be completed during gaining attention
Event 4: Present content • Use clear and concise language • Present content • Content will be presented via app utilizing images, sound, video, animations, and text • Study outline with guidelines of content • Present examples • Present multiple methods of same content via app to address different learning preferences
Event 5: Provide learning guidance • Teacher facilitating learning by guiding instructions • Provide instructional support • Directions will be provided for students to explore app at own pace • Student outline will guide time on task for each learning objective. • Instructions include ability to move backward, forward and review content multiple times • Provide examples
Event 6: Eliciting performance • The learning activities are aligned with learning objectives • Repetitive exploration • Hands-on opportunity working through ECG rhythm and practicing • Give learners opportunity to practice • Elicit student activities
Event 7: Providing feedback • Specific and immediate feedback of learners performance • Any questions or responses from students will be provided feedback from the investigator

• Investigator accessible in room entire session for feedback and guidance • Provide confirmatory feedback • Provide corrective and remedial feedback
Event 8: Assess performance • Posttest at completion of learning session
Event 9: Enhance retention and transfer • Feedback of posttest given (correct answers) • Question and answer session will be held in regards to posttest items

Note. Adapted from Gagné, R. M., Briggs, L. J., & Wagner, W. W. (1992). *Principles of Instructional Design (4th ed.).* Fort Worth, TX: Harcourt Brace Jovanovich College Publishers.

APPENDIX I

IRB Approval Letters

Samford University

irb

Approval Form

Identification and Certification of Research Projects involving Human Subjects

The Institutional Review Board (IRB) must complete this form for all applications for research and training grants, program projects and center grants, demonstration grants, fellowships, traineeships, awards, and other proposals which might involve the use of human research subjects independent of source of funding.
This form does not apply to applications for grants limited to the support of construction, alterations and renovations, or research resources.

PRINCIPAL INVESTIGATOR: Abbey Holthaus

PROJECT TITLE: 3D Application Effectiveness on Nursing Student's Level of Electrocardiogram Knowledge as Evidenced by Exam Performance

_____ 1. This is a training grant. Each research project involving human subjects proposed by trainees must be reviewed separately by the Institutional Review Board (IRB).

_____ 2. This application includes research involving human subjects.
The IRB has reviewed and approved this application on 08/04/2014 in accordance with Samford University's assurance approved by the United States Public Health Service. The project will be subject to annual continuing review as provided in that assurance.

____This project received expedited review.
______This project received full board review.

______3. This application may include research involving human subjects. Review is pending by the IRB as provided by Samford's assurance. Completion of review will be certified by issuance of another APPROVAL FORM as soon as possible.

4. Exemption from subject informed consent based on number(s)_______________

This project has received reciprocal approval from Samford IRB. Original approval gained from University of Alabama where Mrs. Holthaus is a student. She is faculty in the SON at Samford.

Dr. Debra Whisenant

______

Date: 8/04/2014

IRB Committee **EXMT – N-14-SUM-1**

IRB Application Number

Office for Research

Institutional Review Board for the
Protection of Human Subjects

THE UNIVERSITY OF
ALABAMA
RESEARCH

May 22, 2014

Abbey Holthaus
ELPTS
College of Education
The University of Alabama
Box 870232

Re: IRB # EX-14-CM-073 "3D Application Effectiveness on Nursing Student's Level of Electrocardiogram Knowledge as Evidenced by Exam Performance"

Dear Ms. Holthaus:

The University of Alabama Institutional Review Board has granted approval for your proposed research.

Your protocol has been given exempt approval according to 45 CFR part 46.101(b)(1) as outlined below:

(1) Research conducted in established or commonly accepted educational settings, involving normal educational practices, such as (i) research on regular and special education instructional strategies, or (ii) research on the effectiveness of or the comparison among instructional techniques, curricula, or classroom management methods.

Your application will expire on May 21, 2015. If your research will continue beyond this date, complete the relevant portions of Continuing Review and Closure From. If you wish to modify the application, complete the Modification of an Approved Protocol Form. <u>When the study closes, complete the appropriate portions of FORM: Continuing Review and Closure.</u>

Should you need to submit any further correspondence regarding this proposal, please include the assigned IRB application number.

Good luck with your research.

Sincerely,

[redacted], CIM, CIP
Director & Research Compliance Officer
Office for Research Compliance
The University of Alabama

358 Rose Administration Building
Box 870127
Tuscaloosa, Alabama 35487-0127
(205) 348-8461

APPENDIX J

Dean Letter of Approval

IDA V. MOFFETT
SCHOOL OF NURSING
SAMFORD UNIVERSITY

800 Lakeshore Drive
Birmingham, AL 35229
http://nursing.samford.edu
www.samford.edu

July 30, 2014

Ms. Abbey Holthaus, EdD(c), MSN, RN
Assistant Professor
Ida V. Moffett School of Nursing
800 Lakeshore Drive, Birmingham, AL 35229

Dear Ms. Holthaus

Pending receipt of IRB approval from Samford University, you are approved to submit your request for senior-level student volunteers in the Fall 2014 course NURS460 Principles of Critical Care Nursing to participate in your research study "*3D Application Effectiveness on Nursing Student's Level of Electrocardiogram Knowledge as Evidenced by Exam Performance*".

Best wishes for continued success in your doctoral studies.

Sincerely,

Elea[redacted]
Ralph W. Beeson Dean and Professor

APPENDIX K

Course Coordinator Letter of Approval

IDA V. MOFFETT
SCHOOL OF NURSING
SAMFORD UNIVERSITY

800 Lakeshore Drive
Birmingham, AL 35229
http://nursing.samford.edu
www.samford.edu

May 15^{th}, 2014

Dear IRB:

This letter is to serve as a letter of approval for Abbey Holthaus, a doctoral candidate pursuing her EdD in Instructional Leadership for Nurse Educators, from The University of Alabama. I am the course coordinator and I am aware, as well as approve her request to conduct an educational teaching intervention in NURS 460 Principles of Critical Care Nursing during the fall 2014 semester.

Abbey is also an Assistant Professor at Samford for the Accelerated Nursing Program and has no faculty role with NURS 460.

Sincerely,

[redacted]

Cindy Berry, DNP, RN, CNE
Course Coordinator NURS 460
HEAL 242, 726-2924
cgberry@samford.edu