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The Design and Implementation of Online Radiology Modules Using the ADDIE Process and Rapid Prototyping

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The Design and Implementation of Online Radiology Modules Using the ADDIE Process and Rapid Prototyping

by

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We hereby certify that this dissertation, submitted by Leslie Bofill, conforms to acceptable standards and is fully adequate in scope and quality to fulfill the dissertation requirements for the degree of Doctor of Philosophy.

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An Abstract of a Dissertation Submitted to Nova Southeastern University in Partial Fulfillment of the Requirements for the Degree of Doctor of Philosophy

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Leslie Bofill
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Medical schools in the United States have begun the process of changing the teaching methodologies used in the classroom. The traditional, teacher-centered environment is shifting toward a more student-centered, active learning environment. Part of this shift is the integration of online learning to deliver a continuously expanding medical curriculum by moving content learning outside the classroom and creating active learning activities for the classroom. As more medical schools adopt online learning as a supplemental teaching tool, medical education faculty are taking on the role of instructional designers without having any theoretical knowledge on adult learning theory or online learning practices. Schools are developing online learning materials without relying on an instructional design framework to guide the analysis, design, development, implementation, and evaluation of the online curriculum. This can result in developing online materials that do not meet the intended objectives, are designed poorly, or do not incorporate learning principles specific to the way humans use computers to learn.

At the Herbert Wertheim College of Medicine, the third year radiology clerkship is a requirement of the curriculum; however, the rotation only lasts two weeks, versus the four to seven weeks provided the other six rotations. Student group sessions led by the radiology clerkship director are limited to four hours in the afternoon, Monday through Friday. This limited time has driven the need to explore alternative solutions for the delivery of the learning material to students.

This study seeks to apply an instructional design process, ADDIE, to the development of four e-learning modules for a third year, required, radiology clerkship course using the ADDIE process as a framework and incorporating a rapid prototyping approach. The purpose is to identify how to effectively implement an instructional design methodology, ADDIE, using rapid prototyping when developing supplemental online learning materials for a radiology clerkship course.

Acknowledgements

I would like to begin by offering my deepest appreciation for my committee chair, Dr. Steven Terrell. His guidance throughout this long process not only helped me develop a product of which I am very proud, but taught me lessons on research that I will use beyond this paper. Without his support and encouragement, this dissertation would not have been possible.

I would like to also thank my committee members, Dr. Trudy Abramson and Dr. St. Aubin. I was fortunate enough to be a student in one of Dr. Abramson's classes. Her knowledge of instructional systems design and her enviable experience made me thankful to have her on my committee. I also appreciate the work of Dr. St. Aubin for offering her time, support, and guidance.

In addition, I would like to thank Dr. David Graham, clerkship director at the Herbert Wertheim College of Medicine and, without whom, I would not have been able to complete this study. Dr. Graham's willingness to participate in this study allowed me to work on my dream dissertation. His willingness to help and passion for his work resulted in a study that was both fun and educational for me. I am eternally grateful for the opportunity to have worked with him.

Finally, I would like to thank my family, especially my son, Aidan, who made the biggest sacrifice to help me complete my dissertation. He spent many nights without his mom while I toiled away on my computer. To my parents, Carmen and Norberto, I could not have done this without you and the amazing support you have always given me. You have all contributed and sacrified so much for my success.

Table of Contents

List of Tables

Tables

List of Figures

Figures

Chapter 1

Introduction

Background

This study sought to apply an instructional design process to the development of an e-learning module for a third year required radiology clerkship course, using the ADDIE (Analyze, Design, Develop, Implement, Evaluate) process as a framework, and incorporating a rapid prototyping approach. The researcher aimed to identify a process and add to the body of research by identifying a methodology, which medical schools can use when developing e-learning modules for their undergraduate medical education programs. The study focused on the process of developing four e-learning modules for a third year radiology clerkship course at Florida International University (FIU) Herbert Wertheim College of Medicine (HWCOM), and how the application of an instructional design process and rapid prototyping ensures that quality and content standards are met, while reducing the development time needed.

Florida International University is a public, higher education institution in Miami, FL. In 2009, its public research medical school, the HWCOM accepted its inaugural class. Although medical schools in the United States are accredited through the same accrediting body, the Liaison Committee on Medical Education (LCME), the way in which individual schools deliver their medical curriculum varies. The HWCOM provides an integrated curriculum where core concepts are integrated vertically across four strands (basic science, clinical skills, professional development, and medicine and society). The curriculum is further divided into four periods where period one and period two are the pre-clinical years, and period three and period four are clinical years. The focus of the pre-clinical curriculum is on the normal and abnormal systems. Period one covers how normal organ systems function.

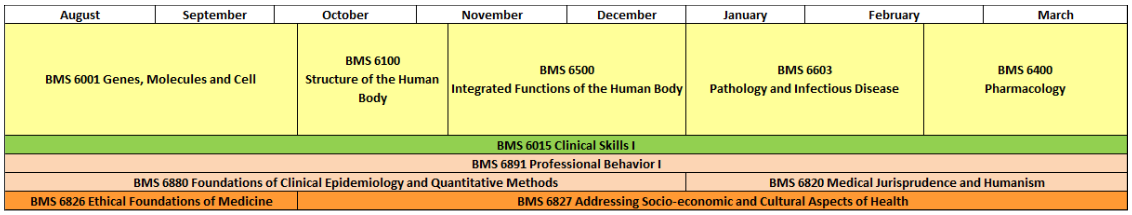


Figure 1. Period one curriculum graphic. This figure illustrates vertical integration of strands: yellow: basic science; green: clinical skills; beige: professional development; orange: medicine and society.

Period two covers the pathologies associated when normal organ systems begin to function abnormally; topics such as breast cancer, leukemia, and neurological disorders are covered.

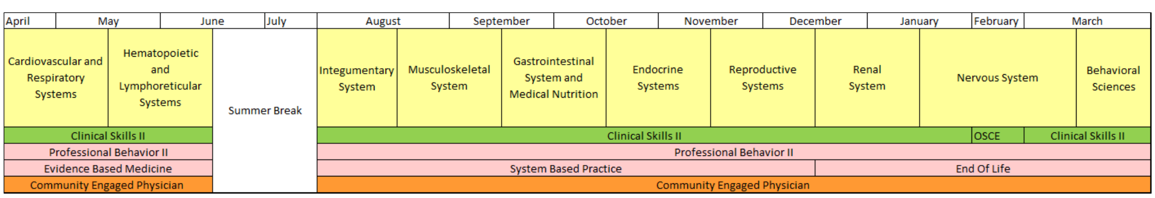


Figure 2. Period two curriculum graphic. This figure illustrates vertical integration of strands: yellow: basic science; green: clinical skills; beige: professional development; orange: medicine and society.

Period three is a significant change for students as the majority of instruction takes place during their assigned clerkship location (e.g., hospitals, clinics), not in a classroom. This period is comprised of seven clerkships. They are primarily outpatient based and during which students attend a weekly didactic session: medicine, surgery, obstetrics and gynecology, pediatrics, neurology, psychiatry, and radiology (Dambach, Simpson, & Rock, 2010). Each clerkship has seven rotations, which can last two to seven weeks, depending on the clerkship (Figure 3).

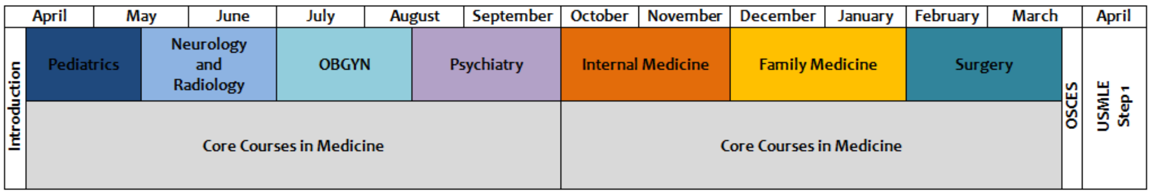


Figure 3. Period three curriculum graphic. This is an example of a clerkship rotation for a period three student. The actual order will vary based on requirements set forth by the HWCOM.

Students are placed into groups of 10-12 and placed into a schedule to complete the clerkships over the year as they rotate through the seven clerkships. Students are no longer primarily receiving their instruction in the classroom; they shadow and work with clinical faculty who act as preceptors and guide students through the learning experiences in the clerkship.

The radiology clerkship is unique in that unlike other clerkships where the learning takes place in a hospital or clinic working with a preceptor, the radiology clerkship requires that students attend faculty led, on-campus sessions every day for the two-week duration of the clerkship. Students do not have clinical duties during this rotation. The curriculum is mostly comprised of self-directed online study of resources selected by the clerkship director. Reading assignments are comprised of PowerPoint presentations, assigned textbook chapters, and journal articles posted to the HWCOM learning management system. The clerkship is divided into seven modules: introduction to imaging, chest, ultrasound and abdomen, spine and central nervous system, nuclear medicine/positron emission tomography, musculoskeletal, and mammography (Graham, 2014).

Radiology is a fundamental component of medical education; however, it is one that currently is underrepresented in the medical curriculum in the United States, where many medical programs offer radiology clerkships only as an elective (Kourdioukova, Verstraete, & Valcke, 2010). Yet, radiology plays a critical role in patient care. Radiology is not a specialty, like neurology or pediatrics; it is a tool to identify illnesses within these areas. As such, all medical students must have a basic understanding of certain aspects of radiology.

The significance of radiology has been further enhanced by technological advances in medical imaging, which give clinicians greater abilities to further narrow down their diagnosis (Chorney & Lewis, 2011). The expanding uses of medical imaging, resulting from medical technological advances, ensures that all medical students will have to interpret and understand radiological studies as clinicians (Chorney & Lewis, 2011). Unfortunately, formal radiology instruction is still primarily provided in postgraduate residency radiology programs (Ianni & Walker, 2006). The limited time allotted to radiology has remained constant throughout the years. The AAMC reports that the average number of clerkship weeks required by U.S medical schools for radiology between 2011 and 2012 was two weeks ("Clinical Sciences, Knowledge, and Disciplines Content: Average Required Clerkship Weeks by Curriculum Year," 2012). This leaves little time to provide students with the instruction needed in this area.

Even with the advancements in educational technology and availability of instructional technology tools, which can assist in the teaching of science and medicine, medical education continues to rely heavily the traditional teacher-centered, lecture focused methodology (Prober & Heath, 2012). The current model of medical education has been described as inefficient, inflexible, and lacking in learner-centeredness (Mehta, Hull, Young, & Stoller, 2013). Additionally, medical educators face continuous pressure to acquire research funding, which results in less focus on their instructional duties and challenging their commitment to teaching (Mehta et al., 2013).

Within medical education, the concept of the flipped classroom is gaining interest as schools find limited time to deliver the continuously expanding medical curriculum (Prober & Heath, 2012). The use of the flipped classroom teaching methodology is widely used in non-medical education (Mehta et al., 2013; Tucker, 2012). This type of teaching methodology is already widely used in gross anatomy courses, where students learn the content through lectures or videos prior to class and then practice this knowledge during human anatomy dissections (Prober & Khan, 2013).

There is interest in medical education to move the flipped classroom methodology beyond the anatomy courses. Problem-based learning (PBL), a type of flipped-classroom methodology, is gaining use in medical education with a reported 60 medical schools worldwide subscribing to this methodology as of 2010 (White & Ousey, 2010). Students are provided with content prior to the class session, and class time is dedicated to working in small groups discussing a patient case (Smith, 2005). With PBL, students are active participants in constructing their own knowledge. This method of teaching is popular in medical schools as it lends itself to case-based studies.

Medical education is moving toward less traditional methods of teaching to more student centered approaches (A. Lewis et al., 2009). Further progress into the use of the flipped-classroom methodology will require a shift from a traditional, didactic based model to a model that shifts the learning of new concepts to outside the classroom. This would mean designing courses that provide students with instructor-developed interactive lessons and/or videos that are viewed online prior to class. In-class time is then dedicated to problem-based learning (PBL), collaborative learning, and the discussion of advanced topics (Tucker, 2012).

Problem Statement

At the HWCOM, the radiology clerkship is a requirement of the curriculum; however, the rotation only lasts two weeks, versus the four to seven weeks provided other rotations. Student group sessions led by the clerkship director are limited to four hours in the afternoon Monday through Friday. During this brief segment in their clerkship experience, students must learn about the common imaging tests and methods available, develop the necessary skills to order appropriate imaging tests for a given clinical scenario, prepare patients for a variety of imaging tests, and interpret imaging findings in common clinical situations (Graham, 2014). There is limited time in which to deliver this curriculum to students in the clerkship. This limited time has driven the need to explore alternative solutions for the delivery of the learning material to students.

A preliminary evaluation of the course has identified the following problems:

- There is limited time in which to cover the required learning materials.
- External content often does not meet the session or learning objectives.

- There is limited time to develop an e-learning module due to competing course director responsibilities (e.g., teaching, researching, and publishing).

By using the flipped classroom methodology, the issue of the limited time allotted for this clerkship may be addressed; however, a critical part of this process is the application of an instructional design model for achieving successful learning outcomes. The research on e-learning in medical education has focused primarily on measuring outcomes, student satisfaction, and student acceptance of the learning methodology. What is missing in the current body of literature within the discipline of medical education is an instructional design framework for the development of e-learning modules.

Because students are required to read the online materials prior to the daily sessions, there is a need to develop online learning modules that students can access prior to the face-to-face session with the clerkship director. An effective instructional design methodology, curriculum development, and assessment process should be identified that will improve student satisfaction, provide the same learning experience for all students, and ensure the e-learning module is designed to meet and evaluate the learning and performance objectives identified for the module. An additional need is to identify a process that is efficient to minimize the time to develop and implement the modules.

Dissertation Goal

The goal was to develop a framework for use by medical schools that models the effective implementation of an instructional design methodology (ADDIE) and rapid prototyping when developing supplemental online learning materials. While the framework focuses on the radiology clerkship course, it is generalizable across much of the curriculum.

Research Questions

Q1. How can the ADDIE process be used as a guide in the development of e-learning modules for a third-year radiology clerkship?

Q2. What do students report about the ease of use and learning value of the modules?

Q3. Based upon an analysis of implementation and necessary revision, what is the framework that is recommended for course development?

Instructional systems design is the use of a systematic model to plan, design, develop, and evaluate training and curriculum (van Merriënboer, 1997). There are several instructional systems design models, such as the Dick and Carey Model (R. V. Reiser & Dempsey, 2012), Kemp's Instructional Design Model (R. V. Reiser & Dempsey, 2012) and ADDIE which is an acronym for each phase of the process: Analysis, Design, Development, Implementation, and Evaluation (Peterson, 2003). Although the models differ in the stages and relationships between them, they all incorporate a shared set of characteristics such as a needs analysis, a task analysis, definition of learning objectives, development of learning material, development of an assessment plan, a pilot plan, and the final implementation of the product (Scafati, 1998). The role of an instructional design model is to bridge the gap between instructional and learning theory, and the design and development of learning environments (Gros, Elen, Kerres, Merrienboer, & Spector, 1997). The benefit of using an instructional design model is that it provides a proven approach for the development of curriculum ensuring that students receive a consistent educational experience, resulting in mastery of the topic (Scafati, 1998).

According to van Merriënboer (1997), there is a difference between instructional systems design (ISD) models and instructional design (ID) models. Instructional systems design (ISD) models break down the instructional design process into five phases: analysis, design, production, implantation/delivery, and summative (van Merriënboer, 1997). In doing so, ISD models provide a theoretical framework for the creation of instructional systems (Gros et al., 1997). Formative evaluation is conducted at each phase and summative evaluation is conducted in the final phase. Instructional design (ID) models utilize the first two phases of the ISD models: analysis and design and focus on the job and task analysis or on the design of the learning environment (van Merriënboer, 1997). For the analysis and design phases, ID models provide more specific guidelines and steps than ISD models; however, it is recommended that ID models be applied in conjunction with an ISD model to account for activities not represented in the ID model, such as a needs assessment and summative evaluation, which are part of the ISD model (van Merriënboer, 1997).

Branch (2009) referred to ADDIE as a product development concept not a model, which is ideal for the development of educational products and learning resources. The phases of ADDIE occur in a cyclical format, evolving throughout the process of instructional planning and implementation (Peterson, 2003). A needs analysis is conducted during the analysis phase to identify the instructional problem, conduct an analysis of the learners and context, identify instructional goals, identify resources (including the curriculum delivery system), and compose a project management plan (Branch, 2009). The audience is the primary focus of the analysis phase (Peterson, 2003). A thorough and accurate analysis of the audience ensures that the subsequent phases are properly developed. During the design phase, performance objectives are composed and appropriate testing methods are identified (Branch, 2009). The design phase mainly consists of research and planning by the instructional designer (ID). Once objectives are identified, the ID must determine how the objectives will be met and the instructional strategies that will aid in achieving those objectives (Peterson, 2003). Content development begins during the development phase and is guided by the output from the analysis and design phases. The development phase sees a shift from research and design into production. In the development phase, the ID selects or develops supplemental media elements (Branch, 2009; Peterson, 2003). This phase also includes the development of guidance materials for the teacher and the student (Branch, 2009). In the implementation phase, the curriculum delivery system is prepared and students are engaged (Branch, 2009). This phase includes an iterative process where the designer continuously analyzes, redesigns, and enhances the course before it is implemented (Peterson, 2003). This is also the phase where quality assurance measures should be applied to ensure that the standards of quality for the product have been met (Peterson, 2003).

The final phase, evaluation is the phase in which the quality of the instructional materials and learning environments are assessed, using the evaluation criteria and tools selected in the design phase (Branch, 2009). Evaluation does not occur in isolation as the last step of the ADDIE process. Formative evaluation occurs throughout each phase culminating in the overall summative evaluation on the effectiveness of the curriculum and modality chosen. Summative data are collected through student surveys, observations, interviews, and assessments, which determine if the learning objectives were met (Peterson, 2003). Additional summative evaluations can be conducted with internal stakeholders such as the subject matter expert (SME) and other decision makers within the organization. These evaluations focus on the return on investment of the project in order to assess future implementations.

Barriers and Issues

In any study, there are barriers and issues inherent based on population, methodology, and other external factors. One barrier was the low response rate. For each module, students completed a pre and posttest and a satisfaction survey. Completing these tasks placed a burden on students' time that they were unwilling to meet. This barrier was partially addressed with the assistance of the SME, who administered the pre and posttest during class time. Administering these assessments during the time allotted for the class increased the response rate for the pre- and posttest. The satisfaction survey for each module still had a low response rate, as the SME did not require students to complete it during class time.

Time was a factor for the SME and for the experts he/she identified to review the modules during the pilot study. The experts were clinicians with patient practices who are highly regarded in their fields. In one instance, an expert interested in pilot testing a module did not respond on time due to other obligations. This issue was anticipated and a contingency plan identified a secondary reviewer, who was faculty at the HWCOM and who agreed to participate in the pilot test of that module.

Assumptions and Limitations

Participants were expected to be honest in their responses to the survey questions about their perceptions of usefulness of learning modules. This was encouraged by using an anonymous, electronic survey that was generated once the module was completed. Students were provided a clear statement on the anonymity and security of their responses in accordance with IRB requirements.

It was also assumed that students were comfortable using CanvasMed and would not encounter any difficulties understanding how to navigate the course, modules, or the pre and posttest. In order to ensure this, the ID provided clear instructions to students and to the SME, which explained how to navigate the course requirements and who to contact for technical support. The ID developed these documents during the implementation phase as part of the ADDIE process.

One assumption made as part of this study was that all the students had gone through similar educational experiences while at the HWCOM. Since students are in a lock-step program, they have all progressed through the same courses at the same time. These students have also shared the same clerkship rotations prior to the radiology clerkship; however, their individual experiences and patient interactions were different.

The main limitation was that it is not a true random sample. Instead, convenience sampling was used. This limitation was addressed by not generalizing the results to the general student population of the United States. As a case study, the results only sought to describe the phenomenon studied at the HWCOM. Small sample size was also a limitation and was due to the radiology program design and length of the research study.

An additional limitation was that participants might not have been honest in the presence of the researcher. There were several instances where the ID needed to contact a participant during the pilot study to get clarification on feedback or because the participant wanted to provide additional information in-person or via email. In these cases, a follow-up email communication or phone call was conducted to gain additional feedback on some of the expert reviewers' original responses to the satisfaction survey. These participants may not have provided honest feedback as their responses were not anonymous, and they provided those responses directly to the ID. This limitation was addressed by assuring the participants that their honest feedback was going to aid in the improvement of the course. They were also assured of the confidentiality and security of their responses as required by the IRB.

Definition of Terms

Alliance of Medical Student Educators of Radiology: Alliance of Medical Student Educators of Radiology (AMSER) is an association for academic radiologists, which seeks to develop a standardized curriculum for use in medical schools.

Clinical Period: Refers to period three in the medical program where the majority of instruction takes place during a student's assigned clerkship location.

Hybrid Problem Based Learning: A modification to the traditional PBL teaching method (defined below). Unlike traditional PBL, hybrid PBL provides students with lecture and reading materials in multimedia format prior to the class session. During class, students work in small groups to examine case studies and report on their finding.

Flipped-Classroom: Teaching methodology where content is made available to learners prior to class allowing for in-class time to be dedicated to student-centered learning activities, such as PBL, small group exercises, and other active learning activities (McLaughlin et al., 2014).

Instructional Design: Principles and procedures that are used to develop instructional materials (Molenda, Reigeluth, & Nelson, 2005)

Instructional Systems Design: The use of a systematic model to plan, design, develop, and evaluate training and curriculum (van Merriënboer, 1997).

Liaison Committee on Medical Education: The accrediting body for medical schools in the United States and Canada

Period one: This is the first academic period in a medical program. The curriculum focuses on normal system functions/

Period two: This is the second academic period in a medical program. The curriculum focuses on abnormal system functions.

Period three*:* This is the third academic period in a medical program; also referred to as the clerkship period where learning primarily takes place in hospitals and clinics, not in a traditional classroom setting.

Pre-Clinical Period: Consists of period one and period two of the four year medical curriculum. Period one covers normal systems (e.g., how normal organ systems function). Period two covers abnormal systems (e.g., the pathologies associated when normal organ systems begin to function abnormally).

Problem-Based Learning (PBL)*:* This is a teaching methodology which provides lecture material to students using the traditional didactic method. Students are placed in small groups and provided case studies of patients diagnosed with symptomatic problems. Working in teams, students identify their knowledge gaps, clarify the learning objectives, then regroup to present their findings/solutions for the problem to the class (Smith, 2005).

Rapid Prototyping: A development process which occurs parallel to the ADDIE process and allows for the delivery of a working prototype of the product at the initial phases of the ADDIE process and not at the end.

Radiology ExamWeb: This is a standardized question database based on the AMSER National Medical Student Curriculum for use in Radiology medical programs.

List of Acronyms

AAMC: American Association of Medical Colleges

ADDIE: Analyze, Design, Develop, Implement, Evaluate

AMSER: Alliance of Medical Student Educators of Radiology

CNS: Central Nervous System

FIU: Florida International University

GUI: Graphical User Interface

hPBL: Hybrid Problem Based Learning

HWCOM: Herbert Wertheim College of Medicine

ID: Instructional Design

ISD: Instructional Systems Design

LCME: Liaison Committee on Medical Education

PBL: Problem Based Learning

PET: Positron Emission Tomography

REW: Radiology ExamWeb

SME: Subject Matter Expert

NSU: Nova Southeastern University

WYSIWYG: What You See Is What You Get

Summary

This chapter provided an introduction into the medical curriculum at the FIU HWCOM and discussed the organization of the pre-clinical and clinical years. It also provided background and a discussion on the problems within the radiology clerkship and the significance of the radiology clerkship within medical education. The chapter provided a summary of the problem with the limited time allotted for this clerkship and the impact on students' medical education as a result. The chapter also covered the changes currently undergoing within medical education from didactic, instructor-led to more student-centered through the use of flipped-classroom, PBL, and hPBL methodologies. This chapter also introduced instructional systems design and the ADDIE process.

Chapter 2

Review of the Literature

Background

Instructional systems design has its origins in the United States military during World War II (WWII) when the U.S. government recruited educational psychologists to develop training materials for military personnel (Dick, 1987). Their work on research and training during WWII continued after the war ended, resulting in a view of training and development as a system comprised of analysis, design, and evaluation procedures (Dick, 1987). In the decades since WWII, the number of instructional design models continued to grow, with 40 models identified by the end of 1970 (Andrews and Goodson, 1980, as cited in R. A. Reiser, 2001). One of those models was the predecessor of the ADDIE model, developed by Florida State University for the U.S. government Naval Training Device Center Army Combat Arms Training Board (Branson et al., 1975). The original model was comprised of 19 steps divided into five phases: analyze job, develop objectives, specify learning events, implement instructional management plan, and conduct internal evaluation. The focus of this model was on training for performance tasks, not on education and was a strictly linear model (Watson, 1981).

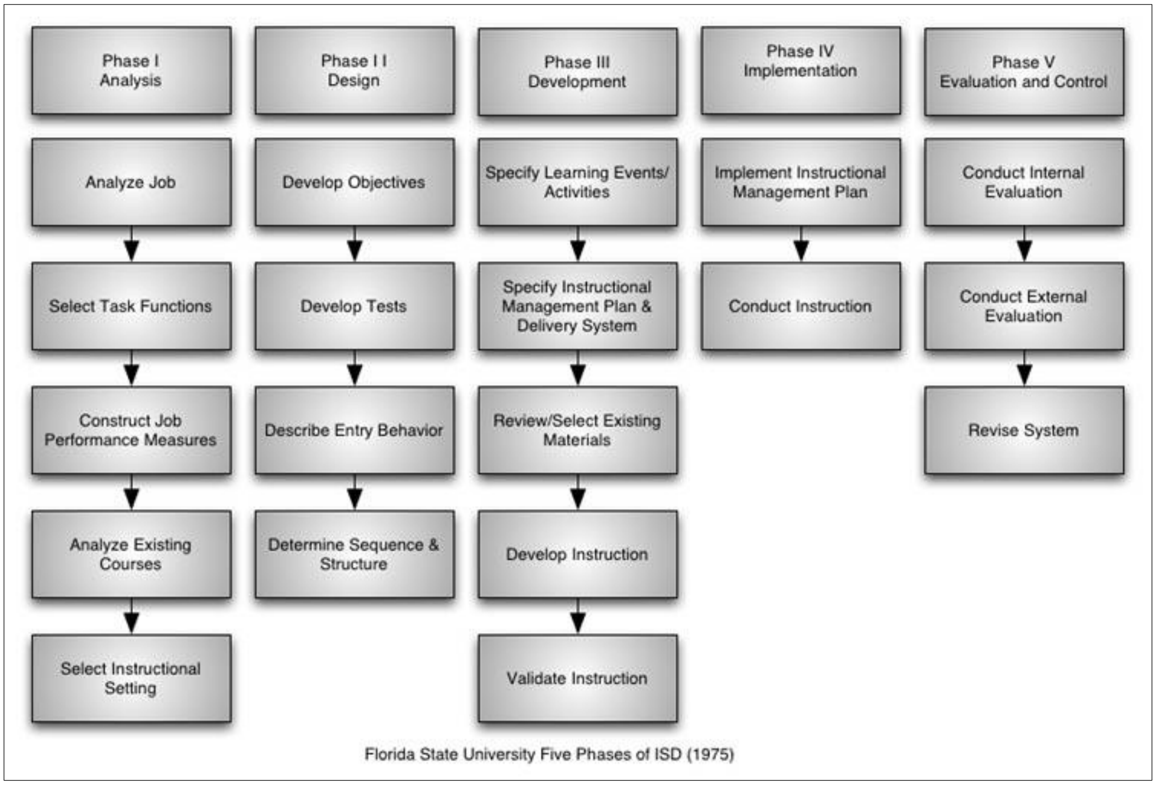


Figure 4. Original ADDIE process.

The original ADDIE process, illustrated in Figure 4, is described as a waterfall process, requiring that all the steps in each phase be completed before continuing to the next phase (Allen & Sites, 2012). This has led to criticism of the ADDIE process as too linear, too systematic, and too time consuming to produce (Kruse, n.d.). One major drawback of the original process was that evaluation was only conducted in the final phase (Branson et al., 1975). The steps of the evaluation phase included conduct internal evaluation, conduct external evaluation, and revise system (Branson et al., 1975). The original process did not allow for continual evaluation within each phase of the process. One criticism levied against the ADDIE process has focused on this weakness. Allen and Sites (2012) wrote that leaving evaluation toward the end of the process is problematic and that continual evaluation is necessary to identify issues and address them as early as possible within the development of the project.

Allen and Sites (2012) criticism of the ADDIE process is inaccurate, as they have failed to address that formative evaluation is present at every phase of an ISD model, such as ADDIE. In direct contradiction of Allen and Sites (2012), the current ADDIE process has been modified to allow for evaluation at each step of the process. According to Branch (2009), evaluation "initiates the ADDIE process, permeates the ADDIE process, and concludes the ADDIE process" (p. 153). Formative evaluation occurs in each of the first four phases. Summative evaluation occurs in the final phase. By allowing for opportunities to evaluate the process and the product from the onset of the ADDIE process, IDs and SMEs can identify and address potential issues before moving on to the next phase.

Instructional systems design models are performed in an iterative and cyclic fashion, not in a linear manner; however, the ADDIE process has typically been graphically represented in linear order, as illustrated in Figure 4. This linear graphic representation of the ADDIE model has resulted in inaccurate criticisms that the process is not representative of how IDs actually work (Bichelmeyer, 2004).

Instead, the current ADDIE process is represented as a circular process ahs shown in Figure 5. Although the original ADDIE process has been described as linear and systematic, the current model has developed into a more dynamic process that allows for changing variables based on the type of learning (e.g., in a classroom, via distance learning, online), and has become a more dynamic model, which can be applied with other instructional design models (van Merriënboer, 1997).

Figure 5. Current ADDIE Process Workflow. From "File:Addie.png," by Braunschweig (2014). This file is licensed under the Creative Commons Attribution-Share Alike 3.0 Unported license.

One such modification is the application of the Agile development model to ADDIE, resulting in the Agile ADDIE ISD methodology used by the Veteran's Affairs Acquisition Academy to develop instructor led virtual courses ("The Cutting Edge," 2012). Agile development is prevalent in software development organizations. Agile development models have iterations instead of phases, where small teams work with stakeholders to develop prototypes, generate and test the software code, and have users validate the code within one program cycle ("Introduction to Agile Software Development," 2007).

ADDIE allows for this flexibility because although it is generally referred to as a model, Branch (2009) indicated that ADDIE is not a model; it is an "umbrella term that refers to a family of models that share a common underlying structure" (p. 5). This flexibility allows IDs to make modifications to the ADDIE process depending on the learning environment or complexity of the training skills.

Rapid Prototyping

A more recent modification to the ADDIE process has been the incorporation of rapid prototyping into the process. Rapid prototyping allows IDs to deliver a working prototype of the product at the initial phases of the ADDIE process, not at the end. There are two principles that drive rapid prototyping: the "What You See is What You Get" (WYSIWYG) output and the process of interaction design/usability (Desrosier, 2011). The WYSIWIG principle has its history in the first software programs that used graphical user interfaces (GUIs) to allow users to interact with their computer systems (Foley, 1996). Prior to GUIs, users had to rely on command prompts and keystrokes. The WYSIWIG principle provides that users are interacting with a computer system through a graphical interface where graphics and on-screen text are representative of the actions the user can take with the software. Interaction design and usability are user-centered approaches to develop solutions where the user experience, not technical needs, drives the design and development of the application (Rogers, Sharp, & Preece, 2011).

Traditional application of an ISD model provides for the use of storyboards to allow the ID and SME to view the layout, interactions/animations, narration, and sequence of a module before beginning development. Within instructional design, storyboarding is the process where the learning module is designed using software, such as Microsoft Word or PowerPoint, to create a one-dimensional view of the lesson. The ID and SME progress through the ADDIE phases as they build out the lesson via the storyboard. Storyboarding is not unique to ADDIE and is used used across industries and with a variety of ISD models. Once the stakeholders agree upon the final design and sequence, the ID begins development of the lesson. Some of the criticisms of ISD models, including the ADDIE process, are that ISD models are inflexible, linear, and difficult to apply when developing multimedia product (Gros et al., 1997). This traditional application of the ADDIE process, without rapid prototyping, also ignores the user experience goals for the project by beginning the development of a usable product toward the middle of the ADDIE process, not at the onset.

Unlike using a static, one-dimensional document to develop the product prototype, rapid prototyping begins the ISD process with a usable, interactive product that looks and feels like the expected project deliverable (Desrosier, 2011). Rapid prototyping directly addresses the criticism levied against the ISD process by allowing for the early identification of technical or design issues within a working product. Rapid prototyping runs in parallel to the ADDIE process allowing for the ID and the SME to work iteratively on the product, identify issues of content and usability, address those issues, and continue along the ADDIE phases.

Evaluation

Another important element when applying the ADDIE process to course development is evaluation which begins with the first phase and continues throughout the process to the final phase (Boulet, 2009). There are two types of evaluation that can be conducted during the ADDIE process: formative and summative. Formative evaluation is used to collect information for program improvement (Fitzpatrick, Worthen, & Sanders, 2004) and to improve instruction (Glover & Ronning, 1987). The purpose of formative evaluation is to collect data that can be used to revise the product before the implementation phase (Branch, 2009). Summative evaluation is conducted after the implementation phase and serves to assist decision makers in making judgments about program adoption, continuation, or expansion (Fitzpatrick et al., 2004). Within the ADDIE process, summative evaluation occurs during the evaluation phase.

Formative Evaluation

According to Glover and Ronning (1987), formative evaluation is comprised of three phases. In the first phase, the ID conducts one-on-one sessions with a small set of students for identifying problematic areas. In the second phase, the ID makes the revisions identified in the previous phase, and the instructional material is tested with a larger group of students. In the third phase, the ID makes revisions based on the data collected, and then conducts a final field trail and final revisions based on the results of the field trial. Branch (2009) refers to these phases of formative evaluation as the one-to-one trial, small group trial, and field trial.

The goal of the One-to-One Trial is to identify glaring errors in the learning content, supplemental materials, and to obtain initial reactions and perceptions from the stakeholders (Branch, 2009). In these sessions, the ID sits with one stakeholder and gathers feedback as they review the materials. The data collected in this trial is used to revise the learning materials before conducting a small group trial. The purpose of the small group trial is to evaluate the effectiveness of the revised instruction in its final form (Branch, 2009). Evaluation tools in this phase include pre and posttests, interviews, and questionnaires (Branch, 2009). The ID uses the data collected to revise the learning materials before conducting the field trial. The purpose of the field trial is to identify if the learning materials are ready to progress into the Implementation phase.

Field trials are divided into a non-credit field test and a credit-bearing field test (Branch, 2009). The non-credit field test is administered before the learning materials have been certified that the participants can meet the learning objectives. The credit-bearing field test is the final step of the development phase and is conducted once the materials have been certified as allowing for students to meet the learning objectives (Branch, 2009).

During the development phase, a pilot test is conducted. This is an example of a formative evaluation (Branch, 2009). Within the field of social science, a pilot study is conducted before a large scale implementation of a study in order to assess the feasibility of a full-scale study, identify logistical problems, and collect preliminary (van Teijlingen & Hundley, 2001).Within software development, a pilot test is conducted with a small group of stakeholders in order to identify technical issues or usability issues in the product. The data collected and issues identified during the pilot study are used to revise the product before it is released.

Summative Evaluation

The goal of the evaluation phase is to measure the quality of the learning module and evaluate the ADDIE process (Branch, 2009). Several processes are conducted during the evaluation phase. The ID working alone or in conjunction with the SME determines the evaluation criteria, selects the evaluation tools, and conducts the evaluations (Branch, 2009).

Kirkpatrick's levels of evaluation have been influential in the field of instructional design (Branch, 2009). Kirkpatrick's levels of evaluations are comprised of four levels: reactions, learning, behaviors, and results (Mowry & Crump, 2013). Level one, reactions, measures how well students liked or valued the learning program (Mowry & Crump, 2013). The ID addressed level one by using a survey that was administered at the conclusion of each module to measure student reactions. Level two, learning, measures the degree to which students understood and retained the concepts in the learning program. Students completed a pre-test at the start of each module and then a posttest at completion to measure the effect of learning. Level three, behavior, refers to the evaluation of behavioral changes that occur as a result of the learning (Mowry & Crump, 2013), or measures of capability improvement (Branch, 2009). This level is seeking to identify if students have changed their on-the-job behaviors (R. V. Reiser & Dempsey, 2012). Changes to on-the-job behaviors are measured by conducting longitudinal studies and assessing behavior in the months after the education program has taken place. The measurement of this level was outside the scope of this study, because this would call for an assessment of long-term retention of information that would require assessment and observation of student behaviors, which is not feasible. Level four, results, measures the impact of learning on organizational criteria (Mowry & Crump, 2013); it is one way to measure return on investment of the learning program. It is important to assess if the learning program was worth the cost of implementation and if the organization sees value in continuing with the implementation of the learning program (Pearlstein, 2008).

Kirkpatrick's Levels of Evaluation is a program assessment method that has been applied in papers and studies of ISD. Battles (2006) posited that the role of evaluation in an instructional program is also to evaluate the program, not only the student. Kirkpatrick's four levels of evaluation assess both. Battles (2006) reviewed the ADDIE process for the development of an e-learning module to improve patient safety and provided a discussion incorporating Kirkpatrick's four levels of evaluation within the evaluation phase. Chan and Robbins (2006) discussed the process for using ADDIE to develop e-learning material in psychiatric education in a study that also used Kirkpatrick's four levels for the Evaluation phase. Neither study discussed the results of the research.

Daugherty, Teng, and Cornachione (2007) asked participants to complete a survey, which had been developed based on Kirkpatrick's first level of evaluation: reaction. The first level in Kirkpatrick's evaluation model measures learners' attitudes and reactions to the learning experience (R. V. Reiser & Dempsey, 2012). It is important that the data that is collected in this level be comprehensive to include reactions to various program components, such as the instructor, content, topics, learning activities, facilities, and how engaged learners felt with the material (R. V. Reiser & Dempsey, 2012). The survey conducted by Daugherty et al. (2007) followed this recommendation as it measured four evaluation areas: content, methods of instruction, materials, and facilities and other resources.

Mowry and Crump (2013) used Kirkpatrick's four levels to develop competency tools to measure the effectiveness of immersion scenarios for Registered Nurses (RNs) in a mental health clinical practice. They developed immersion scenarios using the ADDIE process. The study measured Level one, reaction, through a qualitative survey provided to learners after each scenario that would measure their emotional reaction to the experience, patient care assessments and interventions, teamwork, and communication. Level two, learning, was measured by using quantitative competency grids. Preceptors observed the RNs as they completed the competency grid. The preceptors then assigned them a score. The preceptors also completed a competency checklist the results of which were used to assess transfer. This addressed level three of Kirkpatrick's four levels of evaluation. There was no discussion on Level four, results.

Usability Study

Another method of collecting evaluative data is by conducting a usability study. When developing web-based training or applications for online learning, a usability study should be conducted as part of the pilot study. The primary goal of a usability study is to identify problems within a specific tool (Dumas, Molich, & Jeffries, 2004). There are two types of usability studies: formative and summative. The purpose of the usability study conducted during the development phase of ADDIE is to collect data from the administration and use the results to revise the product before the implementation phase (Branch, 2009), making this a formative usability study. A summative usability study is conducted when the user interface is complete (Ovchin et al., 2009).

When applying ADDIE in conjunction with rapid prototyping, continuous analysis, and evaluation of the process and the prototype is necessary to identify and address process and usability issues that arise before the project reaches the implementation phase. At this phase, usability issues can cause delays in the project as seemingly minor issues can affect the design, functionality, or usability in other areas of the product. By implementing formative evaluation opportunities throughout each phase of the ADDIE process, the ID and SME continuously evaluate an unfinished interface thereby identifying and address usability issues early in the process (Ovchin et al., 2009). The early review process that results from incorporating rapid prototyping into the ADDIE process results in a more effective process by allowing for the identification of software errors and client preferences (Boulet, 2009). This is the major strength of rapid prototyping. Incorporating rapid prototyping into the ADDIE process lessens the project time by identifying and addressing potential issues early in the process.

Active Learning in Medical Education

The concept of active learning is not new to medical education. In 1910, Abraham Flexner published a report, funded by the AMA and The Carnegie Foundation, that resulted in the standardization of medical education in the United States (Beck, 2004). In addition to standardizing the curriculum, the Flexner report also recommended that medical schools shift from a faculty-centered teaching approach to a student-centered approach, where students play an active role in their learning (Pascual, Chhem, Wang, & Vujnovic, 2011). It is only in recent years that medical schools began to embrace this recommendation of the Flexner Report and reevaluate their teaching methodologies. This shift toward active learning has led to the development of integrated medical learning systems. The teacher-centered approach is giving way to a more student-centered approach and to more adaptable and flexible methods of teaching and learning, including e-learning.

As more medical schools turn to e-learning, the selection of an instructional design framework to guide the design of an online learning environment is crucial. There are differences between the delivery of face-to-face and asynchronous courses that impact pedagogical decisions. A significant difference between the two methodologies is that online courses are delivered with all the course content developed at the start of the course where face-to-face courses allow faculty more flexibility to make curriculum changes based on the availability of immediate student feedback (Pittenger, Janke, & Bumgardner, 2009). This difference demands a thorough analysis of the instructional goals, content, and methods of assessment. This analysis can be facilitated through the application of the ADDIE process.

Another benefit to using an instructional design methodology is that it shifts the focus from teaching to learning, a change aligned with the shifting paradigm of medical education. For learning to take place, students must make connections between prior knowledge and new information. These connections must be made in such a way as to allow for easy retrieval when needed (R. C. Clark & Mayer, 2011). According to the constructivist view, these processes occur when students are actively engaged in the learning process, not when they are passively listening to a lecture. Without a proper instructional design methodology, medical schools are developing e-learning modules without considering the pedagogical issues that are specific to online learning, particularly those that encourage active learning in an online learning environment.

e-Learning in Medical Education

As a result of a paradigm shift to a student centered approach and with the growing popularity of computer-assisted learning, medical schools have begun to evaluate the role of e-learning to supplement the required curriculum. This is further emphasized by the shift in medical education toward competency-based curricula that places an emphasis on learning outcomes, not the teaching process (Ruiz, Mintzer, & Leipzig, 2006). The process toward competency-based curricula has been a slow one that medical schools have taken on at their own discretion. In 2013, the AAMC (Association of American Medical Colleges) began a three-year study to measure the feasibility of a competency-based medical education (Greenberg, 2013). If successful, the goal is that more medical education programs would adopt a competency-based track.

As e-learning becomes more popular in medical education, medical programs have also begun to look at other avenues of relaying information to students, such as through multimedia. Prior research has shown the benefits of multimedia materials in non-medical curriculum. Course materials that include multimedia elements appeal to a broad variety of learning styles and creates an inclusive and engaging curriculum (Sankey, Birch, & Gardiner, 2011). There are other significant benefits to providing students with multimedia learning materials such as the ability to control the pace of their learning and review or skip content based on their own needs (Miller, 2013). In addition to these benefits, studies show that student outcomes in an online course improved when students have access to multimedia learning content. Zhang (2005) found that students who had learner-content interaction with the multimedia course content achieved significantly better performance and higher levels of satisfaction than students in a traditional classroom setting. Within medical education, these results have also been supported. Romanov and Nevgi (2007) studied the effectiveness of multimedia learning content in a fully online medical informatics course. They found that students who accessed video clips also accessed the online course more often, participated more often in online discussions, and, subsequently, earned higher grades.

Recently, medical schools have begun to evaluate the role of e-learning in their medical programs. Oeffner et al. (2011) evaluated the role of partially interactive e-learning modules in a vertically integrated genetics curriculum. The e-learning modules developed in the Oeffner et al. (2011) study were offered to students on a voluntary basis. Throughout the four years of academic study, students could optionally access the any of the five modules, which were developed to supplement the traditional lecture-based teaching format employed at the institution. The modules were developed as a supplement to traditional learning courses using a blended learning methodology. Over the course of four years, 3300 students had access to modules on a voluntary basis. Students were not required to view them. The purpose of the study was to evaluate student acceptance of the learning modules. The study relied upon tracking of student views, time spent on the modules, and on a questionnaire completed by the students. An analysis of the results showed that 29%-34% of the students extensively used the learning modules and 56% of them gave the overall learning scenario a rating of good (Oeffner et al., 2011). The authors concluded that the results will enable course faculty to discuss more complex topics during lectures since the foundational learning topics can be learned outside of the classroom.

The use of multimedia content in hybrid courses is becoming increasingly popular in medical schools. Significant research has been conducted in the area of hybrid problem-based learning (hPBL). Problem-based learning (PBL) is a popular method of facilitation in medical schools. Problem-based learning (PBL) places students in a small group and uses case studies of patients diagnosed with symptomatic problems. Working in teams, students identify their knowledge gaps, clarify the learning objectives, then regroup to present their findings/solutions to the problem with the rest of the class (Smith, 2005). During the sessions, faculty act as facilitators, not imparters of knowledge. Traditional PBL courses have students reading course materials from textbooks and/or journal articles. The use of the hPBL methodology has provided students with relevant materials in multimedia format. Studies have shown high levels of student satisfaction with the design of hPBL courses where student access multimedia content prior to the class session (Stebbings, Bagheri, Perrie, Blyth, & McDonald, 2012; Woltering, Herrler, Spitzer, & Spreckelsen, 2009).

Within the discipline of radiology, the use of multimedia lessons to facilitate the teaching and learning of material has begun to gain interest. Radiology is an ideal area for multimedia learning because of its use of images and videos to identify pathologies in patients and with technological advances in medical imaging and increases in the quality of digital images, radiology has gained a renewed interest as a field of study (Pascual et al., 2011). Radiology also lends itself to a case-based format (Howlett et al., 2011) because the identification of pathology through medical imaging relies on the selection of appropriate tests through differential diagnosis.

Flipped Classroom Methodology

Although fully online undergraduate medical courses will not replace the lecture room, medical schools have begun to consider the flipped-classroom methodology as a way to augment the learning environment. This type of teaching methodology provides students with pre-recorded lecture materials prior to the start of class which students are expected to view prior to class. In-class time is dedicated to active learning activities such as problem-based learning, case studies, and team based projects (McLaughlin et al., 2014). Medical, nursing, and allied health programs are beginning to look at the benefits of the flipped classrooms as a means to changing the way they deliver curriculum to meet the demands of a changing student population.

One study looked at the outcomes of transforming a traditional, lecture based pharmaceutics course using the flipped-classroom methodology. The course director redesigned the course and replaced in-class lectures with pre-recorded lectures that were made available online and prior to the class sessions. In class time was used for active learning exercises (McLaughlin et al., 2014). Students were evaluated using audience response systems, open-ended questions, group activities, student presentations, and individual and group quizzes (McLaughlin et al., 2014). At the end of the course, students completed course evaluations. The results showed that the majority of students (91%) felt that the flipped-classroom methodology improved their learning. It also showed that a majority of students (93.1%) agreed or strongly agreed that the "teaching and learning methods using in the flipped classroom promoted understanding and application of key concepts" (McLaughlin et al., 2014, p. 240). The authors also compared student final exam grades of this course administration to the previous year's administration and found a statistically significant difference (p = .001) between the groups. The flipped classroom class averaged 165.34 and the previous year's class averaged 160.06 out of 200 points (McLaughlin et al., 2014).

Research Gap

A review of the literature showed a research gap in the area of teaching radiology to third-year medical students using a multimedia, interactive, e-learning module that follows a case-based design. Although studies have shown positive outcomes and student acceptance of supplemental e-learning modules, these researchers in these studies have not evaluated or identified an instructional design methodology for the development of e-learning materials in medical education.

Curriculum administrators and content experts in medical education have not researched the significance of identifying an instructional design model to guide the design of an interactive online learning module. Although medical schools are developing online modules, the majority of those who take on the ID roles are the SMEs, not education experts (Siribaddana, 2010). The result of not relying on educational experts to develop the modules can result in material that does not meet the intended objectives, are designed poorly, or do not incorporate learning principles specific to the way humans use computers to learn.

Previous studies on similar topics have only looked at student satisfaction (Romanov & Nevgi, 2007) and learner acceptance of the learning methodology (Oeffner et al., 2011). Other studies have looked at student satisfaction and outcomes of a blended PBL teaching methodology without evaluating the role of the multimedia learning module independently (Stebbings et al., 2012; Woltering et al., 2009). Howlett et al. (2011), for example, reviewed the experience of building and deploying multimedia learning content using a hybrid format for fifth year medical students. Howlett et al. (2011) only evaluated student satisfaction and utilization of the module. Student satisfaction was measured via an online student survey, and utilization was measured by a count of the "hits" each module recorded through the learning management system (LMS). The study did not discuss the role of ISD in the development of the modules.

Oeffner et al. (2011) provides no discussion on the development of the e-learning modules. The authors describe the modules as "partially interactive" without an explanation of what this term implies for the design or outcomes of the modules. No other description of the modules or the evaluation process behind the design and development of the modules is provided, except for a listing of the number of pages, tables, and media types included in each.

Sendra-Portero, Torales-Chaparro, Ruiz-Gómez, and Martínez-Morillo (2013) evaluated the role of virtual lectures in radiology education. In their study, they found that virtual lectures could replace conventional lectures without any detriment to the student by evaluating the results of a final oral exam between the students in the control group and those in the experimental group. Although the virtual lectures included images and text, and thus were multimedia, they did not include any interactivity with the images or text. Interactivity is an important element in multimedia design as it has been shown to maintain students' interest and provide a way for students to reinforce their learning (Ruiz et al., 2006). Allowing the student to make choices throughout the lesson also has shown to improve learning (R. C. Clark & Mayer, 2011). Increased levels of student participation can be achieved through interactivity, leading to higher levels of cognitive engagement and, thus, retention (D. Clark, 2002). The lack of interactivity is a major drawback to the Sendra-Portero et al. (2013) study. Additionally, the e-learning modules did not include any formative evaluation of the student as the course progressed.

Another major weakness in Sendra-Portero et al. (2013) was the lack of discussion on how the modules were developed and the instructional design methodology used (if any). Sendra-Portero et al. (2013) discussed the development of the modules from a functional perspective, and provided a limited description comprised of four steps: creating the PowerPoint files, recording voice narration, converting the presentations to Flash, and uploading to a Web server. The authors provided no discussion on how they selected the content, how they evaluated and selected the media elements, and made no mention of having the modules reviewed by experts, as is discussed earlier as part of the Implementation phase of the ADDIE process.

Mahnken, Baumann, Meister, Schmitt, and Fischer (2011) evaluated outcomes in a blended learning radiology courses that provided content through e-learning modules. The authors developed 10 multimedia, case-based e-learning modules that included interactive elements and formative assessments. The authors looked at the differences in outcomes after the application of self-determined (intrinsic motivation) or mandatory (extrinsic motivation) use in fourth year medical students. The study found that students in the extrinsic motivation group accessed the e-learning modules more often than the students in the intrinsic motivation group. One important finding is that both groups showed an improvement in knowledge (intrinsic group: 13.7%, extrinsic group: 15.4%) as compared to the control group that did not have access to the e-learning modules.

The gaps in Mahnken et al. (2011) are founded on the lack of discussion on the instructional design methodology used to develop the modules. A brief discussion of the development of the modules is provided; however, the authors do not provide any discussion on which framework, if any, was used in the development of the modules. Unlike the Sendra-Portero et al. (2013) study, Mahnken et al. (2011) did allow for a pilot-test by experts (two, board certified radiologists and six, fifth-year volunteer students). However, they did not discuss the process for incorporating the pilot testing feedback or for evaluating the effectiveness of the modules during their pilot testing. The study also failed to discuss summative evaluation and student perceptions of the modules.

Chorney and Lewis (2011) developed online multimedia modules following the guidelines provided by the Alliance of Medical Student Educators in Radiology (AMSER). The modules included common conditions, imaging management algorithms, and emergent findings that clinicians would face in the field. Chorney and Lewis (2011) developed the modules using a case-based approach where students are first introduced to a patient case. The cases included formative assessments throughout the lesson which were meant to encourage interactive learning and decision making (Chorney & Lewis, 2011). The cases were integrated vertically throughout the medical curriculum, and students accessed the cases throughout their third and fourth year clerkship rotations, not during a specific time during the radiology clerkship. The authors evaluated student satisfaction with the modules. Results of the study showed that students agreed or strongly agreed that the online cases made good use of their study time (83%), (73%), were appropriate for their level of training (86%), provided useful resources (73%), and expanded their knowledge and understanding of radiology (88%).

Although the study demonstrated positive student perceptions of the online learning modules, it did not evaluate the effectiveness of the modules on learning outcomes or motivation. It did not deliver the content in a hybrid format where students were able to interact with their peers, their instructor, and discuss the application of the e-learning content in a face-to-face format. Chorney and Lewis (2011) also did not discuss the framework for the development of the modules. They failed to identify best practices for the application of the AMSER guidelines using an instructional design framework.

The research attempted to fill the gap in the current literature by evaluating the role of an instructional system design process, ADDIE, in conjunction with rapid prototyping in effectively developing e-learning modules that increase student satisfaction and motivation in a third-year radiology clerkship when delivered using the flipped-classroom methodology. This literature review of similar studies in medical education has identified a research gap in this area.

Summary

This chapter provided the history and background of the development and transformation of the ADDIE process from a rigid, linear, 19 step model to an iterative and cyclical process. This chapter focused on the differences between the perceptions of the ADDIE process as prescriptive, and demonstrated how the application of the ADDIE process to course design provides for multiple opportunities for review, assessment, and improvement. This chapter also discussed the role of rapid prototyping in the ADDIE process and its potential to shorten the development time of course materials developed following the ADDIE process. By developing a working prototype during the second phase of ADDIE, design, rapid prototyping allowed for the early identification of usability, content, and design issues. Traditional instructional design approaches do not develop a working prototype until the development phase, resulting in usability and/or design issues that delay the completion of the project. This chapter also reviewed the role of evaluation, both formative and summative, in the ADDIE process. It addressed one major criticism of the ADDIE process: that it does not allow for evaluation until the final phase. The common belief is incorrect, as this chapter has demonstrated that evaluation occurs at every phase of the ADDIE process.

Within medical education, this chapter also covered the shift toward active learning in medical programs as more schools rely on PBL and hPBL teaching methodologies, also referred to as the flipped classroom methodology. This teaching method provides that students receive lecture material prior to the class session to allow for class time spent working in small groups. This shift toward active learning/flipped classroom has led to an interest in e-learning in medical education.

Although medical schools are now evaluating the role of e-learning in their curriculum, this chapter identified a research gap. A review of the literature identified the lack of research in the regarding the application of an instruction design process to the development of e-learning modules.

Chapter 3

Methodology

Current Radiology Clerkship Curriculum

The current radiology clerkship course provides students with electronic documents posted to the HWCOM Learning Management System, Canvas. The current online content is static and provided in Portable Document Format (PDF) format with hyperlinks to external resources. The PDF files refer students to external sites, which have resulted in significant redundancies in the content, and which is outside the control of the clerkship director. This hypertext design can result in student difficulty in deciphering what information is relevant to their studies. As a result of the design of the online modules, students in the HWCOM Radiology clerkship have expressed dissatisfaction with the hypertext design, the redundancy of the materials, and the lack of clarity on the role of external resources for meeting course and session objectives. In addition to electronic documents posted online, the course provides formative quizzes created with Adobe QuizMaker.

Approach

This study followed the ADDIE process in developing the e-learning modules for a third-year radiology clerkship. Branch (2009) posited that each phase of the ADDIE process includes a concept, a set of common procedures, and a deliverable. Branch (2009) identified the common procedure used as a guide for the development of the modules in this study. The following section provides an overview of each phase of the process that was used for the development of each of the four modules. Throughout this process, the researcher collaborated with the SME (the radiology clerkship director) to gather course content and design preferences.

Analyze

During this phase, the researcher worked with the SME to identify the instructional goals for each module. The SME had already developed the instructional goals for the course which were available in the course syllabus. The researcher verified that there were instructional goals identified for each module. This phase also required an analysis of the intended audience (Branch, 2009). One important element to identify about the audience is their level of previous knowledge on radiology. The ID obtained this information from the SME. This activity was IRB approved prior to the accessing of this data.

The researcher also identified the required resources and determined the delivery system for the learning modules. The delivery system used for hosting the learning modules was the learning management system used by the HWCOM, Canvas, by Instructure. The HWCOM rebranded Canvas to CanvasMed.

The deliverable for this phase, according to Branch (2009) is an analysis summary. The analysis summary was be submitted to the SME for approval before the researcher began the design phase. The analysis summary ensured that the researcher and SME shared the same vision for the project before moving forward.

Design

During the design phase, the ID and SME conduct a task analysis, develop performance objectives, and generate testing strategies (Branch, 2009). During the task analysis, the ID and SME clarify learning outcomes of instruction and arrange the learning components into an instructional sequence designed so students can construct the necessary knowledge to achieve the instructional goals identified in the analysis phase (Branch, 2009; Dousay & Logan, 2011). There are three types of tasks that can be identified during this phase: order tasks; motor tasks, and cognitive tasks (Branch, 2009). For this study, the task analysis was primarily comprised of cognitive tasks as students are evaluated on knowledge, not motor or procedural skills. The SME had previously determined the testing and assessment strategies since the course had been running for three years.

In this phase, the ID and SME compose performance objectives. According to Branch (2009), performance objectives are comprised of a condition, performance, and a criterion component. Developing performance objectives at this phase will aid in the selection of appropriate testing methods, content selection, media development, and developing appropriate instructional strategies (Branch, 2009). Testing strategies are also selected during the design phase.

The first working prototype is also developed during the design phase. The ID begins the development of the framework for the working prototype. The software used to develop the prototype was Articulate Storyline ®. Once the ID developed the module using Storyline ®, the ID published it as a Sharable Content Object Reference Model (SCORM) object, version 4, 2004. SCORM is a set of standards and specifications for web-based e-learning ("SCORM Explained," n.d.). CanvasMed is SCORM compatible allowing for the importing of SCORM objects to track student completion and grading on assessment items.

The prototype included the basic layout of the modules, the sequence of the introductory slides, standard design elements such as font, color palette, and the player design. Following the format suggested by Branch (2009) for module development, the prototype sequence provided for content presentation and exercise presentation was the template that the subsequent modules followed to provide consistency in the sequencing of the learning elements.

The deliverable for this phase was a design brief which included the list of performance objectives, test items, and testing strategy (Branch, 2009). The ID developed the design brief and received approval from the SME before continuing to the next phase of the process. The ID also provided the working prototype as part of the design brief to the SME for approval.

Develop

The development phase sees the development of the learning materials for the course, selection supplemental media, and development guidance for the student and teacher. The SME is the content expert; therefore, he provided the content for the modules. He had developed much of the content had been developed and was provided to students in PDF format. As part of this study, the ID evaluated the usefulness and appropriateness of the content based on the course and performance objectives identified in the previous phases. If the ID identified any gaps, the ID worked with the SME to develop additional material to fill those gaps. The ID also researched and selected supporting media.

Once the ID and SME agreed on the content and multimedia elements, a usability study was conducted with the learning module. Branch (2009) discussed three phases in this type of formative evaluation: one-to-one trial, small group trial, and field trial. Traditionally, the one-to-one field trial in the traditional ADDIE process would occur during the development phase. However, when rapid prototyping is used in conjunction with the ADDIE process, field trials are conducted during the design phase and during the development of the prototype as was the case for this study. The prototype development and formative evaluation tasks occur in parallel to the ADDIE process (Daugherty et al., 2007), allowing for an iterative process of formative revisions (Branch, 2009).

Prior to conducting the pilot study, the SME identified student volunteers to complete the modules. According to Branch (2009), the pilot study should be conducted with the same group of students for which the learning module was designed. Participants for the pilot study were identified by the SME and were comprised of two types of experts: those associated with the HWCOM (i.e., students who have completed radiology clerkship in previous terms and radiology faculty) and physicians currently practicing within the area of focus of a given module. The SME identified physicians who specialized in each of the areas covered in each of the four modules. At least one physician, in addition to the SME and the student-experts, reviewed the modules during this phase.

All the reviewers completed a survey to measure their perceptions of the usefulness of the module and to gather feedback on the functionality of the module. The survey allowed for open-ended comments. The data collected from this formative evaluation was used to revise the module before moving to the next step of the ADDIE process, implementation.

The deliverables for the implementation phase are all the learning resources for the module. The resources include the instructional strategies, supplemental media, a summary of significant revisions, and the results of the pilot test (Branch, 2009). The deliverables also include a completed e-learning module.

Implement

The implementation phase was a major milestone in the project. The ID only moved forward to this phase once the ID had completed making all the required changes to the learning module and the SME approved it moving forward. In the implementation phase, the ID prepares the learning environment, conducts summative evaluations, and prepares the SME and the students to complete the learning module (Branch, 2009).

The LMS used by the HWCOM is CanvasMed. Preparation of the system consisted of the following by the ID: created the course shell, built the modules following sequencing specified in the course syllabus, imported the learning modules, provided the course director access to the course, and enrolled the students. The ID also conducted an additional quality assurance task in preparation of the LMS. The final step in the implementation phase was publishing the radiology course and making it available to students. Once the course was published, the ID transferred management of the learning module and course in the LMS to the team who administer the learning environment at the medical school.

The deliverable for this phase is an implementation strategy, comprised of the instructor plan and the student plan. The instructor plan includes the selection of the instructor, schedule for instructor training, and the development of train the trainer materials. The instructor for the course had already been identified. The SME for this study was also the clerkship director and had facilitated this course for four years. According to Branch (2009), the student plan is comprised of four parts: identification, schedule, pre-course communication, and tracking (Branch, 2009). The students for this course were pre-selected since they were all enrolled in the medical school and were enrolled in the radiology clerkship. The schedule allows for the tracking of the total number of students who participate in the study, the number of students per rotation, meeting venues, and class lists (Branch, 2009). On the first day of the Radiology rotation, the SME explained the study to students, discussed the design of the course, the sequencing of learning modules, and any other pertinent information relating to the course (as specified by the SME). He then handed out the required IRB consent form for students to sign. Students who opted to participate signed and returned the form to the SME, who then submitted the names to the ID.

The LMS was used to collect statistical information on student completion of the modules, such as numerical scores on quizzes, completion/non-completion of the module, and final course grade. The collection and analysis of the data followed IRB policy.

At the conclusion of this phase, the implementation strategy was delivered to the SME. The SME approved the implementation strategy, and the project continued to the evaluation phase.

Evaluate

Kirkpatrick's levels of evaluation have been demonstrated to be effective in studies on the application of instructional systems design within medical education. The researcher in this study used Kirkpatrick's levels of evaluation as the assessment framework. Kirkpatrick's level one and level two were used during the assessment phase of the ADDIE process to develop the appropriate evaluation tools to measure the effectiveness of the learning modules on student satisfaction and usefulness. The researcher used Levels one and two for the study. Level three, behavior, was not assessed in this study as this was outside the scope of the study. Level four, results, was also not used in the study since level three data were necessary to measure level four outcomes (R. V. Reiser & Dempsey, 2012).

The deliverable for this phase was an evaluation plan which is comprised of a summary outlining the purpose, listing of the data collection tools, the schedule for conducting evaluation, the person responsible for conducting the evaluations, the summative evaluation criteria, and the evaluation tools that were used (Branch, 2009). Once the SME accepted the evaluation plan, the project was considered completed, and work on the ADDIE process ended. This process was repeated for all four modules.

Research Methodology and Design

Research design, as described by Creswell (2009), is the intersection of the researcher's philosophical worldview, the selected strategy of inquiry, and the research method. The intersection of these components guides the research design. Based on an analysis of the data that was going to be collected, a mixed-methods approach was selected as the preferred methodological choice.

Philosophical Worldview

Creswell (2009) states that a philosophical worldview greatly influences the selection of a research design and methodology. He provides that there are four worldviews: postpositivism, constructivism, advocacy/participatory, and pragmatism (Creswell, 2009). A researcher's worldview provides the framework for a research design and methodology and helps explain the selection of an approach (Creswell, 2009). The fundamental philosophy guiding this study is that of the pragmatic worldview. This view focuses on "actions, situations, and consequences rather than antecedents" (Creswell, 2009, p. 10). In doing so, the pragmatic worldview does not see the world in absolute terms resulting in a research methodology that seeks to use many approaches to collect and analyze data instead of subscribing to a single method (Creswell, 2009).

Strategy of Inquiry

The research design, or strategy of inquiry as referred to by Creswell (2009) followed a mixed methods strategy. A mixed method strategy is more than collecting and analyzing qualitative and quantitative data. Mixed methods research is defined as "the class of research where the researcher mixes or combines quantitative and qualitative research techniques, methods, approaches, concepts or language into a single study" (Johnson & Onwuegbuzie, 2004, p. 18). Mixed methods research utilizes both approaches in tandem to develop a deeper understanding of the phenomenon and research questions (Creswell, 2009). This complementary use of mixed methods allows a researcher to gather a more complete picture of a construct (Fitzpatrick et al., 2004).

The research questions in this paper required a mixed methods approach as two of the questions were answered through the collection and analysis of qualitative data while a third question calls for the collection and analysis of quantitative data. By using a mixed methods approach, a researcher is not limited to a single methodology which allows for the corroboration of data, a higher level of validity, and results in greater knowledge of the problem (Johnson & Onwuegbuzie, 2004).

Within the quantitative research strategy, survey research allows for the collection of numerical data on attitudes, perceptions, opinions, and trends (Creswell, 2009). Survey research design provides for two types of surveys: sample or census (Gay, Mills, & Airasian, 2012). A census survey is conducted on every member of a population whereas a sample survey is conducted on a subset of a population with the aim of inferring information about a population (Gay et al., 2012). Survey studies can be cross-sectional or longitudinal. Cross-sectional survey studies provide a snapshot view of participants' attitudes and perceptions at a given point in time, whereas longitudinal track participant attitudes over a period of time (Gay et al., 2012). One of the research questions of this paper is "What do students report about the ease of use and learning value of the modules?" The data for this question were collected by employing a cross-sectional survey to collect information from the course participants. At the conclusion of each online module, participants were given an electronic survey to complete. The survey is described in more detail in the instrumentation section below.

Qualitative research is conducted when there is a need to achieve a detailed understanding of a phenomenon (Gay et al., 2012). Within this research strategy, there are a variety of approaches such as narrative and phenomenological research, case study, ethnographic research, and grounded theory. A case study approach was used as this strategy of inquiry allows for the exploration of a program in depth using a variety of data collection procedures (Creswell, 2009). Case study research is a qualitative approach that focuses on a particular instance or situation (Savin-Baden & Major, 2012). To elaborate further on the research strategy, the research approach that was used in this paper was that of evaluative case study. Evaluation research is "the systematic process of collecting and analyzing data about the quality, effectiveness, merit, or value of programs, products, or practices" (Gay et al., 2012, p. 17). The collection, analysis, and reporting of this data are used by administrators to evaluate the continued use of a program or curriculum.

This study sought to evaluate the effectiveness of applying an instructional systems design to the development of an e-learning module in an undergraduate medical education course. The results allowed for the development of a framework for use when designing interactive, online learning modules. Evaluation research uses both formative and summative evaluations. The ADDIE process allows for the application of formative evaluations throughout each phase of the process. Formative evaluations were administered to the clinician-expert and student-expert groups during pilot testing to gather their perceptions on the ease of use and learning value of the modules. The data from these evaluations were immediately analyzed and the results incorporated into the modules prior to the implementation phase.

Qualitative research plays an important role in answering the research questions for evaluating processes and developing the instructional design framework for course development. The necessary data to answer those research questions were collected through open-ended survey questions and interviews with SME. The survey questions and interviews were conducted throughout each phase of the ADDIE process.

Research Methods

The three research questions guided the selection of the research methodology. A mixed methods approach was selected based on an analysis of the questions, the data required to investigate an answer, and the best methods for collecting the data. Mixed-methods research requires the considering the timing of the data collection, whether it is sequential or concurrent (Creswell, 2009). In sequential data collection, either qualitative or quantitative data are collected first. The results are analyzed and the second data collection method is used to gather more information in order to provide a more robust view of the problem (Creswell, 2009). Concurrent data collection specifies that the qualitative and quantitative data be collected at the same time. Qualitative and quantitative data were collected concurrently. Surveys and interviews took place concurrently, thereby providing for the collection of formative data throughout the ADDIE process and summative data at the end.

Data Collection

There were various opportunities for data collection. The data collection process began with the first phase of the ADDIE process and continued until the final phase. After each module was developed, the ID conducted a one-on-one session with the SME to identify problems in the module. The ID conducted this session to identify substantial issues in the content and address them before the small group trial in which the modules were evaluated in their final form (Branch, 2009). Qualitative and quantitative data were collected during the small group trial in the form of questionnaires and open-ended questions. Questionnaires were in the form of an electronic, anonymous survey provided to the small group trial participants at the conclusion of each module. The questionnaire also contained open-ended questions, allowing the participants to include additional comments not prompted by a question. The data gathered through these evaluations allowed the ID to collect qualitative feedback on the attitudes and perceptions of the usefulness of the modules for student learning.

During the evaluation phase, quantitative data were collected from students after the completion of each online module through an anonymous, online survey. The results of the survey were used to assess Kirkpatrick level one, reaction. This survey measured student attitudes, perceptions, and beliefs about the effectiveness and usefulness of the online learning modules. To assess level two, learning, students completed a pre-test and posttest for each module. The data from the results were analyzed to measure learning gain.

Analysis of the data provided an understanding of the relationship between the ADDIE process and the development of online learning modules for a medical course. Some questions required an analysis of qualitative data while others required an analysis and synthesis of both qualitative and quantitative data.

Question 1 "How can the ADDIE process be used in the development of e-learning modules for a third-year radiology clerkship?" required both qualitative and quantitative data. An analysis of the process, issues, and outcomes of each phase of the ADDIE process was necessary. This included an analysis of the quantitative and qualitative data from the Internet Evaluation and Usability Questionnaire IEUQ surveys administered during the Development phase and during the Evaluation phase. Statistical analysis was also conducted on the pre and posttests administered during the Evaluation phase. A fundamental requirement to answer this question was an overall analysis of the process of each phase of ADDIE.

Question 2 "What do students report about the ease of use and learning value of the modules?" was answered through an analysis of the results of the end-of-module student surveys, and through the data collected from the surveys of expert-student reviewers. These surveys provided quantifiable data from Likert-style questions and provided qualitative data through open-ended questions.

Question 3 “Based on an analysis of implementation and necessary revision, what is the framework that is recommended for course development?” required an analysis of the ADDIE process with specific emphasis on issues that arose during the implementation and evaluation phases. A result of this analysis provided a framework that can be used when developing online learning modules in other medical courses.

Instrument Development

One survey was administered to participants to gauge their experiences and perceptions on the usability and utility of the modules. All participants completed the Internet Evaluation and Usability Questionnaire (IEUQ) developed by Ritterband et al. (2008). Participants completed the IEUQ at the end of each module. Several studies have used the IEUQ to assess the utility of Internet interventions of medical issues. The survey is comprised of a generic group of questions that can be used to evaluate various types of internet interventions. This section is comprised of 15 questions that measure ease of use, convenience, engagement, enjoyment, layout, privacy, satisfaction, and acceptability, usefulness, comprehension, credibility, likelihood of returning, mode of delivery, and helpfulness ("Internet Evaluation and Utility Questionnaire," 2009). The two items that measure participants’ perception of helpfulness are measured through open-ended questions.

The expert participant group (expert-clinician and expert-student) completed a modified version of the IEUQ. The changes made were to the terminology and question phrasing. One question was also added. The term “web program” is used in the IEUQ.

This term was changed to "online lesson" because it more closely aligned with the deliverable. One question was added: "How well do you think this online lesson will meet students' needs?"

Changes to the question phrasing were made in order measure the expert reviewers' opinions on the usefulness of the modules for medical students and their perception of how easy it was for medical students to understand the content. These modifications were made because the content was at an elementary level for experts; however, it was important to gather their perceptions on the adequacy of the content for medical students. Table 1 illustrates the changes made to each question.

Table 1

IEUQ Survey Item Wording Modifications

Question Number	Original Wording	Modified Wording
9	How useful did you find the information in the web program?	How useful do you think students will find the web program?
10	How easy was the information to understand?	How easy do you think it will be for students to understand the information?
13	How good of a method was the Internet for delivering this intervention?	How useful do you think an online module is for delivering this content to students?

Additionally, questions that did not apply to this population were removed from the survey. The following questions were removed in the modified IEUQ survey administered to the expert participant group:

- Question 2: How convenient was the web program to use?

- Question 6: How worried were you about your privacy in using this web program?
- Question 8: How good of a fit was the web program for you?
- Question 11: How much did you feel you could trust the information?
- Question 12: If difficulties continue or return, how likely would you be to come back to this web program?

The IEUQ includes two open-ended questions that were included in the survey given to this population. An additional statement "Please provide any additional comments for improvement" was added. The aim of this question was to collect information from the practicing clinicians to improve the understanding and delivery of the content for students.

The IEUQ was also modified for the medical student group. As in the expert group version, one open-ended question was added: "Please provide any additional comments for improvement." The wording in three questions was changed, as well. Changes to question wording were made so that the questions measured the needed constructs and so that the questions aligned with the format of the deliverable. Table 2 illustrates the changes made to the IEUQ version for the medical students.

Table 2

IEUQ Survey Item Wording Modifications for Medical Students

Question Number	Original Wording	Modified Wording
8	How good of a fit was the web program for you?	How well did this online lesson meet your needs?
12	If difficulties continue or return, how likely would you be to come back to this web program?	How likely are you to come back to this online module to review content after completing this clerkship rotation?
13	How good of a method was the Internet for delivering this intervention?	How useful do you think an online module is for delivering this content to students?

According to Kirkpatrick and Kirkpatrick (2007), the survey to measure level one reaction should contain between eight and 15 items. Kirkpatrick and Kirkpatrick (2007) also, recommended ending a survey with a section for open-comments with a prompt asking for suggestions for improvement. According to Kirkpatrick and Kirkpatrick (2007), there are four areas, which must be measured in the level one reaction form: the course, content, instructor, and job relevancy. Instructor evaluation was not included in the survey as this area was outside the scope of this paper. Although Kirkpatrick's Levels of Evaluation were designed for training, they can be used to evaluate courses conducted in an educational setting (Praslova, 2010). Within Level one reaction, two constructs were measured: affective reactions (how much students enjoyed the learning modules) and utility judgments (how much students believed they learned) (Praslova (2010). An additional construct asked students how much they felt that what they learned in the modules would help them during their clerkship rotation (e.g., on-the-job).

Level two was measured through an analysis of the pre- and posttests that were administered to students for each module. Questions for the pre- and posttests were created using Radiology ExamWeb (REW), a national web-based examination system specially developed for use in Radiology programs in medical schools (P. J. Lewis, Chen, Lin, & McNulty, 2012). The SME selected questions based on predetermined categories: system, modality, organ, and etiology. When selecting questions using REW, the SME was provided with a pool of questions from which he selected the individual questions for the quizzes. Some questions included images and some were only text. Questions were selected based on whether the topic met course objectives. Quizzes were not timed and were administered in class and proctored by the SME.

Instrument Validity

In a mixed methods study, validity and reliability need to be addressed for both the quantitative instruments and qualitative instruments. Quantitative data were collected from the pre- and posttests administered before and after each module. Quantitative data was also collected through the IEUQ.

Questions for the pre- and posttest were developed using REW and were correlated with AMSER National Medical Student Curriculum AMSER Standardized Examination curriculum (P. J. Lewis et al., 2012). In 2011, the questions in the REW database went through an extensive validation process. For items that were deployed over 30 times (n = 475), the authors obtained the number of times the item was deployed, the number of times it was correctly or incorrectly answered, and the breakdown of the distractors for each item (6,7) (P. J. Lewis et al., 2012). Items with a level of $p < .65$ (n = 173) or $rbi < 0.2$ (n = 49) were edited to improve psychometric performance (P. J. Lewis et al., 2012). Items were also edited to improve poor distractors, change confusing images, and make question stems clearer (P. J. Lewis et al., 2012). This revision process will occur every year.

The IEUQ has been administered in various studies on medical Internet interventions, such as skin care (Hilgart et al., 2014), insomnia (Thorndike et al., 2008), cancer patients with insomnia (Ritterband et al., 2012), and pediatric encopresis (Ritterband et al., 2008). When evaluating the effectiveness of an Internet intervention, it is important to use an instrument that has established reliability to ensure the consistency of the results and that the instrument consistently measures what it seeks to measure (Gay et al., 2012). Reliability is expressed as a reliability coefficient, where a coefficient of 1.00 demonstrates high reliability, minimum error, and is perfectly reliable. The IEUQ indicated good internal reliability ($\alpha = .69$) in a pediatric encopresis study (Ritterband et al., 2008). Although the IEUQ has demonstrated good internal reliability, the results of the IEUQ were analyzed for reliability during the data analysis phase.

In qualitative research, validity is measured by the degree to which the qualitative data accurately reflects what the research is seeking to measure and are described by the trustworthiness and understanding of a study (Gay et al., 2012). The concept of trustworthiness in qualitative research has been questioned as it is not as easy to quantify as in quantitative studies (Shenton, 2004). In order to evaluate the trustworthiness of qualitative research conducted in naturalistic settings, Guba (1981) developed four constructs: credibility (replaces internal validity), transferability (replaces external validity/generalizability), dependability (replaces reliability), and confirmability (replaces objectivity).

In order to address the issues of credibility, transferability, dependability, and confirmability in a qualitative study, Guba (1981) has identified steps a researcher can take during and after a study. In this paper, the threat to credibility was addressed using peer debriefing, triangulation, and prolonged engagement. In peer debriefing, researchers are constantly checking their knowledge and thought processes against their peers, such as a dissertation committee or colleagues (Guba, 1981). In doing so, others may draw attention to flaws and may expand the vision of the researcher through shared experiences with more experienced peers (Shenton, 2004). This study allowed for many opportunities for peer debriefing through discussions with the SME and other faculty members, in addition to the dissertation committee members. Triangulation provides for the collection of data collected from different sources or using different methodologies to allow for the crosschecking of data. Data collection can include questionnaires, interviews, or focus groups (Guba, 1981; Shenton, 2004). There are several benefits to triangulation, most significantly that it limits the possibility of researcher bias that can result due to reliance on data collected using one method (Cohen, Manion, & Morrison, 2003).

Questionnaires, interviews, and qualitative data were used to address the threat to validity and reliability of the study's findings. According to Guba (1981), prolonged engagement at a site allows the researcher to become known to participants and adjust to the participants' presence. By developing a familiarity with the organization and its culture, a researcher can establish trust with the participants and gain a deeper understanding of the environment (Shenton, 2004). Prolonged engagement was established for this study because the researcher has spent eight years working in the environment where the study took place and had developed an understanding of the organization. Even though prolonged engagement had been established, there was no familiar relationship between the researcher and study participants (students) because there was no significant interaction. The absence of a relationship between the researcher and study participants addressed concerns that the researcher would become overinvolved with participants leading to bias in data interpretation.

Within a qualitative study, transferability refers to external validity in a quantitative study (Guba, 1981). In a quantitative study, external validity provides that the results of the study can be applied to a broader environment. Qualitative research, however, is focused on context specific results, where generalizing to a broader population is unlikely (Shenton, 2004). Qualitative research places emphasis on context, so the sampling methodology should be purposeful and representative of a specific environment (Guba, 1981). This type of sampling is not intended to allow for generalizing of the results but provides for maximizing the range of information extracted from the participants (Guba, 1981). Shenton (2004) contradicts this and calls for random sampling instead, arguing that this sampling methodology can negate charges of bias on the part of the researcher in selecting participants. Although random or purposeful sampling is indicated for qualitative research, convenience sampling was used in this paper for reasons explained below.

Threats to transferability can also be addressed by collecting "thick" descriptive data and by developing thick descriptions (Guba, 1981, p. 86). In a qualitative study, a researcher cannot make inferences about the transferability of his or her study to another population; only the reader of the study can make that inference (Shenton, 2004). The onus is on the researcher to collect and provide as much contextually driven information and descriptive data so as to allow a reader the necessary contextual information to derive an opinion about the transferability of the study to their environment (Guba, 1981). Significant contextual information was collected and reported, such as student demographics and student background knowledge of radiology, while focusing on the specific context in which it was conducted. The researcher did not intend to make inferences about the transferability of the results to other medical schools.

In quantitative research, data needs to be reliable, meaning that a different researcher can conduct the same study using the same methods and tools and yield similar results (Shenton, 2004). Because context is such an important factor in qualitative research, this construct is difficult to measure and has been rejected within the discipline of qualitative research. Instead, Guba (1981) argues for the construct of dependability in a qualitative study which requires a researcher to use complementary methods to collect data simultaneously. This allows for a type of triangulation of data resulting in greater stability of the data when the multiple methods indicate the same results (Guba, 1981). Multiple methods of data collection were used in this paper: interviews, surveys, and through quantitative data analysis. Additionally, Shenton (2004) writes that it is critical that the processes in a study be reported in detail to allow future researchers the opportunity to conduct a similar study with the aim of obtaining comparable results.

Confirmability in qualitative research is comparable to researcher objectivity in a quantitative study (Shenton, 2004). In qualitative research, this construct ensures that the results of a study are based on the data collected, not on characteristics or preferences of the researcher (Shenton, 2004). Triangulation addresses the threat to confirmability by providing data from multiple sources thereby minimizing researcher bias (Cohen et al., 2003; Guba, 1981). To address threats to confirmability, across methods triangulation was used to analyze quantitative data collected from the pre- and posttests, IEUQ surveys, and qualitative data from open-ended questions and interviews. Across methods triangulation uses quantitative and qualitative data collection techniques concurrently (Bekhet & Zauszniewski, 2012). By collecting, analyzing, and triangulating data collected by various methods, the threat to confirmability was appropriately addressed.

Sample Populations

There were three sample populations. The first population was the clinician-experts. This group was comprised of physicians who practice in a specialized area of radiology and who have active practices. These participants were recruited with assistance from the SME and were identified based on their area of expertise within radiology.

The second population was the student-expert participants. This group was comprised of students who had completed the Radiology clerkship before the study. These students were identified by the SME.

The third population was the medical student group. This participant group was selected based on students who are enrolled in the radiology clerkship course during the time the study was running (April 2015 through December 2015). According to Gay et al. (2012), this type of sampling is convenience sampling. This sampling method has a major advantage in that it is simple because participants are selected on availability. Gay et al. (2012) wrote that a disadvantage of this sampling type is that it may be difficult to describe the population sample and making generalization of the results difficult. However, the population sample comprised all students enrolled at the HWCOM.

It was expected that 30 students would cycle through the radiology clerkship during this period. As the data collection ran through December 2015, 77 students cycled through the clerkship, and 46 agreed to participate in the study.

Data Analysis

The research questions were answered through quantitative and qualitative data analysis. Quantitative data gathered from the pre- and posttests in each module were analyzed using SPSS to show the mean, standard deviation, and range of scores. Learning gain was measured through an analysis of the pre- and posttest results. This is a common method of measuring learning gain, referred to as gain score, and is calculated via the difference between the posttest score and the pretest score (Sukin, 2010).

A dependent sample *t*-test was used to determine if the changes between the mean scores of pre and posttest were significant. The goal was to identify if any significant learning gains occurred after the administration of each learning module. Learning gains were measured at the individual module level to identify if certain modules produced a higher learning gain than others. Learning gain was also measured across the four modules to identify if a significant difference occurred between the group pre- and posttest mean. Learning gains across modules were compared to identify which module resulted in greater learning gains.

Quantitative data were also gathered through the IEUQ administered at the end of each module. The questions in the IEUQ were categorized into two constructs: satisfaction and usefulness. The researcher, in conjunction with the dissertation chair, analyzed the questions to identify these constructs. Once the constructs for the questions were identified, the mean of each construct was calculated. Table 3 illustrates the questions associated with each construct.

Table 3

IEUQ Question Constructs

Question	Construct
1. How easy was the online lesson to use?	Usefulness
2. How convenient was the online lesson to use?	Usefulness
3. How well did the online lesson keep your interest and attention?	Satisfaction
4. How well did you like the online lesson?	Satisfaction
5. How well did you like the way the online lesson looked?	Satisfaction
6. How satisfied were you with the online lesson?	Satisfaction
7. How well did this online lesson meet your needs?	Usefulness
8. How useful did you find the information in the online lesson?	Usefulness
9. How easy was the information to understand?	Usefulness
10. How much did you feel you could trust the information?	Usefulness
11. How likely are you to come back to this online module to review content after completing this clerkship rotation?	Usefulness
12. How useful did you feel an online lesson was to deliver this content?	Usefulness

Qualitative data were analyzed by identifying open codes and then axial codes within the participant qualitative responses. The researcher worked with the dissertation chair, who reviewed and agreed with the open and axial codes identified.

The data from the IEUQ were analyzed using SPSS to show mean, standard deviation, and range for each item. Data were evaluated by individual module to identify students' perceptions about distinct topics. An analysis was also conducted by calculating overall statistical data for the four modules. The aim was to identify if specific modules rated higher or lower for student perception of ease of use and learning value. The results of this analysis were used to answer the second research question.

The quantitative data from the pre- and posttest, the quantitative data from the end of module surveys, and the qualitative data from the open-ended questions allowed for the triangulation of the results.

Qualitative Data

The IEQU also collected qualitative data from open-ended questions. These data were analyzed to identify themes or codes that were consistent throughout the student responses. The aim was to identify common ideas among participants about their perceptions of the usefulness and learning value of the modules. The quantitative data from the pre- and posttest, the quantitative data from the end of module surveys, and the qualitative data from the open-ended questions allowed for the triangulation of the results.

Resource Requirements

There were hardware, software, and human resources needed. Hardware resources were limited to a computer with sufficient processing capacities to allow for the use of e-learning software and image editing software needed for this project. The researcher used Articulate Storyline to develop the modules and Adobe Photoshop to edit any images. An LMS was necessary, as the published files needed to be hosted for the research participants to access. CanvasMed was the LMS as it is the system used by the HWCOM.

Human resources were an important element of this project. A SME in radiology was needed and was identified. He was the Associate Dean for Clinical Medical

Education and clerkship director for the radiology program at FIU-HWCOM. Another important human resource was the two expert participant groups. Clinician-experts and student-experts were asked to volunteer their time, which no doubt impinged on their other responsibilities. The final set of human resources was the medical student group, who agreed to participate in the study and complete the quizzes and evaluations.

Summary

This chapter discussed the current radiology curriculum, including how the material in the modules was delivered to students and the resulting challenges for students and the SME. The previous design included links to external sites that may have contained information not relevant to the lecture and was outside the control of the course director/SME. This chapter explained the significance of this and how the module redesign would address these problems.

The five phases of ADDIE were also covered, including a discussion on how each phase was implemented. Each phase covered the significance of evaluation and the iterative process in order to allow for a continual process improvement workflow.

The research methodology and strategy of inquiry for this study was reviewed. Mixed methods was chosen based on an analysis of the data needed to answer the four research questions. On the surface, the questions appear to require only qualitative data; however, in order to apply level two, learning, in Kirkpatrick's levels of evaluation, learning gain must be measured. A discussion on the quantitative and qualitative data collection methods, instrument validation, and analysis was also provided. Instrument validity was discussed from the perspective of validating quantitative data and qualitative data. This chapter covered the pre- and posttest exam database, REW, and how the questions were extensively vetted and validated. Qualitative reliability and validation were also discussed using the constructs from Guba (1981) and the application of the constructs to the qualitative data collection methods and analysis were also examined. This chapter provided a review of the various sample populations in the study, which are comprised of medical students, student-experts, clicician-expert partinapants, and the SME. A discussion on how the qualitative and quantitative data were analyzed and triangulated was also presented.

Chapter 4

Results

Introduction

This study followed a mixed-methods approach and collected data through the phases of the ADDIE process (analyze, design, develop, implement, and evaluate). Quantitative data were collected through the pre and posttests administered using ExamWeb. Quantitative data were also collected through the IEUQ, which was administered three times to three groups of participants throughout the development and administration of the module. Qualitative data were collected through the open-ended questions in the IEUQ.

Study participants were divided into three groups. These were clinician-experts, student-experts, and medical students. Clinician-experts were specialists in the field of the module they reviewed. Student-experts were medical students at the HWCOM who had previously completed the Radiology clerkship and had expressed an interest in Radiology as a specialty. Medical students were currently enrolled in the Radiology clerkship and new to this material.

The first phase of testing was pilot testing and it was conducted during the Development phase of the ADDIE process. The SME identified and recruited the clinician-experts. This group was comprised of four participants, each reviewing one module in their area of specialty. The ID compiled the result of each review and presented them to the SME for consideration. The SME had the final decision on changes to module content.

Once the clinician-experts completed the pilot testing and the results reviewed by the SME, a second pilot test was conducted with the student-experts. The SME also identified and recruited this participant group. The number of student-experts who reviewed each module varied between four and six. The ID compiled the results of the participants' reviews and presented the results to the SME for consideration prior to the ID making edits and changes to the modules.

After the ID made the changes approved by the SME and all the modules had completed pilot testing, the project moved into the implementation phase and the modules were made available to students enrolled in the Radiology clerkship. The implementation phase of data collection for this study was conducted from April 1, 2015 to December 31, 2015. During this time, 77 students in the Radiology clerkship rotation cycled through the course; of these, 46 agreed to participate in the study.

As anticipated, low response rate was an issue. Medical students in their third year have competing priorities. It was expected that few students would agree to participate, as this study required the completion of a pre- and posttest for each module and completion of a survey. The SME elected to make the pre- and posttest mandatory for all students, including those not participating in the study. This improved the response rate for those activities. However, there was still a low response rate for the IEUQ. In order to increase the number of responses for the IEUQ, data collection was extended until December 2015.

This study sought to answer the questions:

Q1. How can the ADDIE process be used in the development of e-learning modules for a third-year radiology clerkship?

Q2. What do students report about the ease of use and learning value of the modules?

Q3. Based upon an analysis of implementation and necessary revision, what is the framework that is recommended for course development?

In order to answer these questions, it was necessary to conduct an analysis of the process, issues, and outcomes of each phase of the ADDIE process, as well as, qualitative data from the end of module survey, IEUQ. The data were triangulated in order to provide for validation of the data. A discussion on the process for triangulating the data is presented at the end of this chapter.

Quantitative Data Analysis

Quantitative data were analyzed using SPSS 20. After the IEUQ survey, questions were grouped by construct, as shown in Chapter 3; descriptive statistics were calculated for each construct. This provided data on the minimum, maximum, mean, and standard deviation for each construct. This analysis was run for the clinician-expert, student-expert, and medical student participant groups.

Statistical analysis was also conducted on the ExamWeb pre- and posttest results. A paired *t*-test was run using SPSS. An analysis of effect size using Cohen's *d* was also run for all modules. The results of these analyses are discussed as part of the evaluation phase section of each module.

Qualitative Data Analysis

The qualitative data were analyzed using a grounded-theory approach. This approach relies on the data to develop a hypothesis unlike other research methods that first establish a theoretical or philosophical position (Savin-Baden & Major, 2012). Grounded theory, then, requires the identification of concepts or themes from the data. This process of identifying common themes in the data is conducted by a process called constant comparisons (Corbin & Strauss, 2014). This process requires the researcher to break the data into chunks of information that are similarly grouped into conceptual headings (Corbin & Strauss, 2014). The conceptual headings are further refined into categories which become codes. There are two types of codes used in grounded-theory: open and axial codes. Open codes are the initial, broad, descriptive labels identified during the coding phase. These codes yield many concepts, themes, or ideas (Savin-Baden & Major, 2012). To identify codes, the researcher examines the data from a broad perspective, identifying the main ideas or general message (Corbin & Strauss, 2014). After the open codes are identified, the researcher reviews them and begins to categorize them into axial codes by grouping similarly coded concepts together (Savin-Baden & Major, 2012). The identification of open and axial codes is discussed in detail further in the development phase of the data section for each module.

Development Phase Data Collection

A pilot test was conducted during the development phase with the clinician-experts and student-experts. The SME recruited clinician-experts who were experts in the topic of the module. Student-experts were also recruited by the SME and were selected based on having completed the radiology clerkship during a previous rotation and having had expressed an interest in radiology as a specialty. Clinician experts reviewed the modules prior to the student-experts. The ID analyzed and presented the results of the IEUQ to the SME. The ID made the changes approved by the SME. The pilot test was then administered with the student-expert group, and the results of the pilot test IEUQ shared with the SME. This process was followed for all four modules.

One clinician expert reviewed each module. They received a modified IEUQ that was worded specifically for an expert viewing the module (Table 4). The Likert scale for the questions was on a 5-point scale: (0) not at all, (1) slightly, (2) somewhat, (3) mostly, (4) very, and an option for NA.

Table 4

IEUQ for Clinician and Student Experts

1.	How easy was the online lesson to use?
2.	How well did the online lesson keep your interest and attention?
3.	How well did you like the online lesson?
4.	How well did you like the way the online lesson looked?
5.	How satisfied were you with the online lesson?
6.	How well do you think this online lesson will meet students' needs?
7.	How useful do you think students will find the online lesson?
8.	How easy do you think it will be for students to understand the information?
9.	How useful do you think an online module is for delivering this content to students?
10.	What do you think students will find the most helpful part of the online lesson?
11.	What do you think students will find the least helpful part of the online lesson?
12.	Please provide any additional comments for improvement.

The clinician-experts and student-experts received identical IEUQ versions. The pilot-test IEUQ excluded three questions that were specifically aimed at the student population, resulting in a nine Likert item survey with three open-ended questions administered during the pilot tests.

The excluded questions were:

1) How convenient was the online lesson to use?
2) How well did you feel you could trust the information?
3) How likely are you to come back to this online module to review content after completing this clerkship rotation?

The student version, shown below in Table 5, contained twelve, 5-point Likert scale items, and three open-ended questions. The Likert scale used was “very,” “mostly,” “somewhat,” “slightly,” and “not at all.” There was also an option for “N/A.” “Very” was worth 4 points and “not at all” was worth 0 points.

Table 5

IEUQ for Medical Students

1. How easy was the online lesson to use?
2. How convenient was the online lesson to use?
3. How well did the online lesson keep your interest and attention?
4. How well did you like the online lesson?
5. How well did you like the way the online lesson looked?
6. How satisfied were you with the online lesson?
7. How well did this online lesson meet your needs?
8. How useful did you find the information in the online lesson?
9. How easy was the information to understand?
10. How well did you feel you could trust the information?
11. How likely are you to come back to this online module to review content after completing this clerkship rotation?
12. How useful did you feel an online lesson was to deliver this content?
13. What was the most helpful part of the online lesson?

14. What was the least helpful part of the online lesson?
15. Please provide any additional comments for improvement.

Although only one clinician-expert reviewed each module, useful data were collected. With the clinician-expert group, qualitative data proved the most useful as this data provided content focused feedback, much of which the SME elected to implement. The student-expert group had more participants: Introduction to Imaging *n* = 4, Ultrasound *n* = 4, Mammography *n*=7, and Nuclear Medicine *n*=6. This group also provided significant data in the open-ended survey questions.

This chapter is organized by module and follows the phases of the ADDIE process, starting with the pilot tests conducted in the development phase, then discusses the results of the implementation phase, and concludes with the results of the evaluation phase. The modules are discussed in the order students completed them in the course: Introduction to Imaging, Ultrasound, Mammography, and Nuclear Medicine.

Next, the results of the implementation phase are discussed followed by the results of the evaluation phase. This section is organized by module following the same order previously mentioned. The results of the quantitative portion of the IEUQ survey are presented, followed by a discussion of the open and axial codes identified through a qualitative analysis of the open-ended questions. The results of the analysis on the pre- and posttest data are presented last.

Development Phase – Pilot Test Results

Introduction to Imaging Module

A clinician-expert who was a expert in the field of imaging conducted the pilot test of this module. The results of the IEUQ completed by this participant showed that the clinician-expert rated this module highly. This participant rated usefulness with a mean of 3.75 and satisfaction with a mean of 3.60. The clinician-expert provided qualitative feedback for improvement within a specific content area "use soft tissue instead of fluid, use the liver for soft tissue." This feedback resulted in changes to the content after the ID presented the results of this survey to the SME. Figure 6 shows the slide where the change to the content was made. The original term used was "fluid." Based on the feedback, the SME agreed to change the term to "soft tissue" and change the highlighted area (in yellow) to indicate the liver. It was originally indicating an area of fluid in the radiographic image.

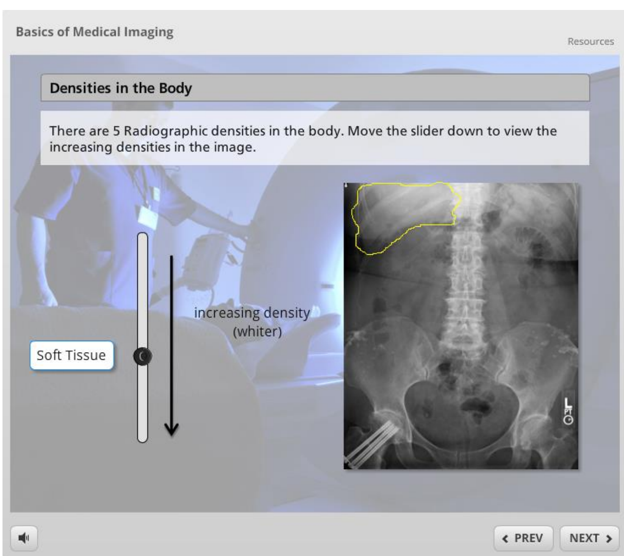


Figure 6. Change to Soft Tissue

This participant indicated that imaging is what students would find most useful, while least useful was the discussion on the costs of imaging tests. Figure 7 illustrates the slide in the module pertaining to costs. While the SME agreed that costs are not useful, he opted to keep this as he felt doctors today need to have costs in mind when ordering tests as this brings implications for health insurance and healthcare costs.

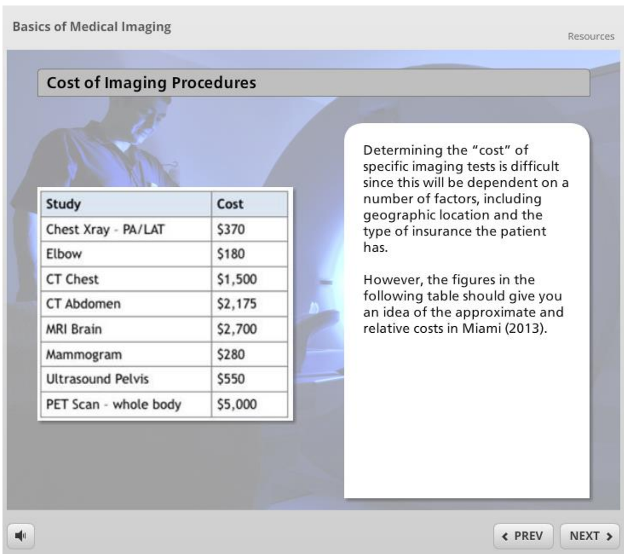


Figure 7. Cost of Imaging Procedures

The four student-experts also rated this module highly as shown in Table 6. Student-experts rated satisfaction higher than the clinician-expert did, with means of 3.80 to 3.60, respectively. Usefulness also rated higher, as well, with a mean of 3.8125. The clinician-expert mean for usefulness was 3.60. All four respondents (100%) indicated "very" to the measure on how well they liked the way the lesson looked and to the measure on how useful they felt the online module was for delivering the content to students. The remaining seven measures had the same mean of 3.75.

Table 6

Introduction to Imaging Student-Expert IEUQ Results

	N	Minimum	Maximum	Mean	*SD*
Satisfaction Mean	4	3.40	4.00	3.8000	.28284
Usefulness Mean	4	3.50	4.00	3.8125	.23936
Valid N (list wise)	4				

The qualitative data supported the quantitative results with the qualitative data being highly complimentary of this module. An analysis of the qualitative data resulted in 18 open codes and three axial codes. The open codes were identified by conducting an analysis of the qualitative responses for the IEUQ for this module. Open codes were identified by highlighting specific areas within the responses that frequently appeared. For example, the words "great, missing a period, next button not working, informative, content, and helpful" consistently appeared throughout the responses. After identifying the open codes, axial codes were identified by categorizing related concepts. This resulted in the open and axial codes shown in Table 7.

The process for categorizing open codes into axial codes was conducted by first grouping similar open codes and identifying an overarching axial code. Most open codes fell under the axial code of compliment with responses praising the content and design. The axial code of problem was further split into technical problems and editorial problems. The table below also indicates the number of times an open code was repeated in the qualitative responses.

Table 7

Introduction to Imaging Open and Axial Codes

Survey Question	Open Codes	Axial Codes
What do you think students will find the most helpful part of the online lesson?	• Practical information • Specific topics • General content • Fun • Informative • Helpful (frequency 3) • Focused • Good review • More material in this format • Suggestion	Compliment
What do you think students will find the least helpful part of the online lesson?	• Great (frequency 2) • Very helpful	Compliment
	• Issue with navigation	Problem (Usability)
Please provide any additional comments for improvement.	• Informative • Very organized	Compliment
	• More information needed Missing colon after term • Missing period at end of sentence	Problem (Editorial)
	• Next button doesn't work (frequency 3)	Problem (Usability)

- Compliment
  Participants were highly complimentary of the content and user interface. Participants indicated that the content "is detailed," and provided "practical information" that students "come across from the first day of their rotation." Participants also stated that the "minimal text with the pictures to go with the information was very helpful." The term "helpful" appeared three times supporting the high mean for usefulness in the quantitative data. Participants felt that the module was "great overall" and "good all around" supporting the high mean for satisfaction (3.93). The highly complimentary nature of the responses supports the high means for this module.

- Problem (Editorial)
  Editorial problems included comments such as "missing a period" at the end

certain phrases on various pages.

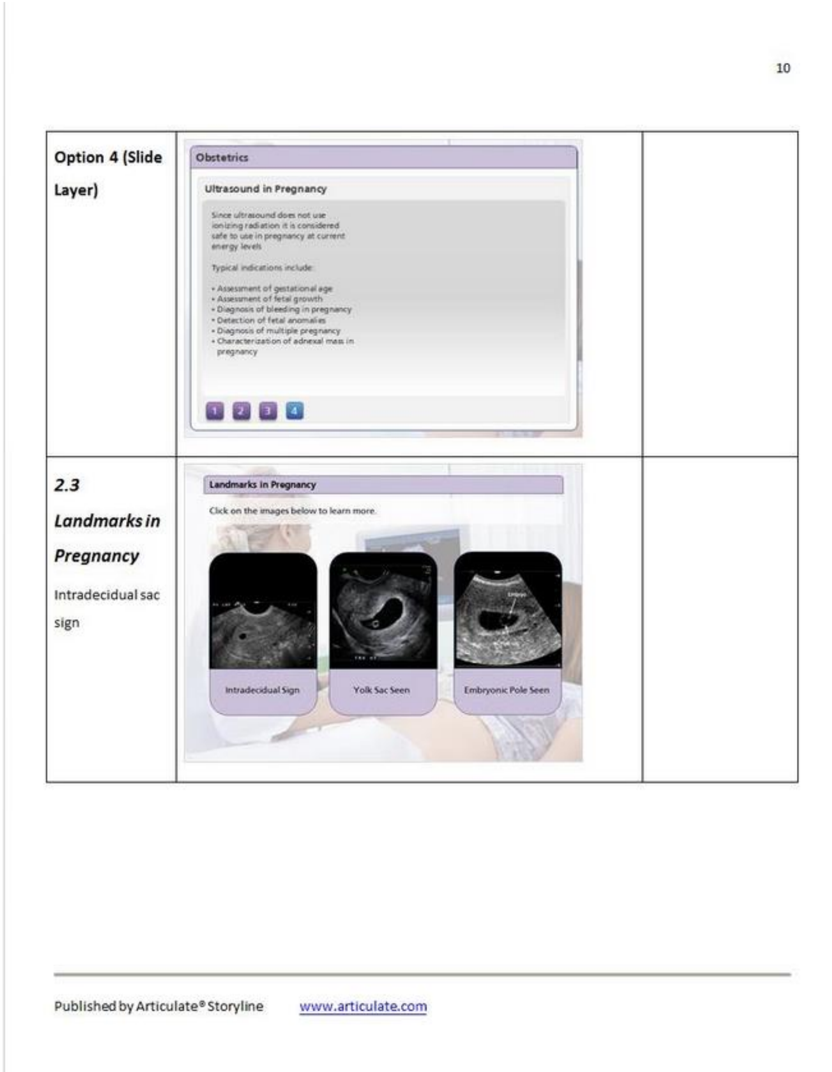
- Problem (Usability)
  Several participants also mentioned problems with the user interface. "In the diffusion weighted images (DWI) module, the previous button does not work." "There was one slide in the MRI section…that wouldn't advance to the next screen." "There was one part on the mri where I got stuck and couldn't continue." "In Plain Firm Radiography…image does not have a zoom button"

The navigation/interface problems identified during the pilot test were assessed by the ID and resolved prior to the Implementation phase. The editorial problems were first reviewed with the SME. The editorial problems identified as ungrammatical were fixed. Some comments called for grammatical changes to content that were correct as-is. Those changes were not made.

Ultrasound Module Data Analysis

The ultrasound module results for the clinician-expert indicated an average mean for usefulness and satisfaction (3.00). This participant provided qualitative data that aided in the improvement of the module. The participant indicated that students would find this module as a "useful orientation to Ultrasound" but that "understanding the complete protocols that are required for accuracy of diagnostic studies" would not be useful for this student population. The participant also indicated that there were "editorial comments, some…semantic or grammatical and others more substantive." In comments for improvement, this participant stated that there were "some concepts that I do not completely agree with or need updating."

As a result of this feedback, the participant was sent the module as a Microsoft Word document formatted as a table as shown in Figure 8.



10

Option 4 (Slide Layer)	Obstetrics Ultrasound in Pregnancy Since ultrasound does not use ionizing radiation it is considered safe to use in pregnancy at current energy levels Typical indications include: • Assessment of gestational age • Assessment of fetal growth • Diagnosis of bleeding in pregnancy • Detection of fetal anomalies • Diagnosis of multiple pregnancy • Characterization of adnexal mass in pregnancy 1 2 3 4	
2.3 Landmarks in Pregnancy Intradecidual sac sign	Landmarks in Pregnancy Click on the images below to learn more. Intradecidual Sign Yolk Sac Seen Embryonic Pole Seen	

Published by Articulate® Storyline www.articulate.com

Figure 8. Ultrasound Storyboard

The participant then provided additional substantial feedback for the module. Some were spelling errors, but the majority of the comments were related to specific content areas. The feedback can be categorized as mechanical (spelling/grammar) or content changes that can be further categorized as additional text or changes to text. All of the mechanical feedback was incorporated. The SME elected to make most of the new content changes. Of the changes to text, the SME elected to make some of the suggested edits. There were areas where the SME indicated a preference for the content in the module. The expert-clinician recommended new text for a slide on Methods of Assessing Gestational Age "First trimester US (in particular, the crown rump measurement) is most accurate ultrasound method for dating of the gestation" as shown in Figure 9.

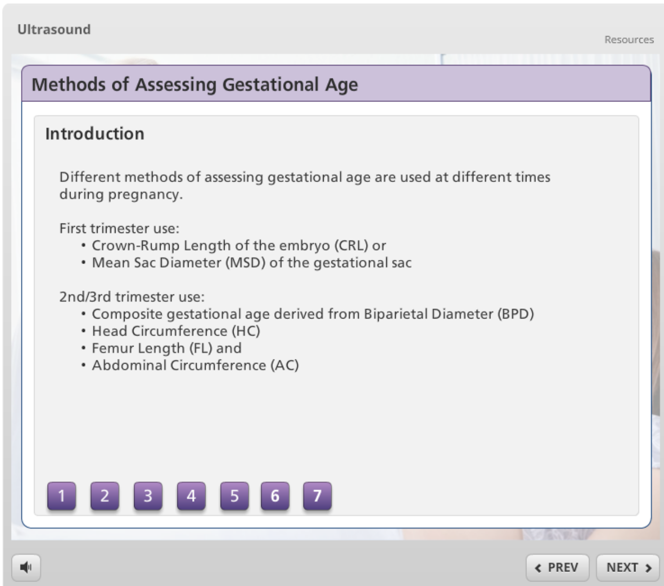


Figure 9. Ultrasound Lesson – Methods of Gestational Age Slide

However, the SME chose not to add this text to this slide and added to the subsequent slide that discussed Crown Rump Length as shown in Figure 10. The SME reworded the sentence and added it as the final sentence in the slide. The clinician-expert also noted an issue with the image "Caliper here does not measure CRL." The SME agreed and decided to change the image also shown in Figure 10.

Figure 10. Ultrasound Lesson – Crown Rump Length

The clinician-expert also noted a mechanical issue with the use of a term in a slide about the ultrasound of the pelvis. The original text was "The uterus and adnexae can be evaluated sonographically in one of two ways…" The clinician offered this comment: "Technical point (probably no one uses): adnexum is singular, adnexa is plural." After reviewing the text in the slide, the SME opted to keep the original text in the slide and did not make the change. Another example where the SME opted to keep the original wording was in a slide about IUCD Localization as shown in Figure 11.

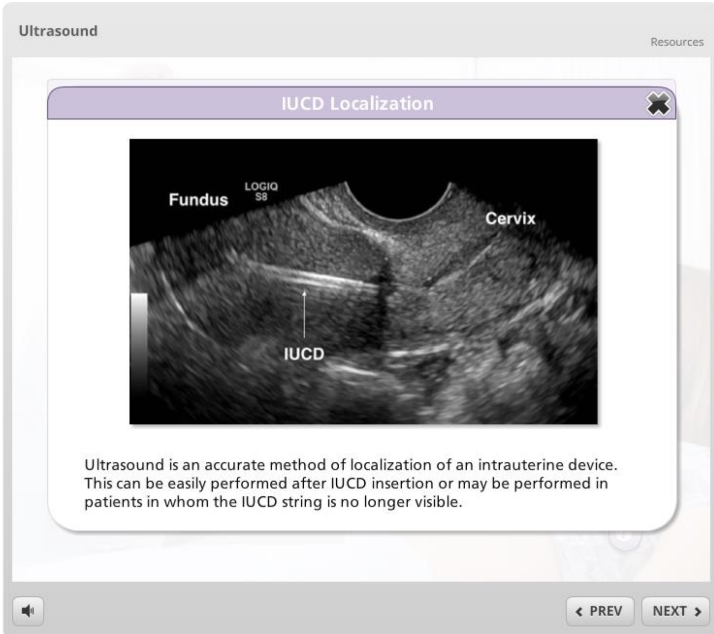


Figure 11. IUCD Localization

The clinician-expert commented, “3D transvaginal Ultrasound is the most accurate way to visualize the IUD and position of the IUD arms.” The change being suggested was minor as the reviewer was suggesting to add “most” to the sentence changing it from "ultrasound is an accurate…” to “ultrasound is the most accurate…” However, the SME also elected to keep the text as it was originally written.

The SME also chose to keep his original text on a slide regarding testicular masses as shown in Figure 12. The clinician-expert stated “Large testicular mass with extra-capsular extension.” However, the SME did not make the change and kept the original text.

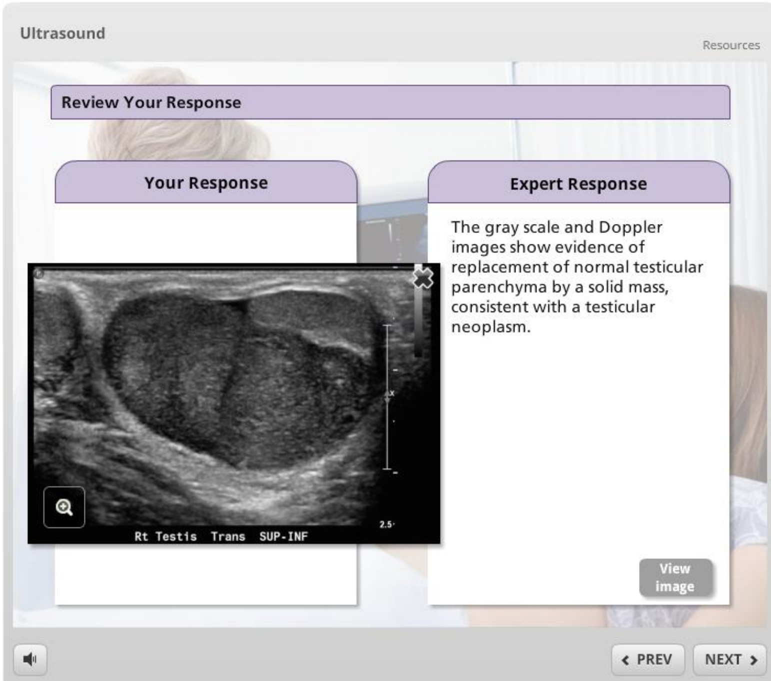


Figure 12. Ultrasound of the Testis

The SME did make a change as recommended by the clinician-expert on a slide about renal ultrasound. The original slide had one statement on the length of time to conduct this ultrasound "Doppler ultrasound e.g. evaluation for possible renal hypertension will add another 15 minutes." The clinician-expert recommended changing the wording to "Doppler will take another 30 minutes. The patient needs to be NPO for a renal Doppler study to decrease gas." The SME opted to change the statement to the one provided by the clinician-expert as shown in Figure 13.

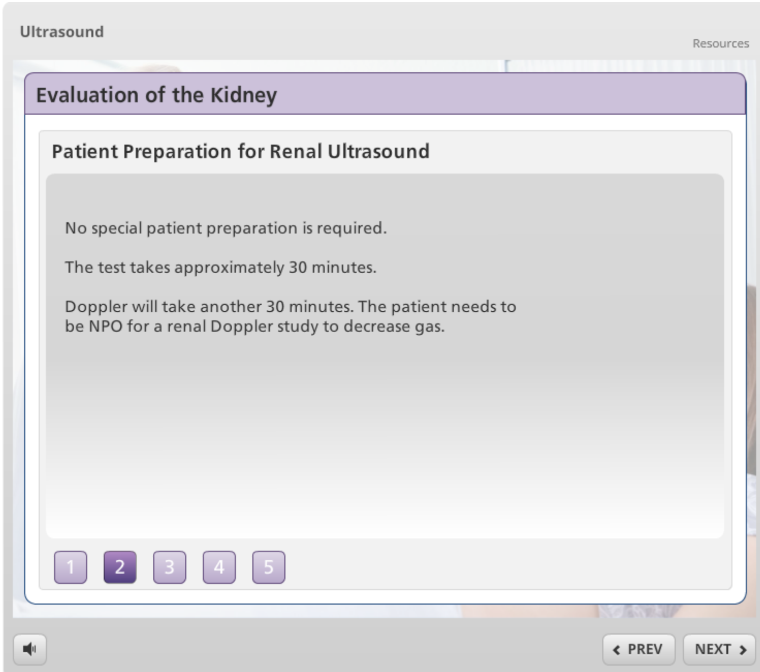


Figure 13. Renal Ultrasound

The remaining suggestions were to fix typographical errors or to add content. One slide associated a type of scan called a FAST scan incorrectly with a procedure. The clinician-expert indicated this error, and it was fixed. In a slide on imaging of the appendix, the clinician-expert recommend additional wording regarding the use of ultrasound vs. MRI in children and pregnant women. The original text stated, "Where ionizing radiation needs to be avoided ultrasound or MRI are alternative imaging methods." The clinician-expert recommended "In children and pregnant women, Ultrasound is first line. MRI is second line in pregnancy." The SME reworded the recommended text to be "Where ionizing radiation needs to be avoided (e.g. children or pregnant women), ultrasound or MRI are alternative imaging methods."

Four student experts participated in the evaluation of the ultrasound module. All the respondents indicated "very" for seven of the measures. The measure asking how well the lesson kept their interest and attention had a mean of 3.75. Three students (75%)

responded “very” and one student (25%) responded “mostly” to this measure. The measure with the lowest mean, 3.50, asked how well they thought this lesson would meet students’ attention. The responses were evenly split (50/50) between “very” and “mostly.” When compared to the expert-clinician review for this module, the student-expert results indicated higher means for all constructs. Student-reviewers rated satisfaction with a mean of 3.95 and usefulness with a mean of 3.8750 as shown in Table 8.

Table 8

Ultrasound Student-Expert IEUQ Results

	N	Minimum	Maximum	Mean	*SD*
Satisfaction Mean	4	3.80	4.00	3.9500	.10000
Usefulness Mean	4	3.75	4.00	3.8750	.14434
Valid N (list wise)	4				

Open codes were identified by reviewing the qualitative responses. An analysis of the qualitative data resulted in 14 open codes and five axial codes. It was immediately clear that the focus of this response set was on the content of the modules. The participants were highly complimentary, focusing the responses on the efficiency and clarity of the content. There were minimal usability and editorial issues, less than with the Introduction to Imaging module. Once the open codes were identified, similar codes were grouped together under an axial code. Because these comments specifically mentioned the module content, a new axial code was created to discern between compliments on usability and compliments on content. Table 9 shows the open and axial codes identified for this module. The number in the parenthesis indicates the times the open code appeared for that question.

Table 9

Ultrasound Open and Axial Codes

Survey Question	Open Codes	Axial Codes
	• User friendly	Compliment (Usability)
What do you think students will find the most helpful part of the online lesson?	• Information to the point • Information easy to understand • Information organization is good • Clear brief slides with images • Content efficient • Visual representation of material • To the point, content brief • Content – better way to review	Compliment (Content)
What do you think students will find the least helpful part of the online lesson?	• Content – needs more detail	Problem (Content)
	• Incompatible phone/slider	Problem (Usability)
Please provide any additional comments for improvement.	• Perfect	Compliment
	• Slide missing a title • Typo	Problem (Editorial)
	• Clarification needed (2)	Problem (Content)
	• Navigation issue with slider	Problem (Usability)

- Compliment (Usability)
  Participants provided comments specific to the module usability, indicating that it was "user friendly." One reviewer stated, "this online module is perfect."

- Compliment (Content)
  The concepts of "efficient" and "concise" appeared consistently throughout the comments. Participants indicated that the "information is to the point," "clear, brief slides with images conveyed points in an efficient and clear

manner," "to-the-point presentation…provides with me highest yield information. It's also a better way to review material."

- Problem (Editorial)
  There were minimal editorial comments. One indicated a "few typos [in the] first module" but did not specify what they were or where. Another participant indicated, "in the thyroid module there is a portion that is missing a title."

- Problem (Content)
  One participant reported an issue with the content. "In the vascular section it says that embolism is a source of ischemic stroke, but I believe that it is often a source of hemorrhagic stroke. Also, the vascular module implies that ultra sound is used to determine the degree of stenosis for endarterectomy but I believe that it is the initial screening. CTA is what determines the NASCET degree of stenosis." The SME did not agree and did not make any changes to this text.

- Problem (Usability)
  Usability problems were also minimal. The use of an interactive slider was not reported to be "smooth and often skipped some images." Another participant indicated the lack of compatibility with phone or tablet interface as a drawback.

The ID was able to address the grammatical issues independently by reviewing the whole module for any grammatical issue. The ID identified slides that contained clerical errors (e.g. two periods at the end of a sentence, sentences missing a period). The ID also fixed the issue with the interactive slider reported by a participant. The ID was able to replicate the issue, noticing that it was not smooth. The ID changed a setting in the slide that added an animation to the images so they would fade in and out. This resulted in a smoother transition between images when using the interactive slider.

Regarding the problems reported with the content, the ID noted the problems reported and met with the SME. The SME reviewed the student-expert comments and the slides, and ultimately decided not to make any changes to the content and leave it as originally written.

Mammography Module Data Analysis

The clinician-expert selected “very” for every item in the IEUQ for the mammography module, which gives the survey a mean of 4.0 for all constructs, the highest mean for any of the clinician-expert reviews. Additionally, the clinician-expert provided minimal qualitative data in this review. The participant indicated that students would find “how important it is to come to a definitive answer” as the most useful part of the lesson. Qualitative data from the mammography module did not provide any recommendations for improvement. The only feedback provided was “excellent.” As a result, no changes were made to the mammography module prior to pilot testing with the student-expert group.

With seven participants, the student-expert pilot test provided more usable data than the clinician-expert did. Seven students (100%) responded “very” to the measures asking how easy the online lesson was to use and how well they liked how the online lesson looked. The lowest scoring measures had a mean of 3.43. Four students (57%) responded “very”, two students (29%) responded “mostly,” and one student (14%) responded “somewhat” to the measures asking how well the lesson kept their interest and attention, how well they thought the lesson would meet students’ needs, and how useful they thought students would find the online lesson. Analyzing the results by construct showed that student-experts rated satisfaction with a mean of 3.75 and usefulness with a mean of 3.6429 as shown in Table 10.

Table 10

Mammography Student-Expert IEUQ Results

	N	Minimum	Maximum	Mean	*SD*
Satisfaction Mean	7	3.20	4.00	3.7500	.36629
Usefulness Mean	7	2.50	4.00	3.6429	.55635
Valid N (list wise)	7				

This group of reviewers also provided significant qualitative responses to the IEUQ survey. This module review had seven participants resulting in substantive feedback and more open and axial codes. An analysis of the qualitative data resulted in 27 open codes and seven axial codes. Table 11 lists the open and axial codes identified for this module.

Table 11

Mammography Open and Axial Codes

Survey Question	Open Codes	Axial Codes
What do you think students will find the most helpful part of the online lesson?	• look and feel • ease of use • layout was helpful • interactive (2) • entertaining graphics • interactive	Compliment (Usability)
	• images clear and helpful • useful and succinct • organization helpful • very good images and videos • good explanation of BIRADS	Compliment (Content)
What do you think students will find the least helpful part of the online lesson?	• videos least helpful • lack of practice and application (2)	Problem (Content)
	• location within module	Problem (Usability)

	• great (5) • nice • very informative • very satisfied	Compliment (Overall)
	• user friendly (2)	Compliment (Usability)
Please provide any additional comments for improvement.	• clinical scenarios were good.; decision tree • videos helpful • great images	Compliment (Content)
	• videos not useful • add quizzes (4) • more content; clarity (5)	Recommendations (Content)
	• spelling • grammar	Problem (Editorial)

- Compliment (Usability)
  Participants provides substantial positive feedback on the usability of the module. Several participants complimented the look and feel: "look and feel of this module was incredible" and "I like the interface and the ease of navigation." Two participants described is as "user friendly." One participant comments on the layout of the module: "the layout of the module is most helpful." Several participants also commented positively on the interaction in the module: "The fact that it has students clicking through interactively is great" and "very interactive."

- Compliment (Content)
  This module received several compliments on the content and the graphics. One participant indicated that the graphics were "entertaining." The high quality of the graphics was praised: "The pictures of benign vs malignant calcifications and masses are very clear and helpful," "great images of benign and malignant lesions," and "very good images and videos." One participant stated that the videos "were helpful to understand biopsies." The content was also praised as being "useful and succinct." One participant felt the "step-by-step approach to breast imaging starting with epidemiology and progressing through each of the different and relevant imaging modalities" would help medical students. This participant also indicated that students would find use for this lesson in other clerkships writing, "the inclusion of screening criteria will be very helpful for other clerkships (especially OB/GYN and Family Medicine)." One participant also praised the specific content on breast cancer indicating it provided a "good explanation of BIRADS." A participant also offered praise to the design of the course content indicating, "The clinical scenarios were good. I liked the decision tree."

- Problem (Content)
  Although some participants complimented the videos, most reviewers felt the videos were not helpful with comments such as "students will find the videos the least helpful" and "I am unsure how many students will listen to the full videos on biopsies without simply clicking ahead." Several participants repeated the need for opportunities to be tested on the material. Two indicated that "the lack of practice and application" and "not asking students to integrate, or apply that information" as the least useful part of the online lesson. These comments were repeated as recommendations to improve the content and were placed within the Recommendations (Content) axial code described below.

- Problem (Usability)
  There was only one comment related to a problem with usability. A participant wrote "it would be helpful to know where you are in the module because at some point [students] are going to start to wonder how much longer they have to go to finish."

- Compliment (Overall)
  Several comments were related to participants' perception of the module as a whole. The word "great" was used by five distinct participants to describe it. One participate stated, "Overall, I was very satisfied with the module." Another described it was "very nice." Another participate stated it was "very informative."

- Recommendations (Content)
  This group of participants provided significant comments for improvement. One often repeated recommendation was to add quizzes. This request appeared four times "add in question sets with 2-3 question and answers after each video;" "I would add in sporadic questions throughout;" and "could also [incorporate] a few practice opportunities." Since this code was so often repeated, the ID advised the SME to develop questions for the module. After developing the questions, the ID and the SME met to identify where to place them within the module. Based on this feedback from the student-experts, the final student version includes 31 non-graded questions. Participants also provided recommendations to specific areas of the content: "I would further clarify what tomography is…why it is particularly useful in mammography;" and "I would have liked a bit more of a summary. I think that's a good opportunity to briefly and succinctly go over things. As well as a short decision tree for what you do in work up for a breast mass." One participant requested additional content for "the guidelines for imaging high-risk individuals would be an elaboration for those have a positive first-degree relative history (that is, starting ten years prior to the affected person's age of diagnosis)."

- Problem (Editorial)
  There were only two comments related to editorial problems. Participants indicated "couple spelling errors" and "the grammar is inconsistent (period at the end of some sentences, not others in the same slide)," but did not specify where in the module this happened.

The ID immediately addressed usability issues. The recommendation about knowing "where you are in the module" was accepted. The ID added a page numbering system to the module formatted in the style of slide number out of total number of slides allowing students to know in which slide they are in and how many slides remain in the module. Although the student-experts provided recommendations to the content, the SME opted to leave the content as originally written as he covered this information more closely during the in-class portion. The editorial problems were all addressed by the ID who reviewed the module for grammar and inconsistency in formatting and fixed any issues that were identified.

Nuclear Medicine Module Data Analysis

The results of the clinician-expert review rated satisfaction with a mean of 3.0 and usefulness with a mean of 4.0. To improve the content, the clinician-expert indicated that there are other ways to obtain the same information that "do not involve radiation and may be easier, less expensive, and give more information." The SME agreed with this; however, felt that it was important for students to learn about the basics of nuclear medicine, even though technological progress in the area made some of the tests covered in the module no longer as useful. Additionally, the SME indicated that he covered these advancements during in-class time. The participant indicated that "overall it is very good" when asked for recommendations for improvement in the IEUQ.

Six students participated in the student-expert review of the nuclear medicine module. Six students (100%) answered "very" to the measures asking how satisfied they were with the lesson and how useful they thought an online module was for delivering the content. The lowest scoring measure, which asked how well the online lesson kept their interest and attention, had a mean of 3.50. Four students (67%) answered "very," one student (17%) answered "mostly," and one student answered "somewhat" to this measure. The results of the IEUQ for the student-expert review showed a lower mean for usefulness, but a higher mean for satisfaction when compared to the clinician-expert review. Satisfaction was rated with a mean of 3.7667 and usefulness with a mean of 3.8333 whereas the clinician-expert rated these constructs with a mean of 3.0 and 4.0, respectfully. Table 12 shows the descriptive analysis for these results.

Table 12

Nuclear Medicine Student-Expert IEUQ Results

	N	Minimum	Maximum	Mean	*SD*
Satisfaction Mean	6	3.20	4.00	3.7667	.36697
Usefulness Mean	6	3.50	4.00	3.8333	.20412
Valid N (list wise)	6				

The student-experts who reviewed this module provided sufficient feedback on this lesson. Twenty-three open codes and seven axial codes were identified in the qualitative responses as shown in Table 13. Evaluating the qualitative responses overall, the focus on the responses was on the clarity of the content. The open code "clear" appeared four times. Student-experts did not indicate as many content or usability issues as in other modules.

Table 13

Nuclear Medicine Open and Axial Codes

Survey Question	Open Codes	Axial Codes
What do you think students will find the most helpful part of the online lesson?	• Easy to click around • Interface user friendly • Easy to click through • Easy to navigate	Compliment (Usability)
	• Clear (3) • Well structured • Succinct • Clear cut and focused • images helpful • module partitioned into several smaller modules	Compliment (Content)
	• useful • organized	Compliment (Overall)
	• more explanation	Recommendation (Content)
What do you think students will find the least helpful part of the online lesson?	• Explanation not clear • Slide was wordy; difficult to understand • scientific background	Problem (Content)
	• Great • No least helpful part	Compliment (Overall)
Please provide any additional comments for improvement.	• Great module to learn	Compliment (Overall)
	• Image caption incorrect • Slide name missing	Problem (Editorial)
	• Horizontal slider difficult to use • Last slide froze my browser	Problem (Usability)
	• Add video to lesson	Recommendation (Content)

- Compliment (Content)
  Student-experts were highly complimentary of the module content. The open code "clear" appeared three times to describe the content (overall or within a specific topic). Student-reviewers stated that the module provided a "clear explanation of FDG-PET," and that this module is "more clear cut and focused on what the essential parts of nuclear medicine are and it is easier to ascertain what is important." One reviewer wrote that students would find most helpful "the information that is presented clearly." The content was also described as "well structured" with the information "presented in a succinct manner." Reviewers also compliment the chunking of information: "I like how the module is partitioned into several smaller modules."

- Problem (Content)
  There were not many problems with the content identified in the results of this module. One reviewer provided an opinion about the degree of scientific background provided in the lesson: "I think some of the scientific background may not be appreciated but it is not a large portion of each mini-module may be helpful for some who are interested in the background and mechanism of some modalities of radiology." One reviewer focused on very specific areas of concern for improvement. One reviewer point out a section on imaging: "I still don't understand MUGA and gated SPECT imaging from the explanation." This reviewer also indicated that "PET in Alzheimer's is a little wordy and difficult to understand." The ID met with the SME regarding these issues. The SME opted to make no changes to the scientific background as he felt it was not overwhelming and important for students to have some understanding of how nuclear medicine works. Regarding the issue of MUGA and gated SPECT, the SME added text left the text as originally written. He did the same for the Alzheimer's slide.

- Problem (Editorial)
  Reviewers did identify two editorial problems in the module: "There was one page that was not complete, I believe it was in the thyroid module which at the top the title read "ENTER TEXT." Another reviewer noticed an issue with an image attribution: "There was one image caption that said something like, "We should use a different image because this one is copyright by Mayo." The ID met with the SME and both issues were addressed and resolved.

- Compliment (Usability)
  The open code "easy" consistently appeared in the qualitative responses for this module. Student-experts described the module as "easy to click around and proceed," really easy to click through," and "easy to navigate." This group of reviewers had very positive comments about the look and feel of the module. One participant wrote "the interface is very user friendly."

- Problem (Usability)
  Usability problems were minimal. One reviewer reported an issue with a

horizontal slider not working properly stating, "I found the bottom horizontal slider difficult to use sometimes. I think a slider that runs continuously would be easier to use." This reviewer also reported another usability issue "I tried accessing the last slide of the bone scan mini-module (triple phase bone scan) on my computer a few times and the module froze when I tried doing so. It may be a personal computer issue but it may be something to keep in mind." The ID tried to replicate both issues on different browsers (Chrome, Firefox, and Internet Explorer) and was not able to do so. The ID did identify that the modules performed better in Chrome and Firefox as text appeared as designed and interactions flowed more smoothly. With Internet Explorer, some text was changed and the interactions were choppy. So, instructions were added to all modules informing students to only use Chrome or Firefox to view the modules.

- Recommendations (Content)
  Only two recommendations to improve the content were provided. One reviewers recommended more explanation to the area FDG-PET stating, "[it] should also include explanation of which things light up normally. This used to confuse me as a medical student." Another reviewer recommended adding video to the lesson "maybe it would be good to incorporate video clips into the lesson, such as for the MUGA scan." The SME did not make any of these changes.

- Compliment (Overall)
  Reviewers also provided compliments to the overall module. Reviewers provided comments such as "The lesson is very useful as a whole and is organized very well." One reviewer wrote, "the online lesson is great. I don't think there is a least helpful part." Another comment was "overall, a great module to learn."

Implementation Phase Data

After the development phase, data were collected and the necessary updates made, the module moves into the Implementation Phase. The data collected during this phase does not aid in the evaluation of the modules. During this phase, the ID creates the course shell and builds the course modules in the LMS. This includes creating the course shell, building the modules following sequencing specified in the course syllabus, importing the learning modules, providing the course director access to the course, and enrolling the students. A final step in this phase is to conduct a quality assurance review following a three-layered review process using an establish checklist. This step focuses on identifying usability and technical issues, which are resolved before moving into the next phase. The data collected in the phase is not used to improve the radiology modules. This phase is strictly concerned with the user experience in the learning management system with the results of the quality assurance reviews used internally by the system administrators.

Evaluation Phase Data

Quantitative and qualitative data were collected during the evaluation phase. Quantitative data consisted of the Likert questions in the IEUQ and scores from the pre and posttests administered through ExamWeb. The IEUQ results were analyzed in the same manner as the results of the pilot test. Using the constructs, a descriptive analysis was conducted. The minimum, maximum, mean, and standard deviation were generated for each construct. The results of the pretest and posttest were also analyzed. Using SPSS 20.0, a paired sample *t*-test analysis was conducted. This statistical test was chosen as it is used to compare two groups (Munro, 2005). In this analysis, it was used to compare the pre and posttest results of the same participants (one group measured twice).

In addition to running the paired *t*-test, it is necessary to measure the effect size in order to evaluate the degree to which the intervention, in this case the module, had on the posttest results. Cohen's *d* is one statistical analysis used to measure this difference. In statistical terms, Cohen's *d* measures the degree to which the independent variable affects the dependent variable (Terrell, 2012). These measurements are grouped into three ranges: .2 or less is small, between .2 and .5 is medium, and greater than 5 is a large (Terrell, 2012). Cohen's *d* was the measure selected for this study as Cohen's *d* was designed for use where scores of two groups are continuous and normally distributed (Rice & Harris, 2005).

Qualitative data were collected through the open-ended questions in the IEUQ. The qualitative responses were analyzed and open-codes identified and categorized. Axial codes were identified based on the categories developed from the open codes.

Introduction to Imaging

Thirty-three students responded to the IEUQ survey for the Introduction to Imaging module. Thirty-two students (97%) reported that the online lesson was mostly or very easy to use. One student (3%) reported N/A. This measure had the highest mean of all the items in the survey (3.88). Thirty-three (100%) reported that the information in the online module was mostly or very easy to understand, convenient to use, and was a useful method to deliver this content with means of 3.85, 3.84, and 3.82, respectively. The question with the lowest mean (2.74) asked students how likely they were to return to review this module after completing the clerkship. This question also had the highest standard deviation of all the items (1.09). Twenty students (60%) reported they would be very or mostly likely to return. Twelve students (36%) reported they would somewhat or slightly likely to return. One student (3%) reported they would not at all be likely return. Of the four modules in this study, this module rated the lowest in this measure.

As discussed previously, the items in the IEUQ were grouped into the constructs of satisfaction and usefulness. Students rated satisfaction and usefulness almost the same with both constructs having high means. Satisfaction had a mean of 3.6485 and usefulness a mean of 3.6084 as shown in Table 14.

Table 14

Introduction to Imaging Student IEUQ Results

	N	Minimum	Maximum	Mean	*SD*
Satisfaction Mean	33	2.80	4.00	3.6485	.42729
Usefulness Mean	33	2.43	4.00	3.6084	.38516
Valid N (list wise)	33				

The qualitative responses supported the high means for satisfaction and usefulness. As shown in Table 15, thirty-four open codes and seven axial codes were identified in the qualitative responses. The majority of open codes were complimentary. The axial code with the most open codes was Compliment (Overall). The open codes in this axial code provided a compliment to the course in general, not a specific area of the course. Although most of the open codes were complimentary, students also reported some editorial issues and usability issues.

Table 15

Introduction to Imaging Open and Axial Codes

Survey Question	Open Codes	Axial Codes
What was the most helpful part of the online lesson?	• Aesthetically pleasing • Interactive • Easy to navigate • Ease of use	Compliment (Usability)
	• Explanations (3) • pictures	Compliment (Content)

	• good overview of everything • simplicity (3) • pictures/images (5) • appropriate length • hold my attention • sequence/order (4) • simple (2) and general overview • good review • straightforward information • efficient	Compliment (Overall)
	• Image and text design needs improvement	Recommendation (Content)
What was the least helpful part of the online lesson?	• No active learning • Issue with posttest • Too much detail in some slides	Problem (Content)
	• Informative • Helpful	Compliment (Overall)
	• Excessive clicking	Problem (Usability)
	• More pictures (pathology films) • Disclaimer on slides we don’t have to learn	Recommendation (Content)
Please provide any additional comments for improvement.	• Overall good module • Nice combination of images and text	Compliment (Overall)
	• A slide was missing an image (5)	Problem (Editorial)
	• Too much clicking • Larger images	Problem (Usability)
	• Add questions • More imaging content	Recommendation (Content)

- Compliment (Overall)
  The students were highly complimentary of this module. Most of the open codes identified were associated with this axial code. Open codes pertaining to pictures or images were the most often repeated. One comment explains this: "As a visual learner, the graphics and the explanations were very helpful." "Lots of images" appeared twice. Students also complimented the organization of the module "everything was in order and the sequence of the modules and lessons made sense and built on top of one another." The open code simple/simplicity appeared three times. "The lesson provided a simple and general overview of basics that were still vague to me." One student indicated that "the simplicity of it" was the most helpful part of the module. Another described it as "very simple," and offered additional explanation of "broken down into pieces of information presented in a logical order to enhance comprehension."

- Compliment (Content)
  Students provided many compliments on the content of this module. The most often repeated open code was relating to the degree and amount of explanations provided. Students indicated that "explanations of the imaging techniques" were the most helpful," and that "each module was an appropriate length." The open code "straightforward" appeared twice as "straightforward wording" and "straightforward information." Twice the open code "pictures" appeared as being the most helpful.

- Problem (Content)
  Only three open codes were associated with this axial code. One of those codes addressed a problem with the posttest, not the module. One problem with the content was reported as "no active learning." Unfortunately, no other description was offered to assist in the analysis of this code and to aid in identifying solutions to address this issue. A student identified an issue with the level of detail provided in the module: "a little too much detail in some slides. Unsure if we are so supposed to learn the detail or not." The final issue identified was not a problem with the module, but with the posttest: "did not correspond well with the posttest."

- Problem (Editorial)
  Several students indicated an issue with missing images or text. Open codes related to this axial code were repeated five times.

- Compliment (Usability)
  Students provided several positive comments on the usability of this module. Students described it as "aesthetically pleasing and easy to navigate," and "interactive." "Ease of use" was mentioned as the most helpful part of the course.

- Problem (Usability)
  The only usability problem identified in the results was that of "excessive clicking." This code was repeated twice; however, no other information was provided making it difficult to identify specifically where the issue existed.

- Recommendations (Content)
  This open code included recommendations for images and content. Two students recommended adding more images and more content: "This is introductory, and so MORE pictures of various imaging modalities would be excellent. Especially pathology films." Another comment indicated the same "would like to see more imaging and examples." One student very specifically recommended "If possible for images to be made larger (nice to be able to blow them up on the screen." In support of the Problem (Content) axial code that stated "no active learning," one recommendation stated, "would be nice to have questions."

Further analysis was conducted on the pre and posttest results to evaluate further the effectives of the online module. A paired sample *t*-test was run with an alpha value of .05. The mean for the pretest was 13.29, and the mean for the posttest was 26.86. The results showed a positive increase in the mean of the posttest as shown in Table 16.

Table 16

Introduction to Imaging Paired Sample Statistics

		Mean	N	*SD*	Std. Error Mean
Pair 1	Pretest	13.41	34	2.595	.445
	Posttest	29.18	34	27.785	4.765

The results of the paired sample *t*-test showed a difference between the means of -15.765 as shown in Table 17. The *t*-test showed a significance of .002 which is lower than the alpha value (.05), therefore supporting the analysis that the posttest scores of students who completed the online module significantly increased.

Table 17

Introduction to Imaging Paired Samples Test

		Paired Differences							
					95% Confidence Interval of the Difference				
		Mean	Std. Deviation	Std. Error Mean	Lower	Upper	t	*df*	Sig. (2-tailed)
Pair 1	Pretest - Posttest	-15.765	27.937	4.791	-25.512	-6.017	-3.290	33	.002

Because the increase was significant, it was important to verify this difference by running a Cohen's *d* analysis to measure the effect size. An analysis of Cohen's *d* showed an effect size of 0.799, reflecting a large effect size.

Ultrasound

Twenty students responded to the IEUQ survey for the Ultrasound module. All students (100%) reported they could mostly trust the information in this module. This measure had the highest mean of all the measures in the survey, 3.95. Nineteen students (95%) reported they found the information mostly or very easy to understand and mostly or very useful. Both measures had a mean of 3.80. Nineteen students (95%) reported that this method was mostly or very useful for delivering this content; one student (5%) reported that it was a somewhat useful method for delivering this content. The mean for this measure was 3.65. Eighteen students (90%) reported they would be mostly or very likely to return to the online module to review the content after completing the clerkship. Two students (10%) reported they would be somewhat likely to return. Of the four modules, this module had the highest mean for this measure (3.55).

An analysis of the IEUQ for the constructs yielded useful information. Satisfaction and usefulness rated highly again. The mean for satisfaction was 3.64 and usefulness rated a 3.7429 as shown in Table 18. This module also had the highest mean for usefulness of the four modules in this study.

Table 18

Ultrasound: Student IEUQ Results

	N	Minimum	Maximum	Mean	*SD*
Satisfaction Mean	20	2.20	4.00	3.6400	.50095
Usefulness Mean	20	2.71	4.00	3.7429	.34870
Valid N (list wise)	20				

The qualitative responses were highly complimentary of this module. Twenty-one open codes and eight axial codes were identified from an analysis of the qualitative responses. The axial code Compliment (Overall) had the most open codes associated with it. Students also complimented the content, particularly the images. There were minimal editorial and usability problems reported. Table 19 shows the open and axial codes for this module.

Table 19

Ultrasound Axial and Open Codes

Survey Question	Open Codes	Axial Codes
What was most helpful part of the online lesson?	• the quiz questions (3) • pictures/images (5)	Compliment (Content)
	• Having it all in one place • Very educative • Enjoyed module thoroughly • Easy to understand • Very helpful • Module organization (2) • Thorough • covers major organs • Accessibility	Compliment (Overall)

What was the least helpful part of the online lesson?	• Some parts too advanced	Problem (Content)
	• Dragging/scroll interaction was choppy (2)	Problem (Usability)
	• grammar	Problem (Editorial)
	• too long	Problem (Overall)
	• Very helpful	Compliment (Overall)
	• More pictures	Recommendation (Content)
	• instead of slider, click through images	Recommendation (Usability)
Please provide any additional comments for improvement.	• Quiz question missing answer	Problem (Content)
	• Missing some pictures	Problem (Editorial)
	• The drag bar did not work	Problem (Usability)

- Compliment (Overall)
  This axial code had the most open codes associated with it. One student wrote, "Enjoyed this module thoroughly. Easy to understand and covers the major organs. Very helpful." This compliment was repeated in another response "all of it was a very helpful introduction and I feel I finally understand U/S." The open code module organization appeared two times. "I liked the way the lesson had smaller lessons within it with more specific information on different organs." This was supported by another comment "breaking the module up per organ or system was great well done." This module was "thorough" according to one student. This open code was repeated by another student "Having it all in [one] place. Normal and abnormal findings, indications, limitations - very educative." One student reported the accessibility of the module as being the most helpful.

- Problem (Overall)
  Only one open code reported for this axial code was "a little too long."

- Compliment (Content)
  The open code that appeared most was related to pictures and images, appearing five times. In response to the question of what they found most helpful, students responded with "pictures," "great images." Three distinct

respondents wrote "great images." Students also found the quizzes useful. This open code appeared three times in the responses. One student wrote, "The problems mixed in were helpful to test understanding." Another student wrote, "I like the quizzes. They help me test my knowledge during each module." One open code indicated that the lesson "cover[ed] all the major organs."

- Problem (Content)
  Students reported minimal problems with the content. One student stated, "I thought some parts of the OBGYN were too advanced" Another stated that a quiz question "did not tell you if your answer was right or wrong." The same student that "you were missing some pictures in this or another module, cannot remember which sorry."

- Recommendation (Content)
  The only recommendation for content provided was "more pictures and examples would be beneficial."

- Problem (Usability)
  A problem with the slider was reported three times. One student wrote "The sliding bar for some of the images (such as endometrial changes throughout the menstrual cycle) would sometimes freeze or be difficult to tell if I skipped ahead two slides on accident."

- Recommendations (Usability)
  An open code for this axial code provided a recommendation for the slider usability issue: "might be better if they were normal slides to click through rather than a slider."

- Problem (Editorial)
  Only one open code appeared for this axial code. It stated "the module could use a quick review for grammer [sic]"

The pre and posttest results were analyzed to evaluate the effectiveness of the module. As in the introduction to imaging module, there was an increase in the posttest mean scores as shown in Table 20. The pretest mean was 31.60, and the posttest mean was 40.33.

Table 20

Ultrasound Paired Samples Statistics

		Mean	N	*SD*	Std. Error Mean
Pair 1	Pretest	31.60	30	16.519	3.016
	Posttest	40.33	30	30.446	5.559

As there was an increase, it was necessary to assess if the difference was significant. Therefore, a paired samples *t*-test analysis was run with an alpha value of .05. The results of this analysis indicated a difference in the mean of -8.733. However, it indicated a significance factor or .096, which is higher than the alpha value (.05). This result indicates that the difference in the means is not significant, and the online module did not have a significant impact on the increase in the mean scores of the posttest. Table 21 shows the results of the *t*-test.

Table 21

Ultrasound Paired Samples Test

		Paired Differences							
					95% Confidence Interval of the Difference				
		Mean	Std. Deviation	Std. Error Mean	Lower	Upper	t	*df*	Sig. (2-tailed)
Pair 1	Pretest - Posttest	-8.733	27.815	5.078	-19.119	1.653	-1.720	29	.096

This assessment was supported by an analysis of effect size. Cohen's *d* showed an effect size of .356 which indicates that the module had a moderate effect on the results of the posttest.

Mammography

Twenty-five students completed the IEUQ for the mammography module. Twenty-five students (100%) reported that they mostly or very well liked the way the lesson looked. This measure had the highest mean of all the items in this survey, 3.84. Twenty-five students (100%) reported they could mostly or very well trust the information, found the information mostly or very much useful, and found the module mostly or very convenient to use. These three measures each had the second highest means, 3.80. Twenty-four students (100%) reported that this was a mostly or very useful method for delivering this content. This measure had a mean of 3.67. The lowest mean was attributed to the measure asking students if they would return to review the content after completing the clerkship, 3.08. Nineteen students (86%) reported they would be mostly or very likely to return. Eight (24%) reported they would be somewhat or slightly likely to return. Of the four modules, this module had the second lowest mean for this measure.

As with the previous modules, satisfaction and usefulness rated highly. Satisfaction had a mean of 3.7280, and usefulness had a mean of 3.6514, show in Table 22. This module had the highest mean for satisfaction of the four modules in this study.

Table 22

Mammography Student IEUQ Results

	N	Minimum	Maximum	Mean	*SD*
Satisfaction Mean	25	3.00	4.00	3.7280	.39950
Usefulness Mean	25	3.00	4.00	3.6514	.39140
Valid N (list wise)	25				

The high means for both constructs is supported by the qualitative responses. Twenty-four open codes and seven axial codes were identified in the qualitative responses. The axial code with the most open codes was Compliment (Overall). Students were highly complimentary of the overall module, and provided specific comments on the elements of the module, which they identified as the most helpful. Table 23 shows the open and axial codes for the mammography module.

Table 23

Mammography Open and Axial Codes

Survey Question	Open Codes	Axial Codes
What was the most helpful part of the online lesson?	• Quiz questions (12) • Videos (4) • Images (2) • Explanation of BIRADS	Compliment (Content)
	• Interactive • Best formed module • Presents content then asks questions • Concise and effective introduction • Clear and direct • Varied methods for teaching • Everything helpful • Good in general	Compliment (Overall)
	• Slide numbering	Compliment (Usability)
What was the least helpful part of the online lesson?	• Long length	Problem (Overall)
	• Quiz questions (6) • Videos (2) • Description of science behind the scans	Problem (Content)

	• Click boxes to see information • Back button missing	Problem (Usability)
	• Provide more information when you click a button	Recommendation (Usability)
	• Nothing least helpful (3) • Everything helpful • Excellent throughout • Everything was perfect	Compliment (Overall)
	• Quizzes • Videos	Compliment (Content)
Please provide any additional comments for improvement.	• Questions (3)	Problem (Content)
	• Questions (2) • Better explanation benign v malignant calcifications	Recommendation (Content)
	• Back button missing	Problem (Usability)
	• Table of contents or index slide	Recommendation (Usability)
	• Great (3) • Excellent • Fun • Awesome • No improvement needed • Helpful	Compliment (Overall)

- Compliment (Overall)
  This most often appearing open code for this module was associated with the axial code of Compliment (Overall). The open code "great" appeared three times. It was described as "excellent, very fun way to learn." Another student wrote that it was "Simply awesome!" The compliments for the overall module were specific in what elements were especially helpful. The module organization was praised three times. "It presented a very concise and effective intro to mammography," and "very clear and direct." The use of quizzes interspersed throughout the module was also complimented: "I like the module present the material and then asks questions." Another comment indicated that the most helpful part of the module was "Everything, I thought this was the best formed module yet." One student found the multimedia design of the module the most helpful: "The different methods utilized for

teaching: pictures, videos, short paragraphs, questions and answers." When asked to identify the least helpful part of the module, four respondents indicated they could not find any least helpful part. The open codes "N/A, none, nothing" appeared as responses to this question. Another student responded with "I found everything very helpful." Three responses indicated no need for changing anything in the module: "It was excellent throughout - no need for changes," and "I think no improvement are needed." While another said "everything was perfect."

- Problem (Overall)
  Only one open code "long length" was associated with this axial code. No other students reported problems with the overall course.

- Compliment (Content)
  The open code that most often appeared in the responses for this module was "quiz questions." This code appeared 12 times in the responses. The students were highly complimentary of the quiz questions with comments such as "The interactive questions kept me engaged;" "The questions throughout the module to assess our knowledge was very helpful;" and "the testing of knowledge throughout was great." Students indicated the most helpful part of the lesson were the quiz questions. The open code "videos" appeared six times in the qualitative responses associated with this axial code. Students wrote, "I enjoyed and found the videos useful." and "The videos were also helpful in understanding what the different biopsies consisted of." The open code "images" appeared two times as being the most helpful part of the lesson. One student specified "comparison images" as being the most helpful. More specific compliments about the content stated that the most helpful was "The explanation of the BIRADS system."

- Problem (Content)
  The open code "quiz questions" appeared six times. Specifically students reported issues with quiz questions missing feedback. "Some of the quizzes don't tell you the right answers." "Some questions did not have explanations;" and "some questions do not tell you the correct answer when wrong." Although the students were highly complimentary of the quizzes, one student wrote "The testing of knowledge throughout was great but minimal feedback was given when correct or incorrect and some questions gave no feedback at all." Other issues with quiz questions were that some" questions are asked before the module presents the information." Another issue reported was that "On the first screen, the 2 true or false questions have an answer bubble pop up when one clicks them, but both pop ups have the answer explanation for the first question." One student wrote that least helpful was "description of the science behind the scans."

- Recommendation (Content)
  This axial only had three open codes, which specifically pointed out areas to

improve in the modules. One student recommended more questions "I would have liked more questions." Another would have like more information on calcifications: "I [sic] think it could have done a better job at explaining the benign vs malignant calcifications. [the SME} explained it very simply in class...the module started out with using terms (i.e., branching, linear and branching, linear [casting]) that i was unfamiliar with and not able to understand until [the SME] explained it." The final recommendation was about the quiz questions: "please always provide correct answers for questions so i can learn."

- Problem (Usability)
  Only two open codes were identified for this axial code: "click boxes" and "back button." One student indicated that the least helpful part of the lesson was" Some parts had you click on boxes for only one sentence to pop up." The open code for "back button missing" appeared twice. Based on the context of where this is mentioned, this issue appears to happen after the quizzes. One student writes, "Some questions did not have explanations or the ability to go back and see where the issue was." This statement includes two distinct open codes. One for "Problem (Content)" and one for "Problem (Usability). However, it was useful in aiding the location of the missing back buttons in the module.

- Recommendations (Usability)
  There were two recommendations to improve the usability of the module. One student recommends a table of contents: I think a table of contents or an index slide with links would be helpful in order to go back and review certain parts without having to go through the whole lecture." Another offered a recommendation to include more information for interactive buttons: "would prefer more information per click or to consolidate that information into one slide."

Thirty-nine students completed the pre and posttest exam for the mammography module. As Table 24 shows, the posttest mean was higher than the pretest, as with the previous modules. The pretest mean was 30.05 and the posttest mean was 33.46.

Table 24

Mammography Paired Samples Statistics

		Mean	N	*SD*	Std. Error Mean
Pair 1	Pretest	30.05	39	26.839	4.298
	Posttest	33.46	39	33.328	5.337

A paired samples *t*-test was run to asses if the difference in the means was significant. The results are shown in Table 25. This analysis showed a difference in the mean of -3.410 and a significance of .083, which is higher than the alpha value (.05) which indicates that although there is an increase in the mean, it is not a significant difference.

Table 25

Mammography Paired Samples Test

		Paired Differences							
					95% Confidence Interval of the Difference				
		Mean	Std. Deviation	Std. Error Mean	Lower	Upper	*t*	*df*	Sig. (2-tailed)
Pair 1	Pretest - Posttest	-3.410	11.973	1.917	-7.291	.471	-1.779	38	.083

This outcome is further supported by analyzing the effect size using Cohen's *d*. This showed an effect size of .113 indicating that the mammography module had a small effect on the posttest scores.

Nuclear Medicine

Nineteen students completed the IEUQ for the nuclear medicine module. The highest rated measure was about how well students felt they could trust the information with a mean of 3.95. Nineteen students (100%) felt they could "mostly" or "very well" trust the information. Nineteen students (100%) reported the module was mostly or very convenient to use and easy to use. These measures shared the second highest mean, 3.74. Sixteen students (84%) reported that this method was mostly or very useful for delivering this content. Three students (16%) reported it was a somewhat useful method of delivering the content. This measure had the lowest mean, 3.32, of the four modules in the study. The lowest mean for this module was a 3.16 and was for the measure asking likelihood of returning to review the content after completing the rotation. Fourteen students (73%) reported they would be mostly or very likely to return; five (26%) reported they would be somewhat or slightly likely to return. Of the twelve items in the IEUQ, this module had the lowest mean in eight measures when compared to the three other modules in this study.

Satisfaction and usefulness rated high with satisfaction having a mean of 3.4316, and usefulness had a mean of 3.5489 as shown in Table 26. Although both constructs rated highly, this module was the lowest rated for both constructs of the four modules.

Table 26

Nuclear Medicine Student IEUQ Results

	N	Minimum	Maximum	Mean	*SD*
Satisfaction Mean	19	2.40	4.00	3.4316	.54676
Usefulness Mean	19	2.57	4.00	3.5489	.46963
Valid N (list wise)	19				

A qualitative analysis of the open-ended responses revealed the students were highly complimentary of the module; however, there were specific content areas that students deemed did not meet expectations. Table 27 shows the open and axial codes identified from the open-ended responses in the IEUQ. Fifteen open codes and 6 axial codes were identified in the qualitative responses. The axial codes with the most open codes were Compliment (Content) and Problem (Content) with four and three open codes, respectively.

Table 27

Nuclear Medicine Open and Axial Codes

Survey Question	Open Codes	Axial Codes
What was the most helpful part of the online lesson?	• Images (5) • Simple and concise information • Different types of studies • quizzes	Compliment (Content)
	• excellent • organized	Compliment (Overall)
What was the least helpful part of the online lesson?	• Identifying key information (2) • Lots of information (3)	Problem (Overall)
	• Lacked comparisons of normal vs pathologies • Details on agents used • Physics part	Problem (Content)
Please provide any additional comments for improvement.	• Not enough detail	Problem (Content)
	• More quizzes (3)	Recommendation (Content)
	• drag bar	Problem (Usability)
	• well developed	Compliment (Overall)

- Compliment (Overall)
  Students described this module as "excellent" and "organized." One student wrote, "In general the modules were excellent. Very organized and not an overwhelming amount of material." Another student was highly complimentary of the module: "I know there is always room for improvement but in my opinion the modules are very well developed, I do not really see anything that could have been done better. Thank you."

- Compliment (Content)
  Specific elements of the content were also complimented. As with the previous modules, students pointed out the helpfulness of the pictures with the open code "images" appearing five times. As with previous modules, the quizzes were reported to be helpful, and one student wrote "I think the quizes [sic] are nice. I am able to test my knowledge during each module."

- Problem (Overall)
  Although only two open codes were identified for this axial code, they appeared repeatedly. Students reported that there was "lots of information" with this open code appearing three times. One student wrote "Too much information, I could not identify what is critical for me to learn." This perception was repeated by another student who wrote "Lots of words, hard to keep up with what's going on." Another and similar problem reported was that as a result of too much information, students could not identify what was important. This open code "identifying key information" appeared three times. One student wrote, "Since I am very unfamiliar with nuclear medicine, extracting key info was more difficult in this module than others."

- Problem (Content)
  The problems with the content were very specific with students indicating the topics that needed more explanation. For example, one student wrote, "i think that the sentinel node imaging section did not go into enough detail and would be more helpful if it were longer…" Another student point out that "It lacked comparisons of normal vs pathologies. For example, I did not feel I grasped the differences between differentiating between a patellar abcess [sic] vs fracture." Other problems reported related to content areas that students felt were not helpful "sentinel node imaging section" and "details about what agents are used."

- Recommendation (Content)
  As with previous modules, students expressed the need for more opportunities to test their knowledge of the content. The open code "quizzes" appeared two times. One student wrote, "more quizzes integrated like in the U/S module." Another student further explained "please include quizzes to test my knowledge, it will help me learn better."

- Problem (Usability)
  Only one student reported a usability problem, and it was that "the drag bar did not work."

Pre and posttest data were also analyzed. Thirty-eight students took the pretest and posttest. The pretest mean was 31.18, and the posttest mean was slightly higher at 31.63 as shown in Table 28. As this preliminary analysis indicated an increase in the posttest mean, it was necessary to conduct further analysis to assess if the difference was significant.

Table 28

Nuclear Medicine Paired Samples Statistics

		Mean	N	*SD*	Std. Error Mean
Pair 1	Pretest	31.18	38	22.335	3.623
	Posttest	31.63	38	32.000	5.191

As table 29 shows, a paired sample *t*-test was run. It showed that the mean difference between the pretest and posttest was -.447. Most importantly, significance measured at .860. This indicates that the difference in the mean was not significant as the significance value is greater than the value of .05.

Table 29

Nuclear Medicine Paired Samples Test

		Paired Differences							
					95% Confidence Interval of the Difference				
		Mean	Std. Deviation	Std. Error Mean	Lower	Upper	*t*	*df*	Sig. (2-tailed)
Pair 1	Pretest - Posttest	-.447	15.491	2.513	-5.539	4.645	-.178	37	.860

This conclusion was further supported by analyzing the effect size, which yielded .016 for Cohen's *d.* This meant that the module had a small effect on the increase in the posttest mean for this module.

Findings

An analysis of the results at each phase of the ADDIE process identified key themes related to content, design, and usability. Another important theme identified during this study was the difference in the focus during the review process between experts and students. The themes identified were used in the design of the framework ultimately recommended for use when designing online learning modules.

Development Phase Data

The results of the Pilot test conducted during the development phase showed that the expert-clinicians focused exclusively on the content of the modules. Qualitative responses provided recommendations for changes to the source material in areas where the expert-reviewer felt changes to the wording or terminology would aid in student understanding. As previously discussed, the SME agreed with many of these recommendations.

Student-experts, however, provided more robust responses which included recommendations on usability, grammar, and content. Yet, as expected, student-expert recommendations on content did not provide for changes to existing content. Instead, student-experts requested additional information, clarification, or clearer explanations on content illustrating the difference in expectations and needs between content experts and medical students. Experts with content knowledge of the topic focus on elements of the material that can be improved or changed. Whereas students, even those who have previous experience with the content, identify areas where additional information is needed. This is an important difference and one that shows how critical a pilot test with a student population is to the development of online modules as this group can aid SMEs in identifying areas in the content where novice students will need additional explanation or images to support their learning. This was especially clear in the Nuclear Medicine module where the student-experts noted that some slides were "wordy, difficult to understand" and that students would find the "scientific background" least helpful.

Student-experts also requested more quizzes, thus, more opportunities to test their own knowledge as the module progressed. This demonstrates a distinct need of the novice learner that content-experts may not identify in their review because of their familiarity with the subject.

Student-experts also provided data related to usability whereas the clinician-expert group did not. Assessing usability of online activities is an important element in the ADDIE process and one that also needs to be incorporated any framework used. In this study, student-experts indicated usability issues with elements of the module player (e.g. "horizontal slider difficult to use").

When analyzing the results of the Development phase data and evaluating both the clinician-expert and student-experts responses, one recommendation for the framework becomes clear. This is the need for online lessons to be reviewed by both content-experts and a novice student population. A pilot test that is comprised of both groups will provide for a robust analysis and identification of gaps from the perspective of two distinct groups. The content-expert can provide for improvement of the content from clinical and practical perspective. The student group will identify areas where the novice learner needs additional information or content scaffolding in order to understand better the source material.

The quantitative data from the student-expert IEUQ also provided useful results. An analysis of the overall responses show that this participant group rated the ultrasound module highest for both the satisfaction and usefulness constructs (3.95 and 3.88, respectively). The lowest rated was mammography with a 3.75 for satisfaction and 3.64 for usefulness.

An analysis of the qualitative data from the student-expert participant group provided for the identification of additional key themes. Qualitative data indicated that this group evaluated the modules from the perspective of understandability of the information. This group primarily provided qualitative responses such as "information easy to understand," "organization helpful," "explanation not clear," "more content," and "clarification needed." This data allowed the SME to evaluate his learning material for areas where a novice learner would need more information.

In conducting an analysis of the data in this phase, several key themes were identified. Experts provide highly focused feedback on content (e.g., changes to terminology, indicating outdated information). Student-experts provided feedback on areas where content was too dense, not enough content was provided, additional information was needed, and lack of areas for self-assessment). The key difference between the feedback provided by the clinician-expert and the student-expert group can be explained. The result of this difference in how experts and novices approach learning material illustrates the need for a diverse group of reviewers when developing an online learning lesson. Experts provide subject matter expertise and aid in improving the content delivery. Novice learners will identify areas where information gaps exist, and areas where other learners will likely struggle to understand. Experts also know how to discern which information is key and which to ignore, minimizing cognitive overload. Novice learners are unable to make that determination. Allowing for both experts and novices to review online lessons prior to implementation provides with robust data for improving course material.

Evaluation Phase Data

The evaluation phase data showed that students were satisfied with the modules and indicated they found them useful. The overall mean for all the modules was 3.61 for satisfaction and 3.64 for usefulness. A comparison of the IEUQ constructs for each module found that the ultrasound module rated highest for usefulness and the mammography module highest for satisfaction (3.74 and 3.73, respectively). Nuclear medicine was the module with the lowest mean for both constructs: 3.43 for satisfaction and 3.55 for usefulness.

The findings indicated that students were satisfied and found the modules useful. This is supported by the qualitative data, as students were primarily complimentary of all the modules. Students provided compliments such as “holds my attention,” “very educative,” “enjoyed module thoroughly,” “good in general,” and “excellent.”

This group also provided data on areas of the modules where they felt additional information, clarification, or explanations were needed. One key theme that appeared throughout the student data was the need for quizzes to test their knowledge throughout the lessons. The open code “quizzes” appeared for all the modules when responding to the question of “What was the most helpful part of the online lesson?” with the exception of the Introduction to Imaging, as this module did not include quizzes. In fact, one recommendation for improvement in this lesson was “would be nice to have questions.”

In modules that included quizzes, students specifically asked for quizzes that provided correct or incorrect feedback. This was most evident in the mammography module where, within the axial code of Problem (Content), the open code “quiz questions” appeared six times. The qualitative data showed that students reported issues with quiz questions missing feedback or when questions were posed before the module presented the information. This key theme was used in the final framework designed and is discussed in the following chapter.

In addition to complimenting the overall modules, the student participant group also provided data on usability and design issues. One key theme in these responses is for efficiency in the interactions. Students indicated that some slides showed minimal information after clicking a button. Recommendations included "would prefer more information per click or to consolidate that information into one slide." Another useful recommendation was to provide a table of contents to aid in the process of review process. This leads to another key theme. When designing a lesson, the ID and/or the SME must take into consideration the needs of students going back to review the content, not just the student visiting the online lesson for the first time. Thus, when designing an online lesson for usability, the framework used needs to account for both learning experiences.

Summary

This chapter reviewed the results of the study beginning with the pilot tests conducted during the development phase and data collected during the implementation phase. During the development phase, two pilot tests were conducted, first with expert-clinicians and then with expert-students. During the implementation phase, data were collected from the medical student population, students who were rotating through the radiology clerkship during this phase.

The chapter reviewed in detail the process for analyzing the quantitative and qualitative data collected through the pre and posttest and the post module survey, IEUQ.

Quantitative data was analyzed using SPSS. Qualitative data was analyzed by identifying open and axial codes. A discussion on the results of the analysis of this data identified elements and concepts for use in the framework. The three themes identified were content, design, and usability. The analysis also showed the difference between content experts and novice learners. Expert learners focus on areas of content that can be improved, whereas novice learners will identify areas where additional information is needed, too much information is present, and areas where the explanations are unclear.

Chapter 5

Conclusions, Implications, Recommendations, and Summary

This study applied an instructional design process to the development of an e-learning module for a third year, radiology clerkship course using the ADDIE (Analyze, Design, Develop, Implement, Evaluate) process as a framework and incorporating a rapid prototyping approach. The ADDIE process was used to develop four online, multimedia modules. Following a flipped classroom design, students viewed the modules before class and then had in-class discussions or practice exercises related to the topic of the online lesson.

This chapter provides a summary of the study results within the context of the research questions. Also included is a discussion on the framework for use in the development of online learning modules. This chapter also reviews the limitations of the study and makes recommendations for future research.

Conclusions

Three questions guided this study.

Q1. How can the ADDIE process be used in the development of e-learning modules for a third-year radiology clerkship?

Q2. What do students report about the ease of use and learning value of the modules?

Q3. Based upon an analysis of implementation and necessary revision, what is the framework that is recommended for course development?

The conclusions for each question are detailed below. Included is a discussion on three themes that were identified through an analysis of the qualitative and quantitative data.

Research Questions

Research Question 1: "How can the ADDIE process be used in the development of e-learning modules for a third-year radiology clerkship?"

In order to answer this question, the qualitative and quantitative data from each phase of the ADDIE process were analyzed. In evaluating the data collected throughout the ADDIE process for each module, implications for the application of the ADDIE process became evident. Following an instructional design methodology when developing online modules allows the SME and ID to collect data from a variety of participant types. This study has illustrated the differences between data collected from experts and novice learners. As previously discussed, experts focused on improvements and enhancements to the content, whereas novice learners aided in identifying areas in the content where students with minimal knowledge of the content require additional information or where clarification is needed. Novice learners identified areas that may be too dense and could benefit from scaffolding or chunking. By incorporating a pilot test with experts and novice learners in the development phase of the ADDIE process, a comprehensive review of the module content is achieved, the results of which can then be incorporated into the source material for improvement before implementation.

The evaluation phase of the ADDIE process calls for the evaluation of the learning material. In this study, Kirkpatrick's levels of evaluation (Level one, Reaction, and Level two, Learning) were used. According to Kirkpatrick and Kirkpatrick (2007), there are four areas that must be measured in the Level one Reaction form: the course, content, instructor, and job relevancy. For this study, neither the instructor nor job relevancy were evaluated as the former is outside the scope of this study, and the latter cannot be measured with this population as they have not had sufficient experience on the job to assess the job relevancy of the content. Instead, two constructs were measured within the area of content: affective reaction and utility.

The Internet Evaluation and Utility Questionnaire (IEUQ) was selected as the tool to assess these two constructs. As discussed in the previous chapter, students indicated high means for both satisfaction and usefulness for all modules. Overall, the means for satisfaction and usefulness were 3.61 and 3.64, respectively. This was supported by the qualitative data where the predominant axial code for all modules was Compliment (Overall).

Kirkpatrick's Level two measures learning. In this study, learning was measured by administering a pre- and posttest to the medical student participant group. The pre- and posttests were created and administered using a web-based program, Radiology ExamWeb (REW). An analysis of the results of the paired *t*-test only showed a significant improvement in posttest scores in the Introduction to Imaging module. Although posttest scores in the Ultrasound, Mammography, and Nuclear Medicine modules increased, none of the increases was significant. This analysis was supported by an analysis using Cohen's *d*, which showed a large effect size for the Introduction to

Imaging module, a moderate effect size for Ultrasound and Mammography, and small effect size for the Nuclear Medicine module.

The results of Level two indicate that conclusions cannot be drawn about the effectiveness of the online learning modules on student learning. Although one module did show significantly improved posttest scores, there is not enough data to prove that online learning modules result in improved learning outcomes.

Nonetheless, the role of the ADDIE process in the development of the modules provided for significant improvement to the content prior to implementation. This is especially important in situations where the SME is also the instructional designer (ID). It gives medical faculty, who might have limited teaching experience or pedagogical knowledge, the opportunity to follow an established and proven process ensuring that objectives, content, and assessments correlate.

Research Question 2: "What do students report about the ease of use and learning value of the modules?"

Analysis of the quantitative and qualitative end-of-module IEUQ completed by the expert-student reviewers during the Pilot test in the development phase and by the students during the evaluation phase provided the response to this question. The analysis of the quantitative data of the pilot test showed that the student-expert group rated the overall modules with a 3.82 for satisfaction and a 3.79 for usefulness. The qualitative data supported the high means.

The medical student group also rated the modules highly. This group indicated a 3.61 for satisfaction and a 3.64 for usefulness overall. The qualitative responses supported the high ratings with the most frequent axial code being "Compliment

(Overall)" or "Compliment (Content)" for all modules. Across the modules, these two axial codes consistently appeared. Medical students especially complemented the use of images in the modules. The open code "images" appeared multiple times in the qualitative results for each module. This open code also appeared when students were asked for recommendations with comments such as "would like to see more imaging and examples." It is evident that students find the use of images especially helpful for this content.

Some of the comments also illustrate the positive attitude students had toward the learning value of the modules. Qualitative responses included comments such as "excellent, very fun way to learn," and "In general the modules were excellent." These positive comments were repeated throughout the qualitative responses. One of the student-expert responses called for more of these multimedia modules, stating "i believe that it would be a great idea to have a module for every session but the student should still read the chapter associated with the subject that is going to be tested because that way they will have a better understanding." Overall, students reported being satisfied with the modules.

In analyzing the quantitative and qualitative data for the medical students, it becomes clear that students were satisfied with the content presented in a multimedia format and found it a useful method for delivering this learning material. One qualitative response was complimentary of the multimedia design of the course. For the question of what was most helpful, one participant responded "The different methods utilized for teaching: pictures, videos, short paragraphs, questions and answers."

There were minimal issues with ease of use reported. The axial code of Problem (Usability) appeared for each module with few open codes. These open codes were mostly associated with navigation issues such as a "next" button not working, or issues with the slider. These technical issues are easily resolved and were not a reflection of a negative user experience with the overall modules.

The quantitative data did show, however, that although students were satisfied with the modules and found them useful, they were not likely to return to review the content after completing the rotation. This measure on the IEUQ "How likely are you to come back to this online module to review content after completing this clerkship rotation?" had the lowest mean for all modules. Across all modules, the mean for this measure was 3.14, the lowest mean for all measures in the IEUQ.

Research Question 3 "Based upon an analysis of implementation and necessary revision, what is the framework that is recommended for course development?"

In order to answer this research question, an analysis of the ADDIE process with specific emphasis on issues that arose during the implementation and evaluation phases was conducted. The result of this analysis provided a framework that can be used with developing online learning modules in other medical courses. The resulting framework incorporates rapid prototyping into the ADDIE process. This element is important when developing modules under aggressive timelines. One of the criticisms of the ADDIE process and a reason for reluctance to implement it in module development is that it is a time-consuming process. The framework developed for this study allows for the flexibility of incorporating rapid development or using the traditional ADDIE development process utilizing a storyboard until the development phase. Included in the framework are design and usability considerations that improve the user experience with the modules. Figure 14, below, provides a visual representation of the framework.

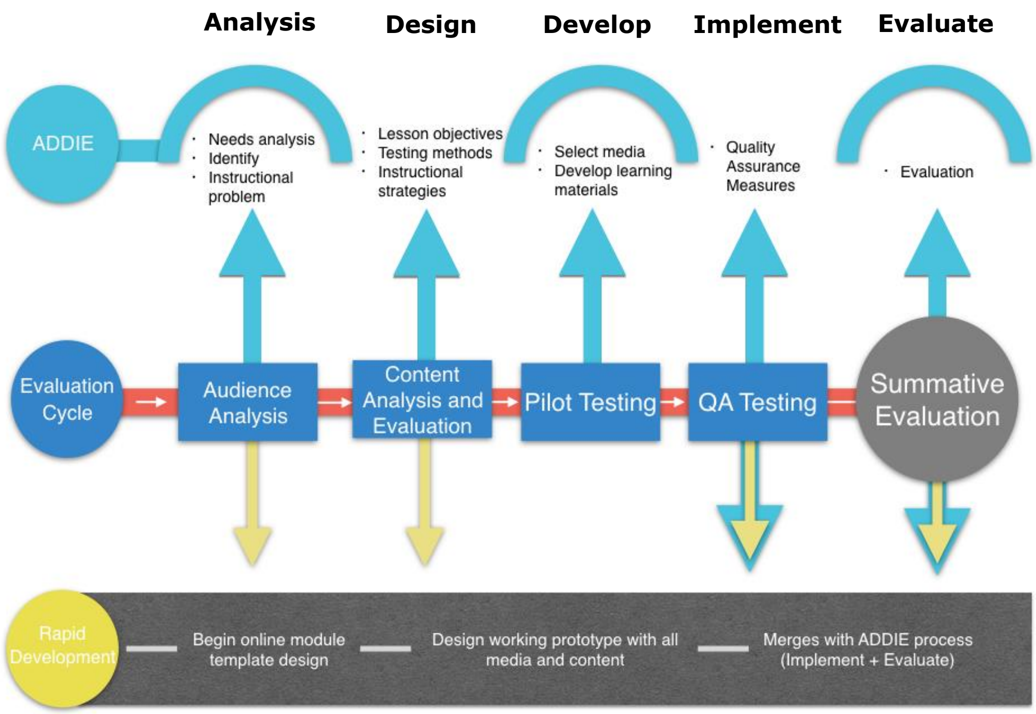


Figure 14. Proposed instructional design framework for medical education.

The framework follows the ADDIE process, but incorporates evaluation points and a rapid development process that move in parallel to the ADDIE process. Within each phase, the primary tasks are abstracted. The framework also provides for evaluation to occur at every phase of the ADDIE process and identifies evaluation tasks that are conducted during each phase. This framework allows for the flexibility of incorporating rapid prototyping or for following the traditional method of storyboarding the project until the development phase.

During the analyze phase, a needs analysis is conducted. Following Branch (2009), this framework proposes conducting an audience analysis, a needs analysis to identify the instructional problem, and identifying resources such as the curriculum delivery system and human resources for the module development. The evaluation task that is conducted during this phase is the audience analysis. This task has the ID and the SME identifying the primary audience for the module including academic background (e.g., undergraduate, graduate) and familiarity with the content. The answers to these questions will guide the academic level of the material developed in the subsequent phase, the design phase. If rapid development is to be used, the ID begins the lesson template design at this phase.

The design phase sees the writing of lesson objectives and the selection of testing methods and instructional strategies that will meet those objectives. The evaluation task that occurs in this phase is content evaluation. This task requires that the ID and the SME evaluate if the selected instructional strategies and testing methods meet the lesson objectives. If the project is using rapid development, this phase sees the completion of a working prototype.

The develop phase is a critical moment in this framework. The SME develops the learning materials, and the ID and SME select the media to support the content. Once the development of the learning materials is completed, the content is incorporated into the working prototype. The evaluation steps required in this phase are to conduct two pilot tests. The first pilot test is conducted with content experts and the second with a student population with similar characteristics as the target audience. One recommendation in this framework is that a pilot test be conducted in order to assess the content from a student's perspective, but also collect data on the usability of the lesson, the results of which are evaluated by the ID. Then, the content issues identified are addressed with the SME. The ID can address technical and usability issues.

Once the ID evaluates the results of the pilot test and incorporates those results into the lesson, the project moves into the implementation phase. The ID prepares the lesson for delivery (such as in a learning management system) and applies quality assurance measures and evaluates the results to ensure standards of quality are met (Peterson, 2003).

The final phase of the process is evaluate. Summative evaluations are conducted based on the testing methods identified during the design phase. The data collected during this phase are analyzed and issues with content or usability are identified and resolved before the next time the online lesson is delivered to students.

This process, as the image shows, is not a linear one, but an iterative one that begins with the analysis phase through the evaluate phase with the aim of ensuring a constant quality improvement process.

This framework also proposes three overarching themes to this framework: content, design, and usability (Figure 15). These themes guide the choices made at each step of the process. Content is the critical element of any lesson. This is especially true for online, multimedia lessons because the selection of content and supporting media is essential to support student learning. The evaluation and selection of the appropriate content starts with the analysis phase and continues through the evaluation phase.

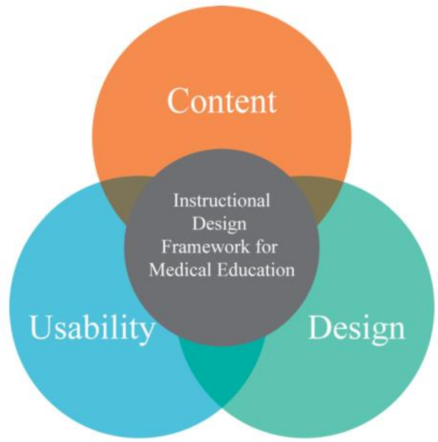


Figure 15. Overarching themes that guide the instructional design framework. These themes were identified through a qualitative analysis of the student responses.

This framework proposes specific requirements related to content for an online module developed for radiology. When developing content, it is necessary to include formative assessments so students can evaluate their knowledge of the content. Questions with contextual feedback must be incorporated throughout the lesson. The feedback should explain why question options are correct or incorrect, essentially using quizzes as both an assessment and teaching tool. The second requirement within the construct of content pertains to the pilot tests. This study identified that experts and novices should review material as part of the pilot test in the development phase. Each audience type provides a distinct perspective about the content resulting in a comprehensive evaluation of the content prior to implementation.

The second overarching theme is design. Within the ADDIE process, design is the second phase where lesson objectives, testing methods, and instructional strategies are selected. However, as a theme that guides the overall framework, design guides the selection of images to support the content and the identification of opportunities for interaction between the student and the content. These choices must be made from the perspective of the student completing the module. Two requirements that were identified from this study were the need to keep students engaged through interaction, yet be careful to avoid excessive clicking.

The third guiding theme is usability. For any online lesson, usability is a guiding factor influencing the design of the user interface, content organization and layout, and interactive elements. As the qualitative data of this study showed, students will notice areas where functionality acts as a barrier to a pleasant user experience.

The aim of any online lesson is to allow the student to focus on the content and learning. The recommended framework provides for an instructional design process that can be easily followed by those with little knowledge of educational or learning theories. It gives medical faculty the guidance they need to assess their material throughout each phase of the process. It also provides medical faculty with three overarching themes to aid in the conceptualization and ultimate design of their learning material.

Limitations

There were two limitations to this study. First, a convenience sample was used instead of random sampling. As a result of using a convenience sample, the results of this study cannot be generalized beyond the HWCOM. A second limitation was due to the interaction between the researcher and some participants during the pilot study. This contact occurred when additional information or clarification was needed after reviewing a clinician-expert or student-experts responses to the IEQU during the development phase. Participants may not have been completely honest with the researcher about their perceptions of the modules.

Implications

This study has several implications for practice and for research.

Implications for Practice

The implications for practice of this study are important within the field of medical education. In identifying the differences between an expert review of content and novice review of content, one major implication for practice is the importance of piloting online modules whenever possible. Therefore, project development timelines should always permit for the administration of a pilot study.

Another implication for practice, and the primary focus on this study, was to demonstrate the value of following an instructional design methodology when developing online, multimedia lessons. The results of the study have shown that by following a proven methodology, such as ADDIE, the content cycles through several iterations of review and analysis prior to implementation. Without this methodology, medical educators develop online learning lessons that might not meet educational goals, contain concepts too complex for the audience, and lack any usability standards. Adhering to the steps of an instructional design methodology allow SMEs to address these issues, resulting in a well-developed online, multimedia lesson.

Implications for Research

This study has demonstrated the need to follow an instructional design methodology when developing online, multimedia lessons for a radiology clerkship. Although pre- and posttests were administered as part of the evaluation phase following Kirkpatrick's Level of Evaluation, the primary goal of this step was not to evaluate the lessons for impact on outcomes. There is an opportunity for future research to evaluate the effectives on online, multimedia lessons on learning outcomes.

Recommendations

This study was conducted in a third-year radiology clerkship course in an undergraduate medical program. One recommendation for future research is to expand this study for additional courses within undergraduate medical education, beginning with courses in the first and second academic periods.

Additional research should be expanded to include graduate medical education (GME) where these lessons will benefit students and clinicians who may lack the time to sit in a lecture room. Expanding research into GME can provide insight into the differences between learner expectations and outcomes between these two groups.

Future research can be conducted to look into the role of online, multimedia lessons when used on conjunction with a flipped-classroom methodology. Within medical education, flipped-classroom methodology is being used more often. This provides for an opportunity to identify a framework for this specific teaching and learning approach.

Summary

The goal of this study was to develop a framework that could be used by medical schools when developing supplemental online learning lessons. This framework would follow an instructional design methodology, ADDIE, and allow for the use of rapid prototyping minimizing the time required to develop these materials.

Four modules were developed for use in a radiology clerkship in an undergraduate medical education program in Miami, FL. The topics of these lessons were Introduction to Imaging, Ultrasound, Mammography, and Nuclear Medicine. At the completion of each module, reviewers completed a survey that collected quantitative and qualitative data, the IEUQ (Internet Evaluation and Usability Questionnaire).

The process for developing the modules followed an instructional design process, ADDIE (Analysis, Design, Develop, Implement, Evaluate). During the analysis phase, the SME and ID met to identify the topics for the lessons and review learning materials. Once the topics were identified, the SME provided the content to the ID to being development of the modules. Using rapid prototyping, the ID built the lessons using Articulate Storyline ®. The review process between the ID and SME was conducted several times. Once the SME indicated module development was completed, the modules moved into the pilot study. At this point, the SME shared with expert-clinicians a link to the lesson. The ID reviewed the results submitted through the IEUQ.

The study followed a mixed-methods design. According to (Creswell, 2009), this research methodology allows for a deeper understanding of the phenomenon or research questions. Qualitative and quantitative data were collected through the IEUQ. If the responses were not sufficiently clear, the ID would communicate directly with the reviewers. After the results of the expert-clinicians were reviewed by the ID, the ID would meet with the SME to review and seek approval for any recommended modifications to the lesson. Once the ID made these modifications, the lesson would move into the second part of the pilot study, and the SME would share the file with expert-students. The ID would then evaluate the results of the expert-student review and share them with the SME for review and approval of any recommendations changes. Once completed, the lesson moved into the implementation phase where medical students rotating through the radiology clerkship would complete the lessons as they progressed through the two-week course.

For all four modules, medical students would complete a pre-test, posttest, and IEUQ. Data from the implementation phase were collected from May 2015 through December 2015. At the end of the study, the process moved into the evaluation phase, and the ID conducted data analysis of the qualitative and quantitative data.

The results of the analysis indicated that students were highly satisfied with the modules and found them useful. A comparison of the IEUQ constructs for each module found that the ultrasound module rated highest for usefulness and the mammography module highest for satisfaction. Nuclear medicine was the module with the lowest mean for both constructs. The qualitative data supported the results of the quantitative data. An analysis of the open codes for the modules showed that students were highly complimentary of the modules.

This study also sought to answer three research questions.

Q1. How can the ADDIE process be used in the development of e-learning modules for a third-year radiology clerkship?

Q2. What do students report about the ease of use and learning value of the modules?

Q3. Based upon an analysis of implementation and necessary revision, what is the framework that is recommended for course development?

For question one, an analysis of the data from pilot study and the data from the implementation illustrate that there are differences between data collected from experts and novice learners. Whereas experts focused on improvements and enhancements to the content, novice identify areas in the content where novice learners need additional information or clarification. This group also identified areas where too much information was provided and areas that benefit from scaffolding or chunking. By incorporating a pilot test with experts and novice learners in the development phase of the ADDIE process, a comprehensive review of the module content was achieved. In essence, following the ADDIE process provided for significant improvement to the content prior to implementation. When medical faculty, who may have little or no pedagogical knowledge, follow ADDIE, it gives them a guideline to follow an established and proven process ensuring that objectives, content, and assessments correlate.

Question two was answered through an analysis of the quantitative and qualitative end-of-module IEUQ completed by the expert-student reviewers during the Pilot test in the development phase and by the students during the evaluation phase. There were minimal issues with ease of use reported. As to the learning value of the modules, the student-expert group rated the overall modules with a 3.82 for satisfaction and a 3.79 for usefulness with the results of the qualitative data supporting these high means. The medical student group also rated the modules highly. This group indicated a 3.61 for satisfaction and a 3.64 for usefulness. The qualitative responses also supported the high ratings.

Question three was addressed through an analysis of the overall ADDIE process used in this study. The framework developed follows the ADDIE process, but incorporates evaluation points and rapid development that move in parallel to the ADDIE process. Within each phase, the primary tasks are abstracted. This framework allows for the flexibility of incorporating rapid prototyping or for following the traditional method of storyboarding the project until the development phase. This framework also proposes three overarching themes to this framework: content, design, and usability.

The aim of any online lesson is to allow the student to focus on the content and their learning. The recommended framework provides for an instructional design process that can be easily followed by those with little knowledge of educational or learning theories. It gives medical faculty the guidance they need to assess their material throughout each phase of the process. It also provides medical faculty with three overarching themes to aid in the conceptualization and ultimate design of their learning material.

This study showed the significance of following an instructional design process when developing online, multimedia lessons. There are important differences between the data collected between content experts and students. Following the recommended framework provides for the guidance that medical faculty need not just when analyzing, developing, and designing the learning materials, but through the implementation and evaluation phase. A robust framework, such as the one recommended, could result in well-designed online, multimedia lessons resulting in high student satisfaction.

Appendices

Appendix A: IRB Approval

FLORIDA INTERNATIONAL UNIVERSITY

Office of Research Integrity
Research Compliance, MARC 270

MEMORANDUM

To:	Dr. Leslie Bofill
CC:	File
From:	Maria Melendez-Vargas, MIBA, IRB Coordinator
Date:	January 30, 2015
Protocol Title:	"The Design and Implementation of Online Radiology Modules Using the ADDIE Process and Rapid Prototyping"

The Health Sciences Institutional Review Board of Florida International University has approved your study for the use of human subjects via the **Expedited Review** process. Your study was found to be in compliance with this institution's Federal Wide Assurance (00000060).

IRB Protocol Approval #:	IRB-15-0023	**IRB Approval Date:**	01/27/15
TOPAZ Reference #:	103013	**IRB Expiration Date:**	01/27/16

As a requirement of IRB Approval you are required to:

1) Submit an IRB Amendment Form for all proposed additions or changes in the procedures involving human subjects. All additions and changes must be reviewed and approved by the IRB prior to implementation.
2) Promptly submit an IRB Event Report Form for every serious or unusual or unanticipated adverse event, problems with the rights or welfare of the human subjects, and/or deviations from the approved protocol.
3) Utilize copies of the date stamped consent document(s) for obtaining consent from subjects (unless waived by the IRB). Signed consent documents must be retained for at least three years after the completion of the study.
4) **Receive annual review and re-approval of your study prior to your IRB expiration date.** Submit the IRB Renewal Form at least 30 days in advance of the study's expiration date.
5) Submit an IRB Project Completion Report Form when the study is finished or discontinued.

Special Conditions: N/A

For further information, you may visit the IRB website at http://research.fiu.edu/irb.

Appendix B: IRB Approval of Signed Consent Form

FIU IRB Approval:	1/27/2015
FIU IRB Expiration:	1/27/2016
FIU IRB Number:	IRB-15-0023

FIU | FLORIDA INTERNATIONAL UNIVERSITY

ADULT CONSENT TO PARTICIPATE IN A RESEARCH STUDY
The Design and Implementation of Online Radiology Modules
Using the ADDIE Process and Rapid Prototyping

PURPOSE OF THE STUDY
You are being asked to be in a research study. The purpose of this study is to evaluate the effectiveness of applying an instructional systems design to the development of an e-learning module. The results of the study will allow for the development of a framework for use when designing interactive, online learning modules that can applied to the development of other courses in the medical school.

NUMBER OF STUDY PARTICIPANTS
If you decide to be in this study, you will be one of 45 people in this research study.

DURATION OF THE STUDY
Your participation will require 4 hours (30 minutes a day for 8 days).

PROCEDURES
If you agree to be in the study, we will ask you to do the following things:
1. Take an online pre-test via ExamWeb.
2. View an online radiology module.
3. Take an online post-test via ExamWeb.
4. Complete an online survey about your opinions about the online radiology module.

RISKS AND/OR DISCOMFORTS
The following risks may be associated with your participation in this study: There are no known risks associated with this study.

BENEFITS
The following benefits may be associated with your participation in this study: There are no known benefits to participants.

ALTERNATIVES
There are no known alternatives available to you other than not taking part in this study. However, any significant new findings developed during the course of the research which may relate to your willingness to continue participation will be provided to you.

FIU IRB Approval:	1/27/2015
FIU IRB Expiration:	1/27/2016
FIU IRB Number:	IRB-15-0023

CONFIDENTIALITY
The records of this study will be kept private and will be protected to the fullest extent provided by law. In any sort of report we might publish, we will not include any information that will make it possible to identify a subject. Research records will be stored securely and only the researcher team will have access to the records. However, your records may be reviewed for audit purposes by authorized University or other agents who will be bound by the same provisions of confidentiality.

Pre and post-test data will be de-identified prior to being stored. All data will be stored in an FIU network drive which is password protected and behind a firewall. Survey data is collected anonymously and cannot be associated with a specific participant.

COMPENSATION & COSTS
No compensation is provided to participants.

RIGHT TO DECLINE OR WITHDRAW
Your participation in this study is voluntary. You are free to participate in the study or withdraw your consent at any time during the study. Your withdrawal or lack of participation will not affect any benefits to which you are otherwise entitled. The investigator reserves the right to remove you without your consent at such time that they feel it is in the best interest.

RESEARCHER CONTACT INFORMATION
If you have any questions about the purpose, procedures, or any other issues relating to this research study you may contact Leslie Bofill at FIU Wertheim College of Medicine, 11200 SW 8 street, AHC2-492, Miami, FL 33199, 305-348-1470, lbofill@fiu.edu.

IRB CONTACT INFORMATION
If you would like to talk with someone about your rights of being a subject in this research study or about ethical issues with this research study, you may contact the FIU Office of Research Integrity by phone at 305-348-2494 or by email at ori@fiu.edu.

PARTICIPANT AGREEMENT
I have read the information in this consent form and agree to participate in this study. I have had a chance to ask any questions I have about this study, and they have been answered for me. I understand that I am entitled to a copy of this form after it has been read and signed.

____________________________ ________________
Signature of Participant Date

____
Printed Name of Participant

____________________________ ________________
Signature of Person Obtaining Consent Date

Appendix C: IRB Approval of Online Consent Form

FIU IRB Approval:	1/27/2015
FIU IRB Expiration:	1/27/2016
FIU IRB Number:	IRB-15-0023

FIU | FLORIDA INTERNATIONAL UNIVERSITY

ADULT CONSENT TO PARTICIPATE IN A RESEARCH STUDY
The Design and Implementation of Online Radiology Modules
Using the ADDIE Process and Rapid Prototyping

PURPOSE OF THE STUDY
You are being asked to be in a research study. The purpose of this study is to evaluate the effectiveness of applying an instructional systems design to the development of an e-learning module. The results of the study will allow for the development of a framework for use when designing interactive, online learning modules that can applied to the development of other courses in the medical school.

NUMBER OF STUDY PARTICIPANTS
If you decide to be in this study, you will be one of 45 people in this research study.

DURATION OF THE STUDY
Your participation will require 4 hours (30 minutes a day for 8 days).

PROCEDURES
If you agree to be in the study, we will ask you to do the following things:
1. View an online radiology module.
2. Complete an online survey about your opinions about the online radiology module.

RISKS AND/OR DISCOMFORTS
The following risks may be associated with your participation in this study: There are no known risks associated with this study.

BENEFITS
The following benefits may be associated with your participation in this study: There are no known benefits to participants.

ALTERNATIVES
There are no known alternatives available to you other than not taking part in this study. However, any significant new findings developed during the course of the research which may relate to your willingness to continue participation will be provided to you.

CONFIDENTIALITY
The records of this study will be kept private and will be protected to the fullest extent provided by law. In any sort of report we might publish, we will not include any information that will

FIU IRB Approval:	1/27/2015
FIU IRB Expiration:	1/27/2016
FIU IRB Number:	IRB-15-0023

make it possible to identify a subject. Research records will be stored securely and only the researcher team will have access to the records. However, your records may be reviewed for audit purposes by authorized University or other agents who will be bound by the same provisions of confidentiality.

All data will be stored in an FIU network drive which is password protected and behind a firewall. Survey data is collected anonymously and cannot be associated with a specific participant.

COMPENSATION & COSTS
No compensation is provided to participants.

RIGHT TO DECLINE OR WITHDRAW
Your participation in this study is voluntary. You are free to participate in the study or withdraw your consent at any time during the study. Your withdrawal or lack of participation will not affect any benefits to which you are otherwise entitled. The investigator reserves the right to remove you without your consent at such time that they feel it is in the best interest.

RESEARCHER CONTACT INFORMATION
If you have any questions about the purpose, procedures, or any other issues relating to this research study you may contact Leslie Bofill at FIU Wertheim College of Medicine, 11200 SW 8 street, AHC2-492, Miami, FL 33199, 305-348-1470, lbofill@fiu.edu.

IRB CONTACT INFORMATION
If you would like to talk with someone about your rights of being a subject in this research study or about ethical issues with this research study, you may contact the FIU Office of Research Integrity by phone at 305-348-2494 or by email at ori@fiu.edu.

PARTICIPANT AGREEMENT
I have read the information in this consent form and agree to participate in this study. I have had a chance to ask any questions I have about this study, and they have been answered for me. By clicking on the "consent to participate" button below I am providing my informed consent.

(Insert Consent to Participate Button Here on the Website)

Appendix D: Clinician and Student Expert Survey

Internet Evaluation and Utility Questionnaire

These questions are about your use of this online lesson. Please read the items and tell us how you felt about using the online lesson. If the item does not apply, please choose "NA".

1. How easy was the online lesson to use?

Very (4)	Mostly (3)	Somewhat (2)	Slightly (1)	Not at all (0)	N/A

2. How well did the online lesson keep your interest and attention?

Very (4)	Mostly (3)	Somewhat (2)	Slightly (1)	Not at all (0)	N/A

3. How well did you like the online lesson?

Very (4)	Mostly (3)	Somewhat (2)	Slightly (1)	Not at all (0)	N/A

4. How well did you like the way the online lesson looked?

Very (4)	Mostly (3)	Somewhat (2)	Slightly (1)	Not at all (0)	N/A

5. How satisfied were you with the online lesson?

Very (4)	Mostly (3)	Somewhat (2)	Slightly (1)	Not at all (0)	N/A

6. How well do you think this online lesson will meet students' needs?

Very (4)	Mostly (3)	Somewhat (2)	Slightly (1)	Not at all (0)	N/A

7. How useful do you think students will find the online lesson?

Very (4)	Mostly (3)	Somewhat (2)	Slightly (1)	Not at all (0)	N/A

8. How easy do you think it will be for students to understand the information?

Very (4)	Mostly (3)	Somewhat (2)	Slightly (1)	Not at all (0)	N/A

9. How useful do you think an online module is for delivering this content to students?

Very (4)	Mostly (3)	Somewhat (2)	Slightly (1)	Not at all (0)	N/A

10. What do you think students will find the most helpful part of the online lesson?

11. What do you think students will find the least helpful part of the online lesson?

12. Please provide any additional comments for improvement.

Appendix E: Medical-Student Survey

Internet Evaluation and Utility Questionnaire

These questions are about your use of this online lesson. Please read the items and tell us how you felt about using the online lesson. If the item does not apply, please choose "NA".

1. How easy was the online lesson to use?

Very (4)	Mostly (3)	Somewhat (2)	Slightly (1)	Not at all (0)	N/A

2. How convenient was the online lesson to use?

Very (4)	Mostly (3)	Somewhat (2)	Slightly (1)	Not at all (0)	N/A

3. How well did the online lesson keep your interest and attention?

Very (4)	Mostly (3)	Somewhat (2)	Slightly (1)	Not at all (0)	N/A

4. How well did you like the online lesson?

Very (4)	Mostly (3)	Somewhat (2)	Slightly (1)	Not at all (0)	N/A

5. How well did you like the way the online lesson looked?

Very (4)	Mostly (3)	Somewhat (2)	Slightly (1)	Not at all (0)	N/A

6. How satisfied were you with the online lesson?

Very (4)	Mostly (3)	Somewhat (2)	Slightly (1)	Not at all (0)	N/A

7. How well did this online lesson meet your needs?

Very (4)	Mostly (3)	Somewhat (2)	Slightly (1)	Not at all (0)	N/A

8. How useful did you find the information in the online lesson?

Very (4)	Mostly (3)	Somewhat (2)	Slightly (1)	Not at all (0)	N/A

9. How easy was the information to understand?

Very (4)	Mostly (3)	Somewhat (2)	Slightly (1)	Not at all (0)	N/A

10. How much did you feel you could trust the information?

Very (4)	Mostly (3)	Somewhat (2)	Slightly (1)	Not at all (0)	N/A

11. How likely are you to come back to this online module to review content after completing this clerkship rotation?

Very (4)	Mostly (3)	Somewhat (2)	Slightly (1)	Not at all (0)	N/A

12. How useful did you feel an online lesson was to deliver this content?

Very (4)	Mostly (3)	Somewhat (2)	Slightly (1)	Not at all (0)	N/A

13. What was the most helpful part of the online lesson?

14. What was the least helpful part of the online lesson?

15. Please provide any additional comments for improvement.

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