# Design and Implementation of an Ultrasound Interactive Console Simulation System for Medical E-Learning Scenarios

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System for Medical E-Learning Scenarios

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## ABSTRACT

**Background:** Simulation plays a fundamental role in the provision of healthcare education. It endows the trainees with a safe environment where they can develop, improve and sharpen their medical skills through continual and purposeful self-practice as well as constructive feedback. This study delves into the fundamental role simulators have with regard to educational theory and promotion of effective learning and to examine the effectiveness of a Ultrasound Interactive Console Simulator (USICS) relative to a Ultrasound Scanning Machine and to validate the functionality of the USICS.

**Method:** This study's core objective was to establish whether it is possible to implement an effective web-based distance education system that will facilitate users become fully acquainted with the elements and uses of an actual ultrasound instrument. Ultrasound Interactive Console Simulator (USICS) is an online application that was developed to enhance the learning effectiveness, which utilizes the qualities and supplies of the World Wide Web to build a significant learning atmosphere where learning is adopted and maintained. The participants were registered to enable them to use the system. During registration, the participants were given directions about the ultrasound simulation system's basic functions and keys. There are two different methods in this study; one is a questionnaire that consist of eighteen multiple choices questions was used in the data collection of this study to investigate the similarity, the content effectiveness, construct validity, and easiness of usage. A Likert scale (1 - 5) was used to get the assessment from sonographer experts over the use of the USICS. After that we apply Cronbach's

alpha test to test the face, content, construct validity. The other method is pretest and posttest experiments to examine that the USICS is a comparative effectiveness for learning factor. Paired T-Test was applied on this experiment.

**Results:** Some of the important results found in this study were:

- The results of operations performed by the USICS are similar to the other ultrasound machines such as the Philips Clear Vue machine.
- There are no variations in the content effectiveness and construct validity between the simulator system (USICS) and the Philips Clear Vue machine.
- The USICS is a useful and effective supplement to conduct training on a real-life Ultrasound Scanner.

**Conclusion:** To facilitate the acquisition of technical skills as would be obtained from a generic Ultrasound scanning machine a simplistic perspective frames simulation was employed to endow the students with a safe and comprehensive alternative to conducting clinical procedures. It is firmly believed that the Ultrasound Interactive Console Simulator (USICS) aims to satisfy the growing demand for effective tools for online healthcare education and specifically in the area of Ultrasound scanning training. In a bid to strike the right balance in the simulation of an ideal clinical scenario it is imperative to align the simulator in a way that replicates clinical environment in that is authentic and realistic. The results from the use of USICS indeed seem to meet this need and hold much promise for other and in-depth ventures into similar online healthcare training applications.

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# CHAPTER 1 INTRODUCTION

## 1.1 Statement of the problem

Medical simulation was incepted in the 1960s [1] and since then, it has become imperative in medical education and its merits have become extensively acknowledged in the present day. [2–5] The state of simulation in the medical profession has been comprehensively covered in recent studies. [6–8] In the present day, simulators are designed in the context of a burgeoning rise in the power of computers and a decline in their prices. There has been an increase in Internet coverage and bandwidth as well as a pervasion in wireless technologies. The inception of smartphones and tablet computers changed the manner in which users interact with their computers. New user interfaces wield the ability to extensively improve the simulation experience. The delivery of the results of complex mathematical models is made possible on nearly all computer platforms when browser-based interfaces are used.

Concurrent with the underscored importance of evidence-based medicine, practice efficiencies, and patient safety, the evaluation of how health professions education impinges on patients has in the last ten years become an imperative priority in the society. [9][10] Being acquainted with the clinical topics that have and have not been delved into can researchers who may want to measure patient effects, consequently, healthcare education has espoused technology based simulation as one of the important tools in the learning process. [11][12][13]

In medical education, simulation is extensively used for the purpose of medical imaging and its development has been undertaken by a myriad of companies. As a corollary, in last three decades, simulators have undergone various evolutions. Simulation refers to the replication of a real object, situation, or procedure. [14] Medical education that is based on simulation endows learners with a centered way of acquiring technical clinical expertise through frequent practice in an environment that is "safe". [15] Based on the needs of the learner, a training agenda can be formulated where an entire procedure or a particular part of the procedure is being simulated. The inclusion of objective measurement of skills is of paramount importance in the development of a medical education curriculum. [16] Simulators have the ability to give objective performance evidences thereby enabling formative and summative evaluation.

Furthermore, simulation enables standardization in medical education. The acquaintance of the basic structure, pattern recognition and appearance, as well as the range of 'normal variation' can be familiarized with multiple times until it is mastered. [17] There are a myriad of merits of using simulation, which include: zero exposure to radiation that has ionizing effects; provision of real-time images in different interfaces; as well as the availability and portability of equipment (NMC 2007). [18] The achievement of this can be improved through either increasing the time, which medical students spend in supervised internships alone, or through integration of the supervised internships with numerous simulation techniques that replicate high fidelity clinical settings. [19]

Simulation has been confirmed by numerous studies to improve patient care among healthcare professionals, knowledge and safety and the learning of sonography scanning performance. The learning of sonography scanning performance according to several studies, is improved through simulation as it enables learners be acquainted with the knowledge and expertise needed for the process [Harbir S. Sidhu, MBBS, FRCR, Babajide O. Olubaniyi, MBBS, FRCR, Gauraang Bhatnagar, MBBS, FRCR]. The researchers in all these studies reach the consensus that additional simulation training enables the healthcare professions in the enhancement of patient care, safety and satisfaction as well as the in the reduction of the risk of complications, unforeseen circumstances and procedural time. [20] Studies have demonstrated that, learners who undergo simulated training perform better on successive simulations. Medical students from five institutions participated in a chart study. One group of the participants was trained how to handle cardiac problems using the Harvey Cardiology patient simulator for two weeks. The other groups were only trained using traditional ward training but for four weeks. The group that was trained using simulation outperformed their counterparts by two times even if their training time was half that of their counterparts. [21] According to a study conducted by Devita et al., better results are seen on the simulated patients if the doctors are trained to team up whereby they perform their pre assigned roles in the course of the simulation exercise. [22] In addition, the study also confirmed that through simulation-based education, the medical residents' knowledge could be drastically improved.

The study's core objective was to delve into the correlation between the student's sonography scanning score and the power of the learning system score. If the study results show a positive correlation, it would mean that distance learning of ultrasound that is simulation based would be confirmed to be an appropriate for sonography scanning achievement. This study aimed at examining construct and content validity by utilizing this system for students to acquire their scores of performance.

Five chapters have been used to compile this dissertation. The first chapter comprises of the introduction, which contains the problem statement, background of the problem, the study's purpose, and a discussion of the study's aims and objective. Chapter two comprises of an evaluation of premises of pertinent literature. It has various sections and subsections, which are then followed by a summary of the entire chapter. In the third chapter, a description of the study's population as well as the data collection methods and instruments is given. The third chapter is also where errors are measured to evaluate the reliability of the new system. In the fourth chapter, a discussion about the manner in which the system was evaluated is comprehensively covered. In fifth and final chapter, a discussion about the outcome and the main findings of the study is given. Conclusions are then made and recommendations for future studies are given.

### 1.2 Background of the problem

In simple terms, simulation refers to the replication of a situation that that resembles a similar real life situation, usually with the variables made simpler, for instruction purposes. [23] Simulation has been confirmed to by a manifold of studies to be very effective in the education of clinical knowledge and basic science, procedural skills, and communication in addition to in the assessment of undergraduate and graduate medical students. The burgeoning prevalence of simulation in resident education and medical school increases the need to conduct more studies aimed at delving into how simulation training impinges on patient outcomes. [24]

Medical profession leaders according to Coleman (1995), base the accreditation of endosurgery physicians on a training period in a simulated situation. The goal of the simulated training period is to improve the manual agility skills of the physicians before they become clinical assistants in real-life operations. Through the Virtual Clinic, surgeons are provided with highly pragmatic and interactive training scenarios that endow them with a chance to acquire clinical proficiency before being exposed to a real life surgical operation. [25]

Bienvenue, Curtis and Thakkar (1995) conducted a study to examine whether educational researchers in ultrasound simulation classes for education and learning can use virtual environments, as well as if teachers can regard virtual reality as a discovery tool instead of method of illustrating principles. [26]

Simulation has a long time been used a training model in the aviation and aerospace industries. In the present day, simulators are commonly in the training of various high-risk vocations and disciplines, such as nuclear power plants, the military, medicine, commercial airlines, as well as business. [27] Simulation is a term that has been explicated as the technique of replicating the activities of a circumstance or practice (for example economic, military, and mechanical, etc.) using a suitably comparable situation or equipment, particularly to enhance learning and training of personnel. Little understanding, and pre-knowledge of method is required in simulation. Simulation conveys information or attitudes of a particular situation and this attribute makes it fundamental in bridging the gap between theory and real life practice. [28]

Simulation can also be defined as a situation wherein specific sets of circumstances are artificially generated with the intention of imparting expertise or experience to personnel. In short, simulation is the artificial replication of real life activities so as to realize educational objectives through experimental education. [29] Based on these definitions, a simulator is therefore a tool that facilitates the replication of outcomes and conditions that are likely to happen in actual real-life during an experiment. Simulation based medical education is therefore any instructive procedure that uses simulative models to reproduce clinical scenarios. Instead of using real patient in educational experiments simulation tools are used as alternative. Simulation tools allow students as well as trainers to make errors and learn from them absent the fear of causing harm to the patient. [30]

Simulation enables experiential learning where the learner actively engages in the construction of knowledge through integration new and previous knowledge and experience. In the course of simulation, experiential learning, which is also referred to as learning from experience, entails the use of clinical scenarios to aid the learning process. [31][32]

Simulation as a technique is very flexible and pertinent for education at all levels, and in addition it has no constraints. In a bid to envision the simulation of manufacturing systems, Hollands and Mort (1995) explore the utilization of virtual reality. The study establishes that people who do not have prior knowledge from simulated processes quickly comprehend the dynamics involved and those who are well acquainted with the real system can instantly relate to the results of the simulation process. [33]

In simulation learners and trainees can conduct themselves in a natural manner, and make mistakes without being reprimanded in an atmosphere of normality. Consequently numerous researchers have noted there is a transfer of training. In essence, simulation endows the trainees or sonographers with an environment where they can attempt a solution knowing that the solution could be wrong without being reprimanded. Transfer is deemed to be of utmost significance in the process of training.

Through simulation, the cost and time used in learning and education is extensively reduced and as a result, a lot of time and money is saved. The design of this system is aimed at endowing the educators and sonographer with the feeling of touring a substation for regular assessment. Utilization of this system can also improve the training of unskilled personnel as well as the work schedule preparation trough the substantiation of contents and construct procedures.

The good aspects of the methodology were determined on the basis of what was deemed viable. Hence, simulation is a technique, a method, as well as an alternative, where skill is the only point of reference. This means that simulation is a method that can be used by everyone who needs it. [34]

Implementation of medical simulation techniques in training can help transition medical education from the traditional method of "See One, Do One, Teach One" into a contemporary more successful method of "See One, Practice Many, Do One". [35] Studies that have delved into the validity and results of simulation-based education have come up with findings that confirm that indeed simulations are just as valid and effective as the conventional methods for education, learning, and evaluation. [36][37]

The gap that exists between theory and real life practice can be bridged through virtual reality simulations as the learner/trainee is immersed in a pragmatic, dynamic, multifaceted environment that resembles that of the real world. At Rutgers University, there is an on-going endeavor aimed at improving the basic technology that supports virtual environments. A comprehensive all-inclusive approach of supporting and development the system is presented in this dissertation.

Simulation endows students and trainees with a learning environment that is safe and supportive. [38] Through simulation, users from all skill levels, from novice to expert, can sharpen their skills as they can make errors, which they can learn from without posing the risk of harm to patients. Simulation promotes the attainment of skills through experiential learning, [39] in an environment that is ideally pragmatic and realistic, and it also enables the learners to reflect on their performance. [40] Through simulation, students and trainees can sharpen their skills at their own speed and using their most preferable style of learning. Since simulation scenarios can be generated exactly as needed, simulation has the ability to facilitate on demand learning. [41] In addition, simulation based training can facilitate the transfer of expertise to the real life clinical setting. Moreover, since simulators have the ability to give objective performance evidences, they can be used to enhance formative and summative evaluation.

Simulation has numerous applications that can facilitate professional development for individuals at all skill levels. Simulation is used a technique in undergraduate programs to help students in the acquisition of various fundamental clinical skills (such as physical examination, history content, and procedural) as well as communication skills. Simulation can also be used as a tool that enhances teamwork and inter professional education. In addition, simulation can also be used to support and guarantee continued professional development among personnel.

### 1.3 The purpose of the study

This dissertation was compiled with the primary goal of helping students and trainers to identify their own constraints and knowledge gaps as well as to present them with the equipment that can fill these gaps. All forms of simulation are valuable tools in healthcare education as they help the students to realize their educational goals without posing the risk of harm to patients. According to Dr. David Gaba, simulation is an instructional process that uses artificial models, live actors, or virtual reality patients in the place of real patient during training. [42]

Simulation aims at generating artificial patient care scenarios that resemble real-life patient care scenarios with the intention of getting feedback and for assessment during training. Simulation, when appropriately orchestrated, endows students with an ideal environment for learning as it makes learning activities consistent, predictable, reproducible and standardized. Such an environment facilitates experimental and experiential learning where learners learn through a trial and error methodology, which they can rewind, rehearse, and practice without causing detrimental effects to patients. This dissertation suggests that the contemporary forms of simulation are satisfactory alternatives for the real-life clinical scenarios. The dissertation also holds that the most ideal environment for clinical education is the real-life clinical environment, but sadly in this case, it is not practical.

Another merit of implementing simulation based healthcare education is that simulation based training is realistic and inexpensive. Simulation based training minimizes the need for real ultrasound hardware as well as human subjects thereby saving on time and money. The use of this system also supplements need for conducting training in a clinical setting thereby endowing the trainees with a learning environment that is flexible. However, the system has a number of shortcomings with the most significant being its cost. Another merit of implementing simulation based healthcare education it can be used in student assessment where students are required to reach or surpass the minimum passing score on a simulated test before being allowed to engage in a real-life clinical setting.

The general aim of this study is to investigate that the images generated by Ultrasound Interactive Console Simulator (USCIS) via a distance education are mimicking and be similar to the other ultrasound machines such as Philips Clear Vue. In addition, this study will examine the construct validity and content effectiveness of the simulator system and assess the easiness of usage. On the other hand, this study will evaluate the comparative effectiveness of learning case of Ultrasound Interactive Console Simulator (USICS).

### 1.4 Research hypotheses

**Hypothesis 1:**

It is possible to design and implement an Ultrasound Simulator System, which mimics the look and the operations for other ultrasound machines such as of Philips Clear Vue machine.

**Hypothesis 2:**

The results of operations performed by the Ultrasound Simulator System are similar to those of ultrasound machines such as the Philips Clear Vue machine.

**Hypothesis 3:**

There are no variations in the content effectiveness and construct validity between the simulator system and the ultrasound machine such as the Philips Clear Vue machine.

**Hypothesis 4:**

The Simulator System is an effective supplement for the need to conduct training in a real-life clinical setting.

**Hypothesis 5:**

There are a difference in the scores in using the real system and the simulator system.

## 1.5 Objectives and specific aims

As a corollary, the study's purpose was to give foundational empirical evidence supportive of this aim, wherein the goals and objectives outline below were given emphasis:

1. To design a user-friendly web-based or stand-alone simulator system (operable on any operating system platform) for mimicking the look and functions of other ultrasound machines such as Philips Clear Vue machine to use via Online Education and Training.
2. To investigate the similarity between Ultrasound Interactive Console Simulator (USICS) and Philips Clear Vue machine for the results of operations performed for

the modification of Time Gain Compensation control, overall gain control, Focal Zone control, and Depth control.

3. To examine the content effectiveness and construct validity of USICS.
4. To delve into the assertion that USICS is supplementing the need to conduct training in a real-life clinical setting.
5. To evaluate the comparative effectiveness in the learning case by Ultrasound Interactive Console Simulator (USICS).

# CHAPTER 2 REVIEW OF RELEVANT LITERATURE

This literature review is an attempt to make an assessment of the power of the learning system score. The simulation based medical learning accomplished by way of distance education system may turn out to be the right technique for accomplishment in sonography learning in a situation where positive score is discovered. The literature review will also look into content validity and construct validity through the adaptation of a system where students could garner their performance score. Furthermore, the review will examine the power of distance learning with regards to cost factor, equipment control which is not required in utilizing the system and human subject, the importance of training as an essential factor in clinical environment, and the time element.

## 2.1 Simulation of ultrasound machine

### 2.1.1 Definitions

Simulation is generally defined as active portrayal of certain components of the actual world, accomplished through the development of a computer model, and passing through time. The services of computers are commonly utilized in the assessment of healthcare system. Starting from then, the use of computer simulation has become a healthcare tool that has different applications. Such applications range from scientific research to planning, as well as training and demonstration. [43] In simpler terms, simulation can be described as one that creates a condition that could take place in real life situation especially when the variables become simplified for learning purposes, and when competitiveness becomes part of the simulation. The technique of simulation can be flexible, thereby making it essential to be integrated into training at every level with no restrictions imposed on how far it can go. Furthermore, simulation is a means of relaying information or attitudes. Essentially, this is a technique that can be used in closing the gap existing between theory and practice, which will be able to provide situations and circumstances. With this, students and trainees can act naturally. They can make mistakes without fear of being censured since of the atmosphere of normalcy is created in simulation, and this is probably why many researchers have noticed the transfer of training. Essentially, simulation is able to permit students or sonographers to try solution secure in their learning so that they might fail without fear being censured. This is because, true or false, there is no complete feeling. In other words, transfer of training can prove to be remarkable. [44]

It does not take great knowledge to master the technique of simulation, and neither does a prior knowledge of the method required. When education was first introduced in industries or when industries were first introduced into education in the past, there was no integration of education; rather, what was taking place then was the imposition of education on industry. One had something to offer to the other for sale. While education offered program learning, the industries devised teaching machines, which they offered for sale. The good thing about the method was concealed by the thought of being practicable. At this time, simulation has turned into a technique or an alternative method where nothing offered for sale is needed but the individual skills. There is nothing to patent here. What is offered is a technique, which anyone who wants to use can avail of it. [45]

### 2.1.2 Classifications

There are different categories of classifying simulators. [46][47] Such classification can be in the manner they resemble reality. They are low-fidelity, medium-fidelity and high-fidelity simulators. [48] In low fidelity, simulators are most of the time stationary and do not have pragmatism, and neither do they have situational context. They are usually utilized in the teaching of basic technical skills to the novices. Moderate fidelity simulators come close to reality as they posses such features as pulse and heart sounds, including breathing sounds. Nonetheless, they lack the ability to talk as well as chest or eye movement. They can be applied in the introduction phase as well as in deeper understanding of definite, rising complicated abilities. In the case of high fidelity stimulators, they utilize a combination of parts or whole body manikins in carrying out their interventions and with the aid of computers to push the manikins in order to generate physical movements and sign that can be fed to the computer monitors. The designs are produced in a way that they resemble the real thing. They have the ability to talk and breath, as well as the ability to blink and automatically or manually respond to physical and pharmacological interventions when direct to do so. [49]

Nonetheless, they only possess the ability to imitate reality and can never to replicate it. Important conditions are therefore essential during the course of simulation practice as a way of making learning effective. The intended results must have to be defined prior to carrying out training in a controlled environment.

### 2.1.3 Simulation as educational tool and formative assessments

At any stage of learning, whether undergraduate, graduate, or postgraduate level, the medical learner is a true adult learner. Education theorists define an adult learner as one who is poised to learn with the aid of different techniques and learning for different reasons compared to the kind of education that was available during the early stages. Bryan et al [50] in 2008, utilizing the works of other education scholars such as the father of andragogy (adult learning theory) Knowles, came up with five descriptions of adult learning principles that are applicable to the medical learner (see table 1).

| Table 1. Five Adult Learning Principles That Apply to the Medical Learner. |
| --- |
| 1. Adult learners need to understand the purpose for which they are learning. |
| 2. The motivation of adult learners is their quest to seek solutions for problems. |
| 3. Adult learners' prior experiences must have to be accommodated and developed upon. |
| 4. Adult learners' diversity and background in educational approach should be matched. |
| 5. There is a need for Adults to actively participate in the process. |

Table 1: Adult Learning Principles That Apply to the Medical Learner. [50]

Clinical skills require direct instructions on its simplest level for the fact that they are considered as psychomotor skills acquired through reinforcement. Students, in certain ways, appear to find it easier mastering clinical skills since they are able to remember 90% of the activities they perform but could only remember 10% of the things they read

[51]. But clinical skills are made up of things that go beyond motor memory. There is a need to consolidate problem solving skills and communication skills, together with technical skills in putting up a complex medical context, all of which require practice.

The final goal of acquiring medical education is to become an expert and master the trade. One educational technique utilized in generating professional performance dependent upon 4 conditions is deliberate practice. The four conditions involved are intense skill repetition, strict evaluation of that performance, precise feedback of information, and enhanced performance in a controlled setting. [52]

Producing a professional or master of any trade is the true goal of deliberate practice, which is identical with the true goal of medical education. Eppich et al. [53] stated that by just merely participating in an activity would not result in the mastery of such unless the end goal for the participation is improved performance. It therefor means that improving medical education will require searching for a method where one engages in deliberate practice. A recent study conducted by Wayne et al. [54][55] made an evaluation of the value for the utilization of simulation technology and deliberate practice in improving acute resuscitation skills. This study involved 41 student participants who were second-year internal medicine residents. Through the use of deliberate practice, the students were taught advanced cardiac life support (ACLS). The result demonstrated statistically remarkable improvements in education. Such improvement included standard ACLS protocols compliance, acquisition of knowledge, and skills retention after a period of 14 months.

Many studies have demonstrated how valuable simulation is as an educational tool in undergraduate medical education. It has been utilized as an evaluation tool in evaluating knowledge gaps taking place among medical students and residents in the management of severely sick patients. [56] Simulation based teaching has demonstrated its superiority as a teaching tool in comparison to traditional problem based learning format. Steadman et al, [57] demonstrated in their study that students who received simulation intervention significantly outperformed problem-based learning students in terms of greater improvement in scores from baseline.

The design of simulation is made in a way that provisions are made for all sessions to be followed by debriefing, thereby making it to become a very efficient tool when it comes to formative assessments [58] since there would be no performance improvement if there are no debriefing or feedback simulation. There is a rise in the utilization of computer enhanced manikin simulation in making summative evaluations recently. [59]

### 2.1.4 Simulation based medical training

Simulation-based training has discovered certain values in strategic and surgical skills training. Students have acquired greater knowledge and have seen their performances in simulated surgeries improve as a result of their medical training with the use of virtual reality simulation. . [60] However, medical students who have undergone simulation training are more comfortable and as such feel more confident and wiling to perform these procedures compared to medical students trained without the use of simulation. [61]

### 2.1.5 Area and approaches in simulation

The system area is a reference to the medical field where provisions are made for care. The type and amount of medical information changing hands would be greatly dependent on the medical field being utilized. There are several methods of classifying ultrasound simulation program applications for the purpose of medical imaging science.

### 2.1.6 Utility of using simulation in medical education

Perhaps the best discovered beneficial features of using this system are that students do not need to worry anymore with regards to communicating with patients as they would be able to continue with their practices without any high level supervision. It is helpful to have a tutor nearby whom one can consult when the need arises. There are other simulation based trainings found in other values as demonstrated below:

- Sonographers are given the opportunity to obtain hands-on experience with regards to conditions and pathologies that would not have been possible under normal training since such conditions are very rare. [62]

- The simulated environment provides the opportunity of learning and relearning as many times as may deem necessary correct to any mistakes. [63]

- The simulated environment makes it possible to for trainees to bring their steps to perfection while fine-tuning their skill for optimum clinical results. [64]

- Simulation training aids learners to handle any anticipated medical situation, thereby boosting their confidence. [65]

- Computer simulations make it possible to come up with decisions and make corrections to errors. This iterative learning procedure through evaluation and decision-making as well as through error correction develops a much robust learning environment compared to passive instruction. [66]

- Some of the other advantages that may be gained through the use of simulation system. [67] [68]

- Conducting hand-on practice as well as invasive procedures
- Regular and repetitive practices
- Errors are allowed while the procedures go on until they conclude naturally.
- There is avoidance of risks to learners and patients.
- Undesirable interferences are brought to the barest minimum.
- There is opportunity for multiple students learning similar procedures to access the same learning materials
- Clinical cases are planned based in the students' need rather than on the availability of patients.
- Students are exposed to rare and complicated clinical situations.
- Feedbacks are received immediately after debriefing sessions.
- Real medical equipment is used
- Improved the transformation of training from classroom to real situation.
- Increased rate of retention and accuracy are derived.
- Improved standard used in evaluating students' performance and diagnoses of educational needs.

### 2.1.7 Weaknesses of using simulation in medical education

The drawbacks of this system are mostly technical in nature although the majority of such restrictions can be corrected in the system's upgraded version. The system is mostly beneficial at the beginning stages of learning as sonographers are unable to scan.

### 2.1.8 Why use simulation?

After all is said and done, we are still grappled with the questions that seek answer on why simulation should be used. Proponents of the concept have always put up good arguments on why simulation should be utilized. They argue that simulation makes provisions for an educational environment that is both safe and supportive. [69] It makes it possible for users, from the level of a novice to that of a professional, to conduct practice and develop skills with the understanding that there are no penalties for mistakes and there is no fear of harming patients in the event that a mistake occurs. It gives encouragement to leaners to acquire skills through experience, [70] preferably in a practical scenario or environment, and is able to activate reflection on performance. [71] Learners are able to progress at their own pace while learning as well as learning styles can all be allowed to function. Simulation is able to accelerate on-demand learning and make possible the creation of situations as the need arises. [72] In addition, training by way of simulation will be able to accelerate skills transfer to real world of the clinical environment. There is also the possibility for it to become an essential tool for formative and summative assessments.

Nonetheless, there is the likelihood that this may not be realized if there is no evidence of popular support in the adoption of the method, in spite of the long speeches and the accepted potentials of simulation to be popularly used in health care education support at every level and within every discipline.

## 2.2 Web-based distance education

### 2.2.1 Definitions

Distance education is a medium of instructing and learning that has remarkably expanded in the past decade, judging by the number of higher educational institutions that now offer courses and award diplomas through long distance learning. The number of degree-awarding higher educational institutions which offer courses through distance education jumped from 33 percent in 1995 to 44 percent in 1997-98 based on the records of the National Center for Education Statistics (NCES) (1999). To put it in a more specific term, there has been increase in the use of computer-based technologies from 22 percent in 1995 to 60 percent in 1997-98. [73].

Over the years, web-based distance education definition has been refined and redefined as witnessed in the definitions of Moore's distance education evolution. Moore came up with the description of distance education in 1990 as “all preparations for instruction provision, by way of print and electronic media to all individuals involved in planned learning in a location or time quite different from that of the tutor or tutors.” [74] Moore and Kearsley were to redefine this later in order to specify that there is planning in learning which has within it, organizational and administrative arrangements”. [75]

Majority of the definitions reiterate that distance education is the art of teaching and learning that do no take place at the same time since the learners and the instructors are separated by time and space. However, they utilize different of technical media in support of the teaching and learning technique. [76][77][78]

Web-based learning can be defined as a teaching strategy whereby the web is utilized in the provision of materials and communications going on between the student and the instructors. [79] In many occasions, students find it more convenient to utilize the web in acquiring knowledge, thereby boosting their confidence in the utilization of the information technology, and in the long run throwing support to independent and distance learning. [80]

### 2.2.2 Classification

Currently, Web-based learning embraces all educational activities utilizing the Internet or the local intranet. There are three broad classifications or configurations that are presently within WBL that are as follows: tutorials and online discussion groups, together with viral patients. There is a blurred line distinguishing these configurations since a given WBL is capable of utilizing a combination of two or three intervention. Nonetheless, the teaching implications necessitate, even though it is sometimes random, separation. [81]

There are some similarities that online tutorials have with face-to-face lectures as both contain information that are information structured in a manner that it would accelerate learning. Features such as multimedia, in the form of sound and pictures as well as movies and animations help in improving tutorials. Other features that help improve tutorials are links to online resources that give access to full-text journal articles or other related websites, as well as other areas that are within the course, including self-assessment techniques. Effective online tutorials sometimes utilize the cases of patients. [82]

There are some similarities that online discussions have with face-to-face small group session. As is always with small group, there is always that method of teaching from the instructor that follows a steady scientific approach or educational style as a way of engaging the student's mind such as in brief tutorial, but the core of the teaching lies in the group interactions. Teacher assume the facilitator’s role by defining the scope of the discussion, observing and directing the discussion as may deem necessary, and making provision or helping the students locate additional resources. Interactions among group members such as sending and receiving messages may not be taking place at the same time as there may be some delays such as in a asynchronous situation or sometimes, the sending and receiving of information may be taking place live as they happen, just like in a synchronous situation. [83]

Virtual patients are patients’ encounter not on actual people but computer-based simulations. Students are given the opportunity to ask the computerized ‘patient’ questions, based on the situation, in order to gather information on history and findings of physical examination, and request and interpret results coming from the laboratory and other tests, and finally initiate treatment. [84]

It is also good to state what Web-based distance education is not part of. There are lots of functions in medical education that has been discovered by the Internet whereby the main intension is not associated with any educational intervention designed for web-based delivery. Such would include archives where face-to-face teaching and interaction is mandated like in cases of Power-Point slides or videotaped lectures. Others include course syllabi and online administration of tests, together with administration of online tests and assessment of courses, and administrative interactions. [85]

### 2.2.3 Benefits of teaching by web-based distance education

There are lots of advantages that distance learning provides. According to McGrath, distance learning gives the learner the option of taking charge of the learning environment and time of learning. It proves to be more convenient to many health professionals who would be able to arrange their learning activities to fit into their busy schedules. [86] Furthermore, distance learning provides lots of benefits to school faculty, students, and school administrators as it actually increases knowledge learning, enhances skills performance, and increases professional growth. Distance learning can serve as a tool that helps in the improvement of quality education that is an essential factor in the improvement of the quality of healthcare delivery. Thus directing attention to the use of electronic systems is now a new technology used in distance learning. There are other advantages that are listed below:

- Web-based distance education provides the opportunity for individualized learning as learner are provided with the opportunity to have greater control over the environment that they learn, by giving them the opportunity to choose from the numerous learning activities availing within a particular course and then allowing them to proceed at their own pace. [87]

- Web-based distance education demonstrates to the learner the way to be flexibility with regards to timing of participation, as well as in physical location. [88]

- Web-based distance education helps in the acceleration of the evaluation and documentation of educational of educational goals. [89]

### 2.2.4 Challenge of teaching by web-based distance education

There are also certain restrictions that saddle Web-based distances learning tools and strategies, and they can be in the form of technical problems. Improper operation of web learning may be the result of inadequate information literacy, which can be a significant matter at the starting stage. [90] Another problem that students may encounter is the problem of isolation that is present in web-based education. [91] This may result in the possible loss of social interaction involved in learning. [92] Other apprehensions include time and skills that are needed in the development of learning materials. [93]

## 2.3 Summary of literature review

Simulation-based medical learning through distance education is likely to become a preferable approach to accomplishing sonography learning. The flexible nature of simulation makes it essential in integrating it into training in various levels without restricting the extents that it can reach. This is while permitting students or sonographers to try solutions securely in their learning, which eliminates the fear of failure even without trying. Simulation is credited, as it does not require great or prior knowledge.

In various stages of learning, a medical learner is a true medical learner. Students are observed to master skills more in those activities that they perform and only remember a limited portion of things they read. This is because clinical skills go beyond motor memory. Problem solving skills and communication skills need to be consolidated with technical skills to put a complex medical context that calls for practice. With the final goal being to be an expert and mastering the trade, deliberate practice is a technique needed to facilitate professional performance. Simulation has been demonstrated a valuable educational tool in medical education. It has been associated with greater knowledge, comfort and confidence in strategic and surgical skills. However, simulations are criticized mainly due to technical drawbacks, but these can be corrected through system upgrading.

Whereas, web-based distance education arises as the learners and instructors are separated by time and space, prompting the use of the Internet to facilitate the provision of materials and communication between them. It promotes convenience for the many health professionals as they can take charge of the learning environment and time of learning considering their busy schedules. This would enable the learner to be flexible while accelerating the evaluation and documentation of educational goals. However, it poses restrictions in handling technical problems. Also, inadequate information literacy is likely to be an issue due to improper operation of web learning. Furthermore, isolation and inadequacy in time and skill required to develop learning materials have been advanced as problems associated with web-based distance education.

# CHAPTER 3 MATERIALS AND METHOD

Computers are used to host the software that replicates an ultrasound scanner. There are four sections of a real ultrasound scanner instrument that are covered in an Ultrasound Interactive Console Simulator (USICS) i.e. the 2D gray scale, Continuous Wave Doppler, Pulsed Wave Doppler, and Color Doppler. These sections are replicated in various medical fields such as abdomen, obstetrics, gynecology, cardiac, vascular, and other miscellaneous that include breast, Neuro, and thyroid. The cases presented in the ultrasound simulator system are usually categorized by specialty and all tools are provided the different modules in an easy way. All cases are accompanied by their prerequisites upon which the students or sonographers should base each model's description as well as their effects. All the tasks are clearly described and given a particular characteristic visual effects and figurations in a free public library image. The simulator system lets both sonographers and professionals to continuously perform medical practices on these tools thereby enabling them to sharpen and improve their knowledge, skills, and performance. Moreover, the simulator system will enhance the practice and learning efficiencies.

In this chapter a general description of the system material, its methodology as well as technique applied in Ultrasound Interactive Console Simulator (USICS). This played a part in achieving the study's goal, which was to devise and implement USICS system that would facilitate effective web-based distance healthcare education.

The chapter's first section consists of a description of the system material through provision of a study design that the study that demonstrates how the system would be delved into. The section also provides a description of the study population as well as the sampling procedures and methodologies that ware used to determine the participants of the study. The specific criteria of data collection are also explained in the first section. Finally, sampling methodology for this material would explain in detail.

The chapter's second section explains the method that was used in the creation of the simulation environment as well as the features that were used in the achievement of the study's core objective of developing an Ultrasound Interactive Console Simulator (USICS) with a minimum of 95% of the ultrasound machine concepts so as to facilitate effective web-based distance healthcare education.

The last section of this chapter provides a description of the design and architecture of the system by explain how the simulation environment was developed as well as the tools that were used to put the system into operation. It is also in this section that the hierarchy of Ultrasound Interactive Console Simulator (USICS) is then illustrated and comprehensively explicated. This chapter concludes with an overview of the USICS environment along with a few screenshots of this work.

## 3.1 Material

### 3.1.1 Study design

In this study, a comparative research method will be used to investigate the similarity of the simulator system that is USICS, content effectiveness, construct validity, and supplementation of the need to conduct training in a real-life clinical setting. In addition, the study will also evaluate the comparative effectiveness in learning case as well.

The population for the questionnaire was domain experts of 25 years and older currently teaching the course in Diagnostic Medical Sonography Department at Rutgers and different sites. A sample of experts where (n= 15) will be invited by the researcher to participate voluntarily in the questionnaire. Thus, the anticipated sample size for this study is n=15.

The second population for this study was students of 18 years and older currently studying in Diagnostic Medical Sonography Department at Rutgers. A sample of students where (n= 16) was tested by the instructors. Thus, the anticipated sample size for this study is n=13.

This study was carried out at Diagnostic Medical Sonography Department in Rutgers University, where the institution's curriculums were to users registered for distance learning as well as on-campus programs. All keys and functions of a real ultrasound scanner machine were covered in the Ultrasound Interactive Console Simulator (USICS) provided to the students, sonographers and professionals. There will be two different methodologies; first one is a questionnaire and it is for domain experts and the other is pretest and posttest experiments and it is for students. Respondents will have assurance that their identity would be anonymous, and sets conditions for them to be more truthful.

### 3.1.2 Sample size Justification

As discussed before, to explore the study's goals and objects, there were two different measurements. First measurement was a questionnaire that was administered to the 15 respondents of the target population would be invited to participate in the study. Thus, a sample size of approximately 15 is anticipated. Another measurement was taken on 16 respondents of the target population was invited to participate in the study. Thus, a sample size of approximately 13 is anticipated.

| Desired Confidence Level | z-score |
|---|---|
| 80% | 1.28 |
| 85% | 1.44 |
| 90% | 1.65 |
| 95% | 1.96 |
| 99% | 2.58 |

$$Sample\ Size = \frac{\frac{z^2 \times p(1-p)}{e^2}}{1+\left(\frac{z^2 \times p(1-p)}{e^2 N}\right)}$$

Population Size = N | Margin of error = e | z-score = z

N=16 students,

E = 10%, z = 1.96

SS= 14

### 3.1.3 Study Sites

The study will be conducted at the Diagnostic Medical Sonography site in Scotch Plain Campus.

### 3.1.4 Inclusion criteria

Inclusion criteria for first questionnaire in this study were domain experts such as the teachers teaching the ultrasound concepts, speaking the English language, and between the ages of 25 to 65.

Inclusion criteria for second measurement in this study were students such as students who have an ultrasound background, speaking the English language, and between the ages of 18 to 35.

### 3.1.5 Exclusion criteria

An exclusion criterion for this study should be children of 17 years and younger, and someone who doesn't have an ultrasound background.

### 3.1.6 Ethical Approval

An IRB was applied for and approval obtained to conduct the experiment.

### 3.1.7 Sampling methodology

This study concentrated on a particular number of medical domain experts and sonography students. The study was used to investigate the mimics' validities of the Ultrasound Interactive Console Simulator. If the first stage of the simulation would be successful, the trend would carry on in the other stages. More emphasis was placed on the 2D gray scale aspect of the ultrasound scanner machine in medical fields such as abdomen, obstetrics, gynecology, cardiac, vascular, and miscellaneous for example breast, neuro, and thyroid.

## 3.2 Research Methods and Design

### 3.2.1 Introduction

In order to develop and construct a distance education environment, there are main components of Ultrasound Interactive Console Simulator (USICS) has been taken to create a new way of learning to facilitate web-based distance healthcare education. Here are the main components of the simulator system that have been used on this present study.

1. Free public image library.
2. Personal Computer.
3. Project Software (Figure 3.1).
    - Aptana Studio v3 - an open-source web development IDE.
    - MAMP v3 - a local server environment.
    - Apache Server - HTTP Server and a web server.
    - MySQL Server v5.5.33 - open-source relational database management system.
    - Photoshop CS6 - a raster graphics editor developed.
    - SPSS v 18.0 - Statistical analysis.
    - PHP - a server-side scripting language.
    - Cascading Style Sheets (CSS) - style sheet language.
    - Client-side scripting such as JavaScript Library.

- JQuery - a cross-platform JavaScript library.

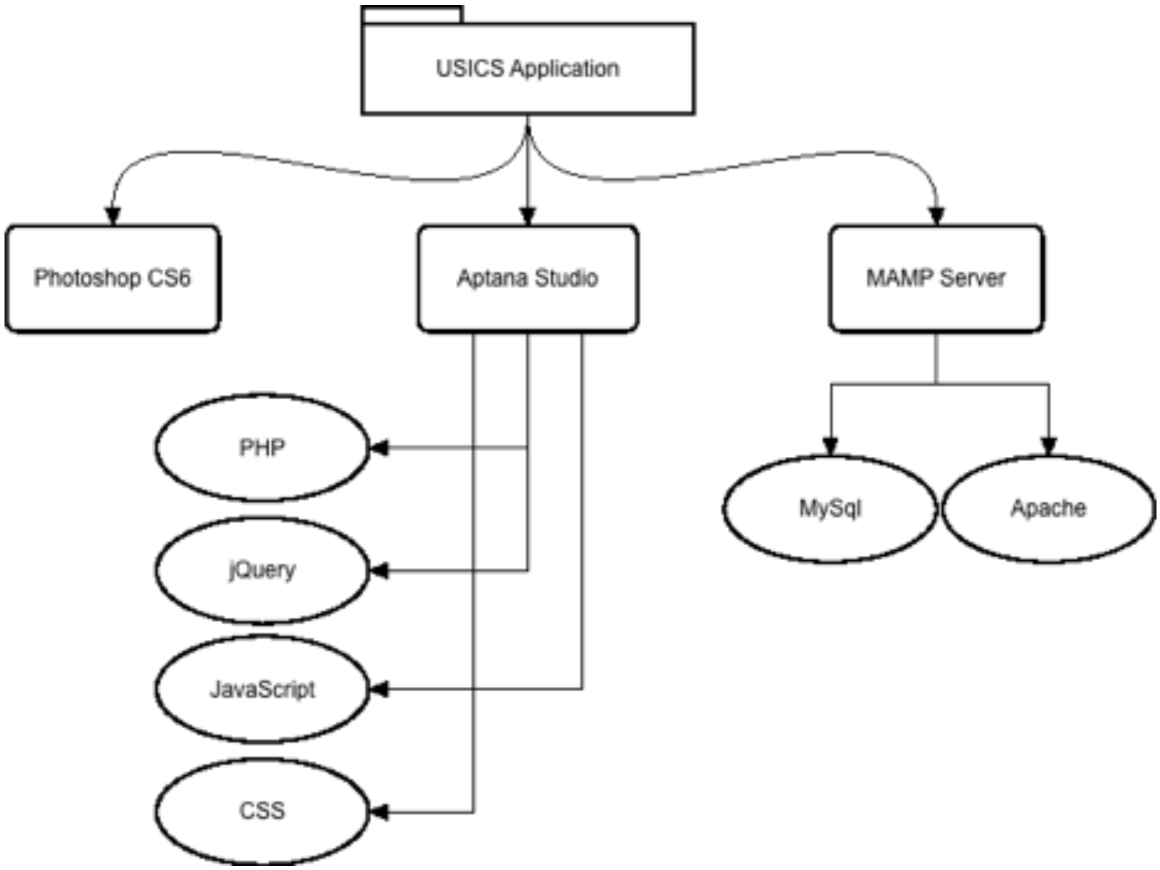



Figure 1: Main components of the USICS

### 3.2.2 Ultrasound Interactive Console Simulator (USICS) Structure

The development of USICS was done in HTML5, PHP, JavaScript, JQuery, as well as CSS using Aptana Studio. I used Aptana Studio in the programming of the website.

A three-tier application consists of the logic tier, the service tier (otherwise referred to as the middle layer tier) as well as the storage tier. In a two tear (client-server solution) application, the client is responsible for handling the logic tier. "Thick" clients are common in two tier applications. Thick" clients occur when heavy traffic is experienced in the server and this makes it hard for clients to use the system difficult especially if they are using slow network connections such as Internet and Wireless (3G, Edge or Wi-Fi). A three-tier approach was therefore used in the development of USICS in a bid to avert the aforementioned constraints.

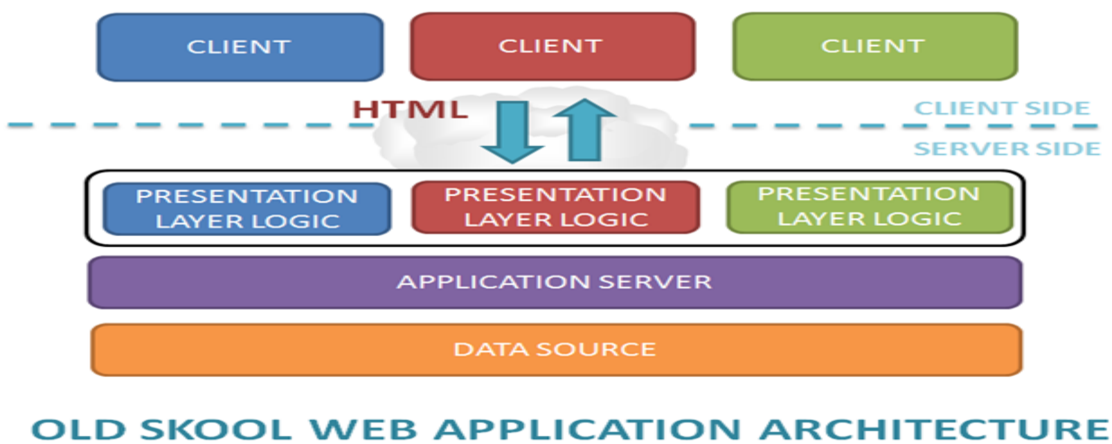



Figure 2: Three tier Architecture. Source: http://devcentral.f5.com/weblogs

A self-regulated middle layer is added in the three-tier architecture and as a result the client is only responsible for handling the logic tier. As a corollary, the clients' communication with the middle tier is significantly reduced thus leading to occurrence of a "thin" client, where the client can use his/her Internet browser to see and share information fast with little or no delay. Another reason why the three-tier approach was used is due to its scalability. The three-tier architecture is also more secure because the middle layer protects the database tier.

The development of research study's web application is done using HTML5, JQuery, JavaScript, PHP, as well as CSS using Aptana Studio. The database capabilities were enhanced using MySQL 5.5.33.

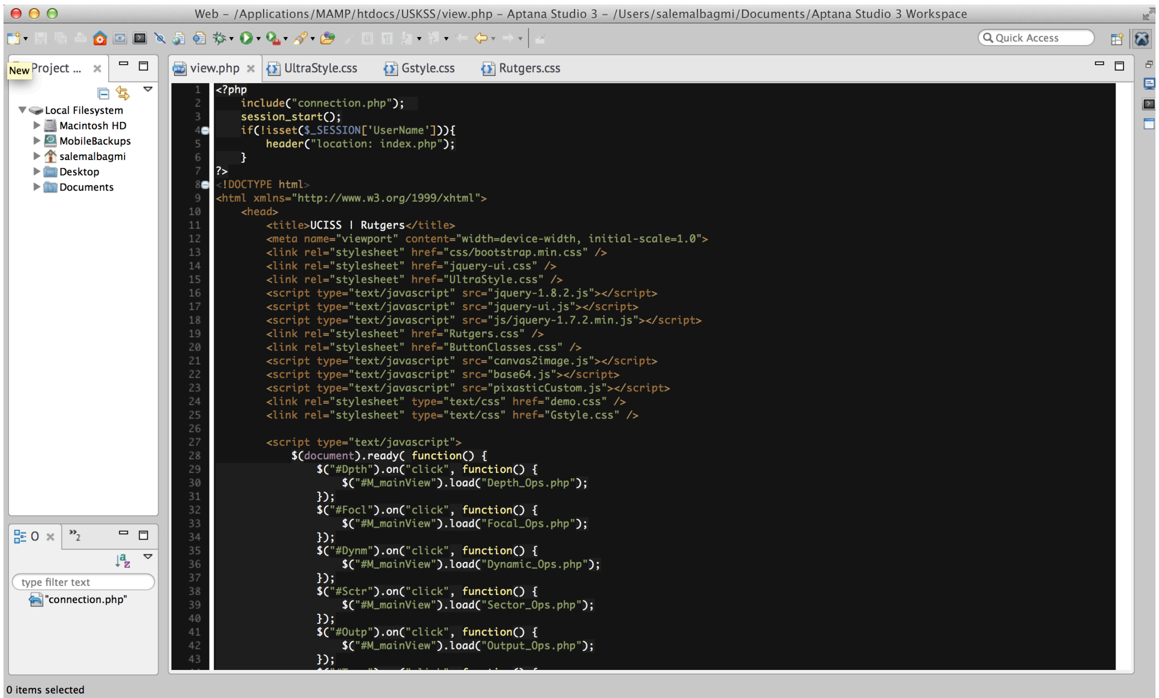



Figure 3: Aptana Studio v3

Aptana Studio 3 improves on the core aptitudes of Aptana Studio 2 thereby enhancing the generation, previewing editing, and debugging of websites that are created using HTML, CSS and JavaScript. Furthermore, Aptana Studio 3 is considered to be an open source integrated development environment (IDE) and can there be used to create Ajax web applications. Using Eclipse, Aptana Studio 3 also has the capability to support HTML, DOM, JavaScript, and CSS in code-completion, debugging of JavaScript, outlining, giving notifications about errors and warnings and performing integrated documentation. Aptana Studio also has extra plugins that enable it to support Ruby on

Rails, Python, PHP, Perl, Apple iPhone Adobe AIR, and Nokia Web Runtime (WRT). Aptana Studio can be used a plugin for Eclipse and is also supported by different operating systems such as Microsoft Windows, Mac OS X as well as Linux. [94]

I used PHP provided in Aptana Studio 3 to support the PHP application developments listed below [95]:

- Syntax Coloring in accordance with the preferred themes;
- Code Assist;
- Annotation of syntax errors;
- Code Formatting and Automated indentation;
- Hyper-linking to classes, functions and variables through hovering over of elements and pressing the Ctrl key;
- Popup of PHP Doc when hovering over items that have documents attached to them;
- Read and write Occurrences Markers once certain PHP elements are clicked on.

Through the add-on PHP plugin, version 1.5 of Aptana supported the development of PHP applications, which included:

- An in-built PHP server that allows for preview in the Aptana Studio,
- Comprehensive code assist, code outlining and code formatting,
- A PHP debugger that is integrated,
- An in-built Smarty,
- Type hierarchy view,

- Go to declaration,
- A PHP manual that is integrated (online or local).

### 3.2.3 Database Design and Architecture

The first database for ultrasound simulation was first established in Jun 2012 using design principles and evaluation methods. Two years later i.e. April 2014, the Ultrasound Interactive Console Simulator (USICS) was developed to enhance the online learning platform. The USICS medical imaging curriculum is considered to be relatively comprehensive and serves nine courses in the medical field which include abdomen, obstetrics, cardiac, vascular, gynecology, breast, Neuro, thyroid, and other miscellaneous medical cases for all 2d gray scale instrumentations which include Time Gain Compensation (TGC), Depth, Overall Gain, Focal Position, Sector Width, Transducer Frequency, Transducer, Dynamic Range, and Output power. The hierarchy of database used in USICS is illustrated in Figure 2. The learning materials were re-arranged and grouped in accordance with USICS's imaging modality as well as the information that was documented in the database.

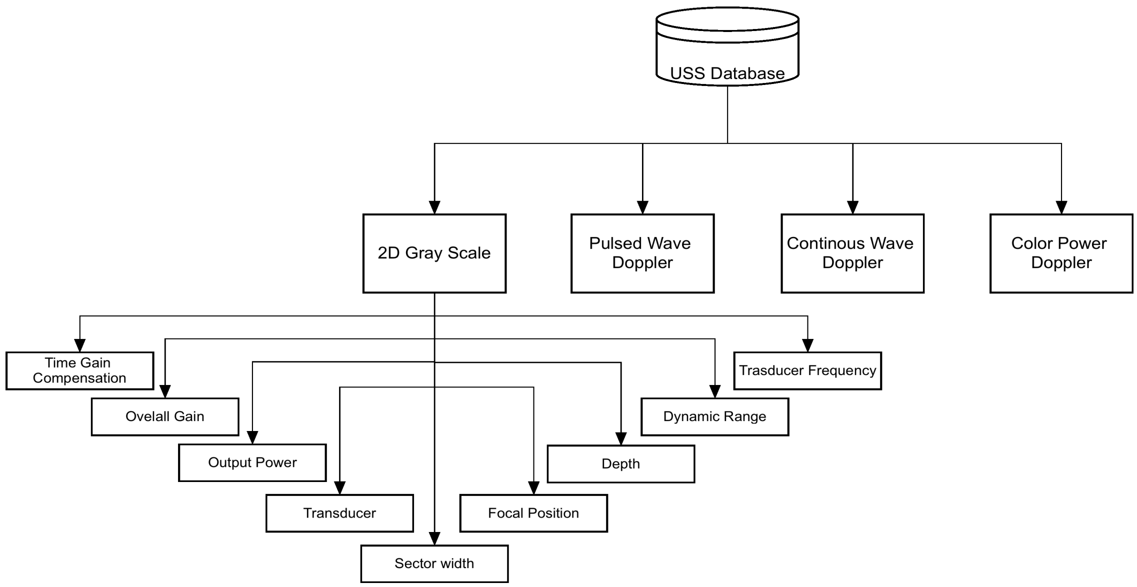



Figure 4: Hierarchy of Database

Moreover, the system's modules can also be pre-defined by an instructor using a variety of instrumentation in order to address his/her particular education purpose. The following are the components comprised in each module:

1) Review of history and background.

2) Illustration of texts and figures.

3) Animation that enhances interaction.

4) Simulation that is dynamic and interactive.

5) Application, demonstration etc.

Likewise, some specific modules of the system can be fitted with dynamic assessment questions that are chosen from the database at random. In a bid to improve the module as learning progresses, it is imperative to calculate the learning gain.

The Ultrasound Interactive Console Simulator (USICS) was developed using version 5.5 of MySQL relational database management system server. The database has the ability to store data safely and is supported by both Windows and Mac operating systems. A myriad of software that was used in the development of USICS such as: PHP version 5, JQuery, CSS, JavaScript, Apache web server and MySQL 5.5.33. The implementation of every module was done within the database. The development of the total system was achieved through the integration of a variety of stored procedures. In Table 2 is shown all database tables developed in this dissertation work.

| **Database Tables** | | |
|---|---|---|
| Database item Name | Item Type | Purpose |
| Users | Table | To store all user information |
| ImageBasket | Table | To store all content about the categories |
| Counter | Table | To store the system usage |
| Schools | Table | To store the institutions information |
| Grade | Table | To store the students grade |

Table 2: All database tables developed in dissertation work

| Users Table | | |
|---|---|---|
| Field | Data Type | Function |
| Fname | Varchar(20) | To store the user first name |
| Lname | Varchar(20) | The store the user last name |
| userID | Varchar(20) | To store user email address that is an unique identification |
| Pass | Varchar(20) | To store component's password |
| Count | Int(10) | To count the user usage time |
| startDate | Date | To store the user start date |
| lastApp | Date | To store the last time that is assigned in. |
| Active | Int(2) | To store the value either 0: Not Active or 1:Active |
| School | Varchar(20) | To store the name of institution. |
| Admin | Int(2) | To store the value either 0: Not Admin or 1:Admin |
| Account_Type | varchar(20) | To store the user account type |
| fullName | varchar(20) | To store full name of this account |
| FullAddress | varchar(20) | To store the user address |
| phoneNumber | int(10) | To store the user phone number |
| usingSystem | int(10) | To store the session tracking |
| Clicked | int(100) | To store the number of clicking for each section |

Table 3: Main fields of users table and their MySQL data type.

| Counter Table | | |
|---|---|---|
| Field | Data Type | Function |
| counter | Int(10) | To store the usage time of the system in general |

Table 4: Main fields of counter table and their MySQL data type.

| Image Basket Table | | |
|---|---|---|
| Field | Data Type | Function |
| id | int(10) | To store an unique identification of an image |
| iSection | Varchar(50) | To store the section name of the image |
| iType | Varchar(100) | To store the type name of the image |
| iSample | Varchar(10) | To store the sample number of the image |
| iRange | Varchar(10) | To store the range number of the image |
| iID | int(10) | To store an unique identification of the Image uploaded |
| iName | Varchar(100) | To store an encryption name of the image |
| iSize | longblob | To store an encryption size of the image |
| iFigure | text | To store the figure of the image |
| iDescription | text | To store the description of the image |
| iEffect | text | To store the Effect of the image |
| iApp | text | To store the application point of the image |

Table 5: Main fields of Image Basket table and their MySQL data type.

| Schools Table | | |
|---|---|---|
| Field | Data Type | Function |
| School_ID | Int(10) | To store random id for each school |
| School_Name | Varchar(50) | To store school's name |

Table 6: Main fields of Schools table and their MySQL data type.

| Grade Table | | |
|---|---|---|
| Field | Data Type | Function |
| Grade_ID | Int(10) | To store random id for each grade |
| QuizNum | int(10) | To store quiz number |
| QuizResult | int(50) | To store quiz score |
| QuizDate | date | To store the quiz date |
| QuizTime | time | To store the quiz time |

Table 7: Main fields of Grade table and their MySQL data type.

The development of USICS was done based on the guideline of creating a website that is a simple, an efficient and one that can be maintained and extended with ease. There were a number of other common guidelines that were considered and espoused such as:

1) No storage of repetitive data.

2) Stratification of flexibility and extendibility; field that require lesser storage requirement should be given more consideration.

3) Tables and fields that are accessed frequently can be efficiently queried.

### 3.2.4 USICS Design and Implementation

Ultrasound Interactive Console Simulator (USICS) will provide a solid comprehension of the features and functions of a real ultrasound instrument. The development of simulator system was done to aid in the investigation of these goals and objectives of this study to facilitate the achievement:

- The similarity to other ultrasound machines such as Philips Clear Vue
- The construct validity of the simulator system
- The content effectiveness of the simulator system
- The easiness of usage
- The effectiveness of learning case

Participants were given access to the website where they could undergo the learning process. After registration, the students were provided with information regarding the features and functionalities of the simulation system.

The study provided an opportunity to delve into how web technology can be used to increase the rate at which I could diagnose my goals and objectives. The user interfaces of the USICS web system used in the conduction of this study are illustrated in Figurers 6 – 20.


Figure 6: USICS - Home Page

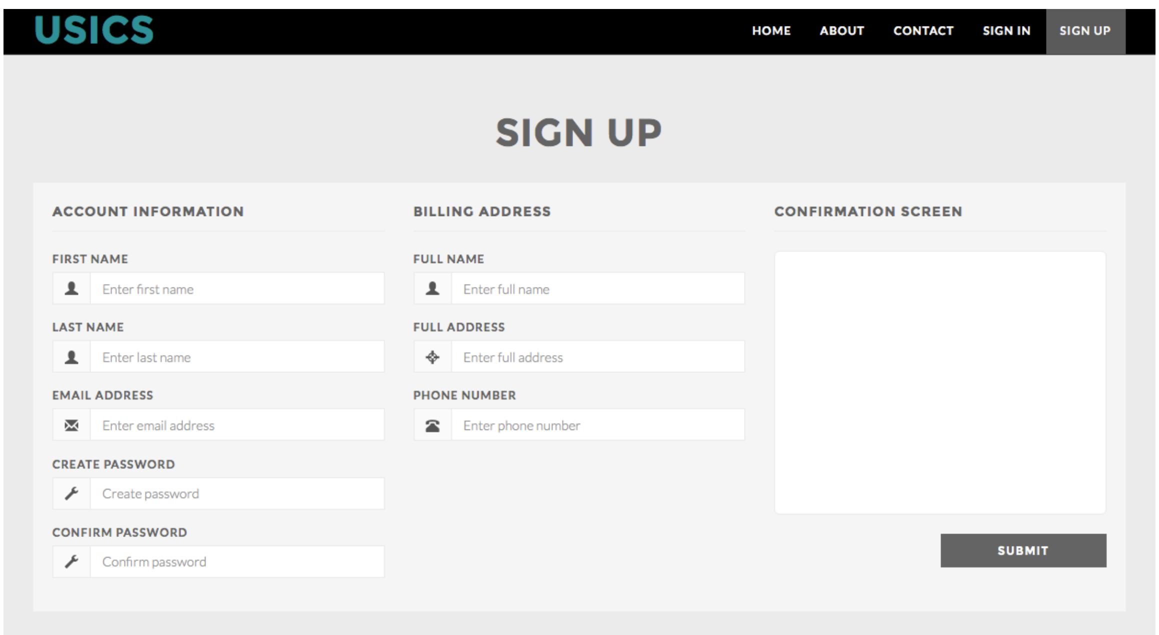



Figure 7: USICS - Registration Page

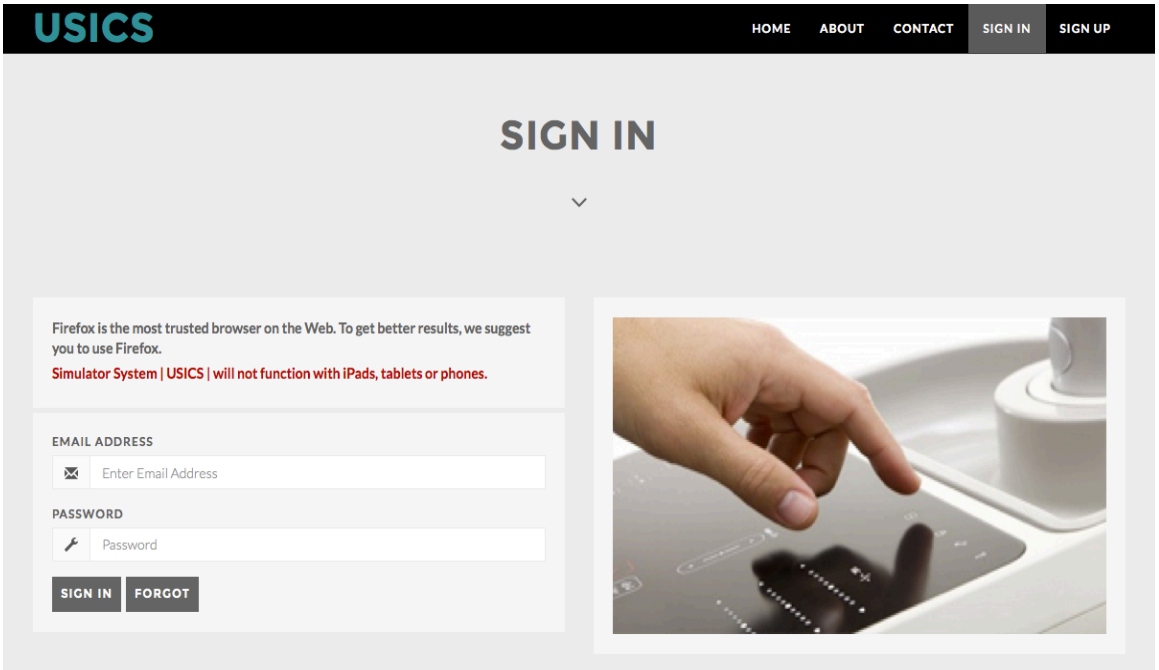



Figure 8: USICS - Sign In Page for Users

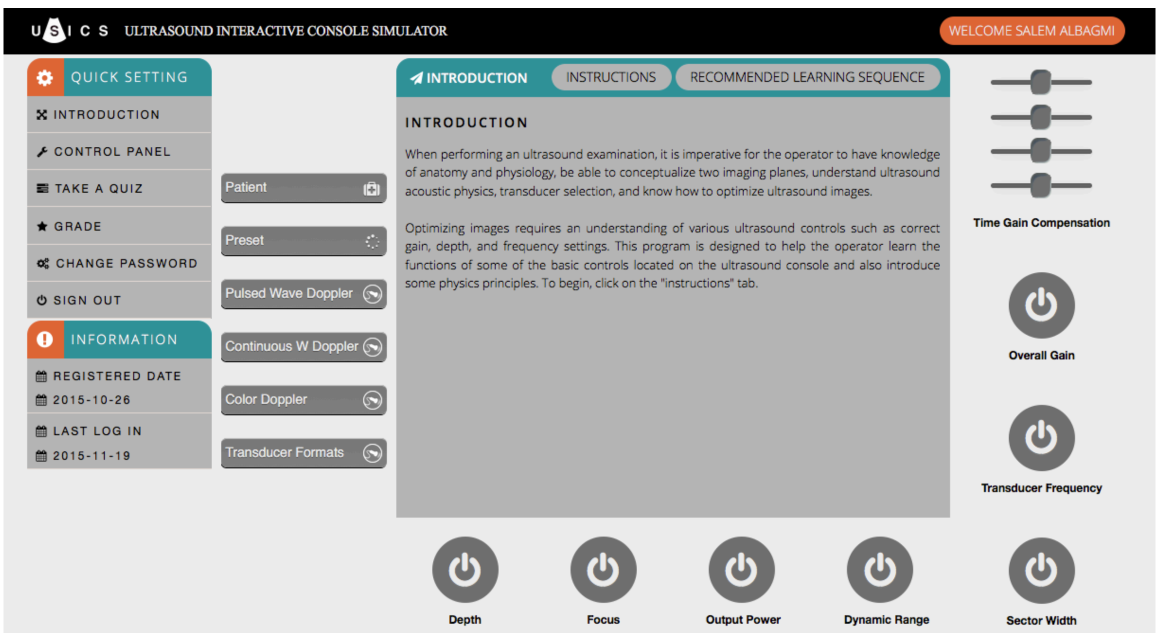



Figure 9: USICS - Welcome Page

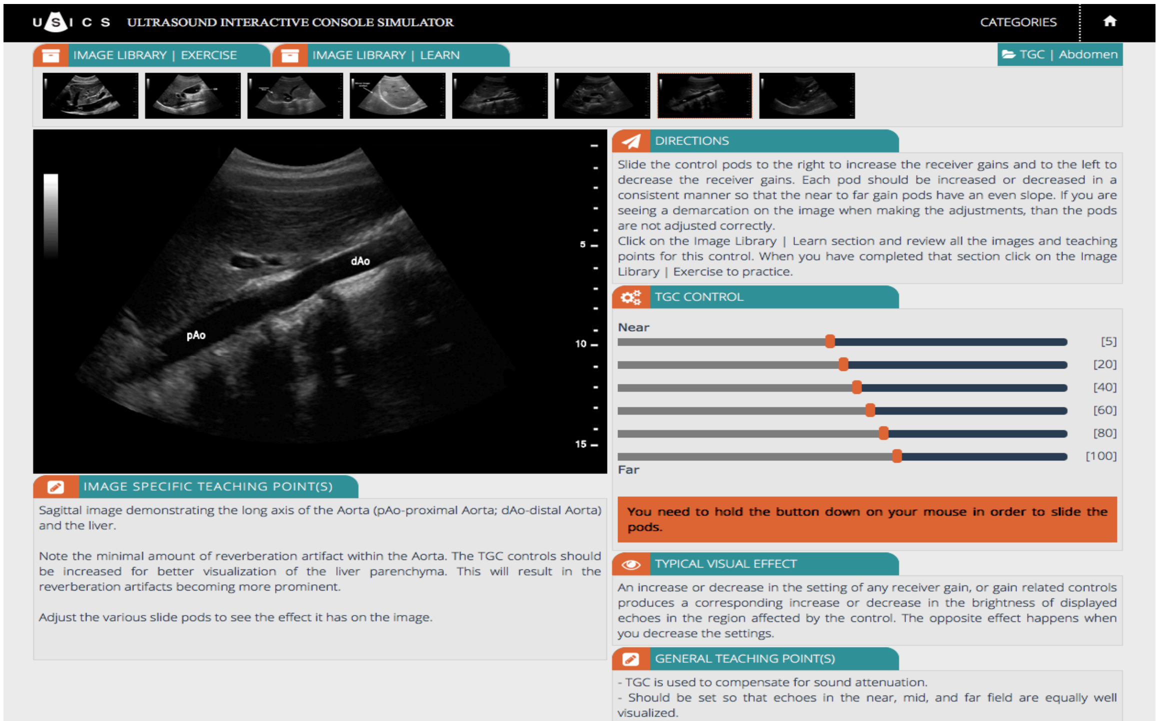



Figure 10: USICS - Learning Page (TGC Case)


Figure 11: USICS - Learning Page (Overall Gain Case)

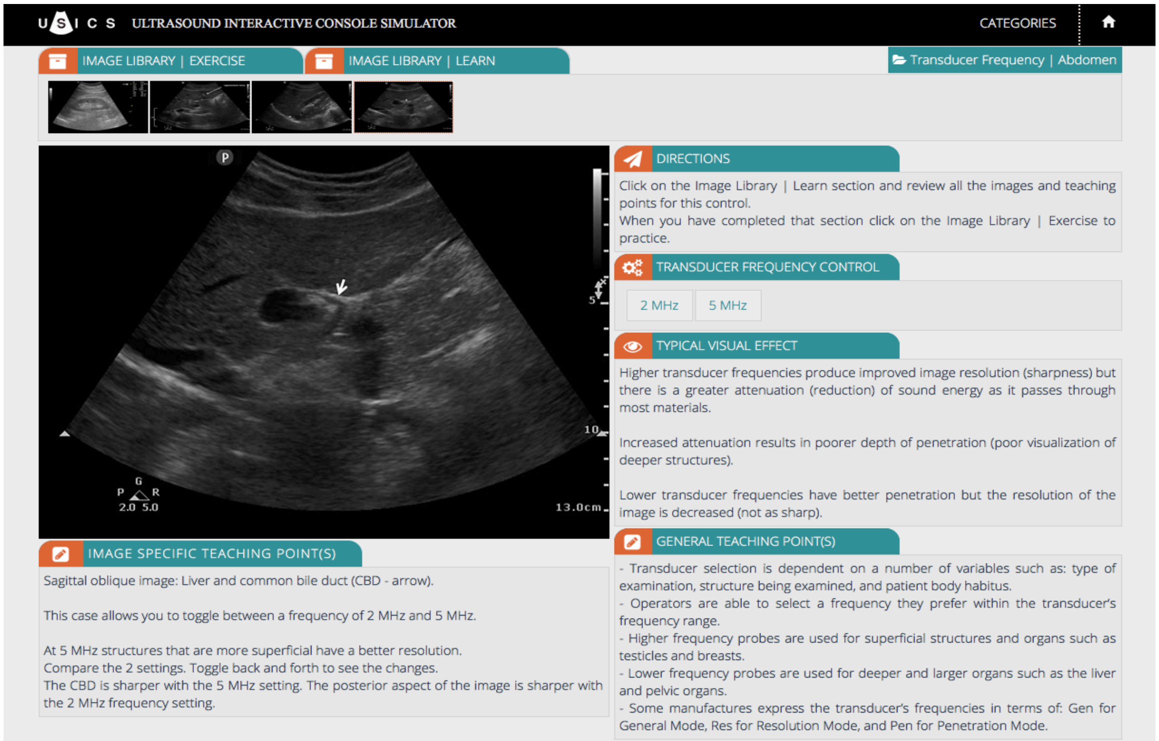



Figure 12: USICS - Learning Page (Transducer Frequency Case)

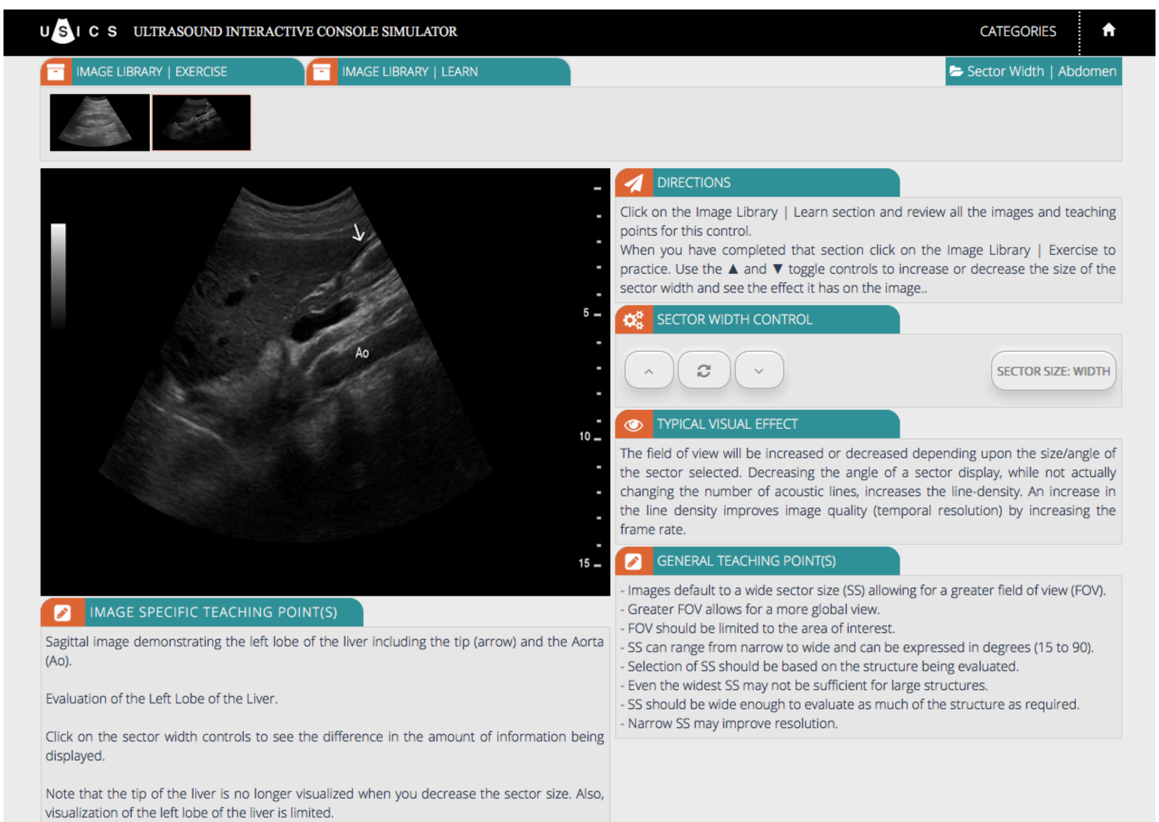



Figure 13: USICS - Learning Page (Sector Width Case)


Figure 14: USICS - Learning Page (Dynamic Range Case)

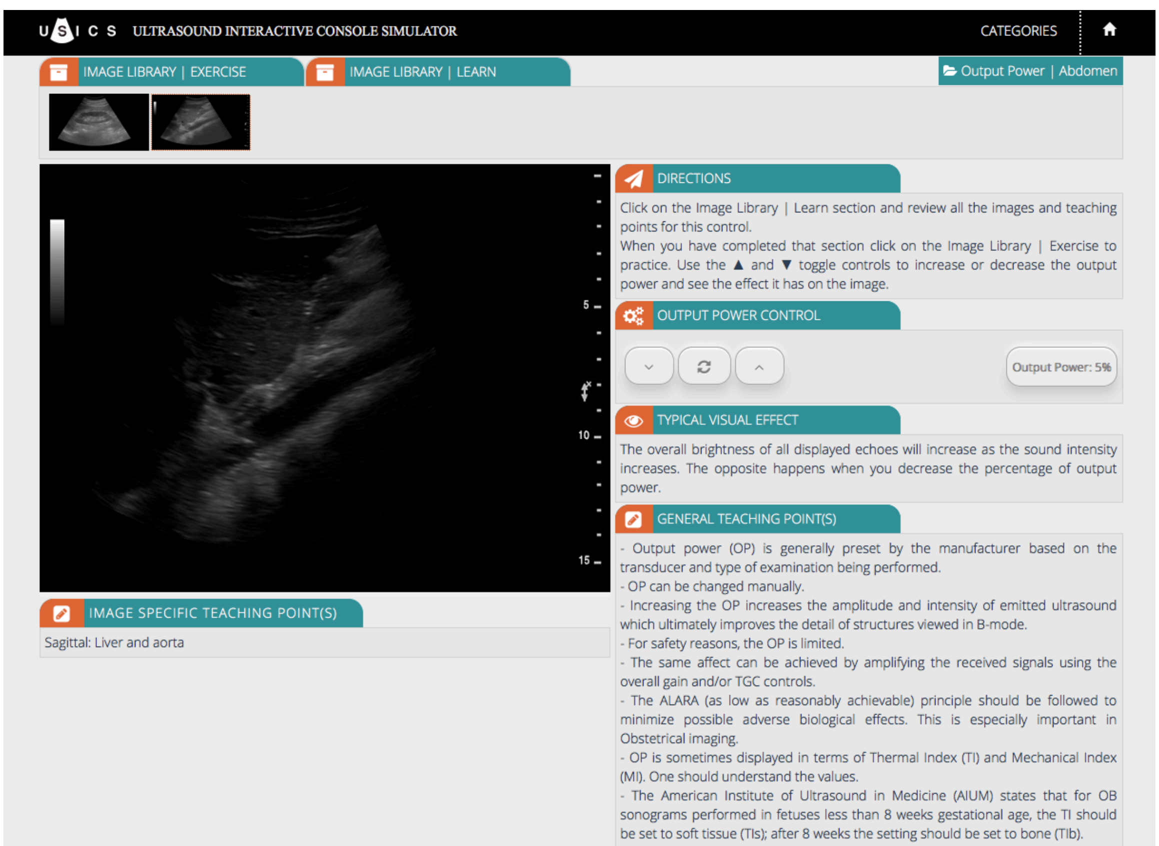



Figure 15: USICS - Learning Page (Output Power Case)

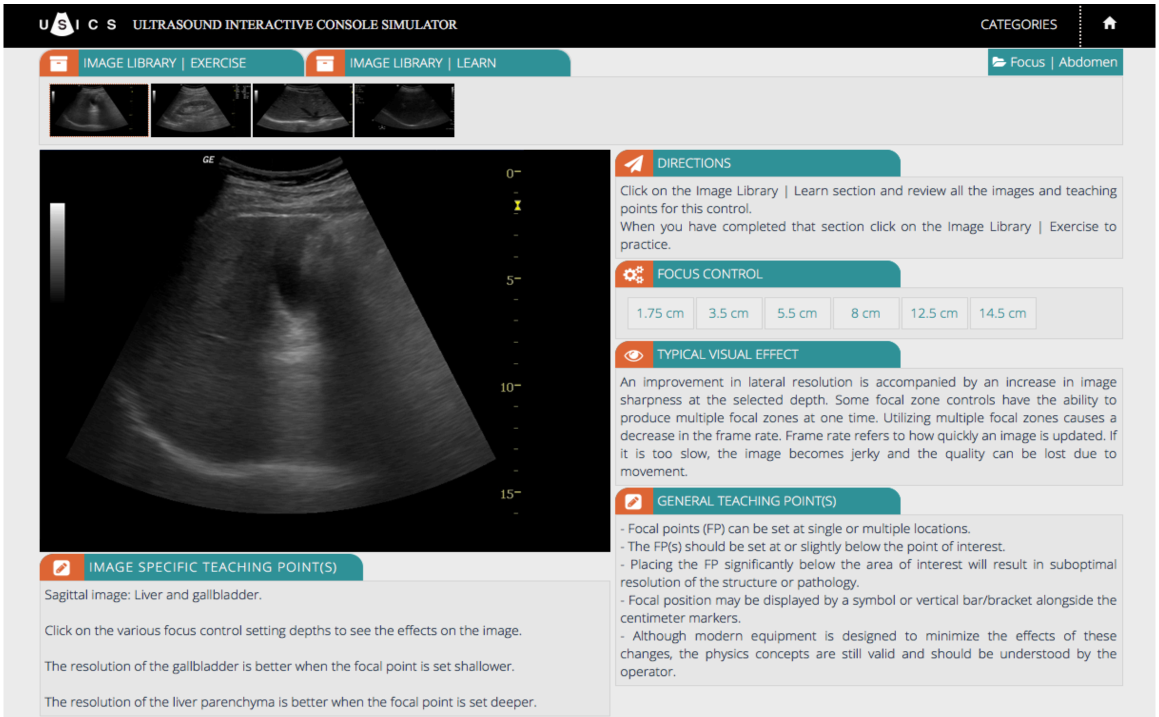



Figure 16: USICS - Learning Page (Focus Case)

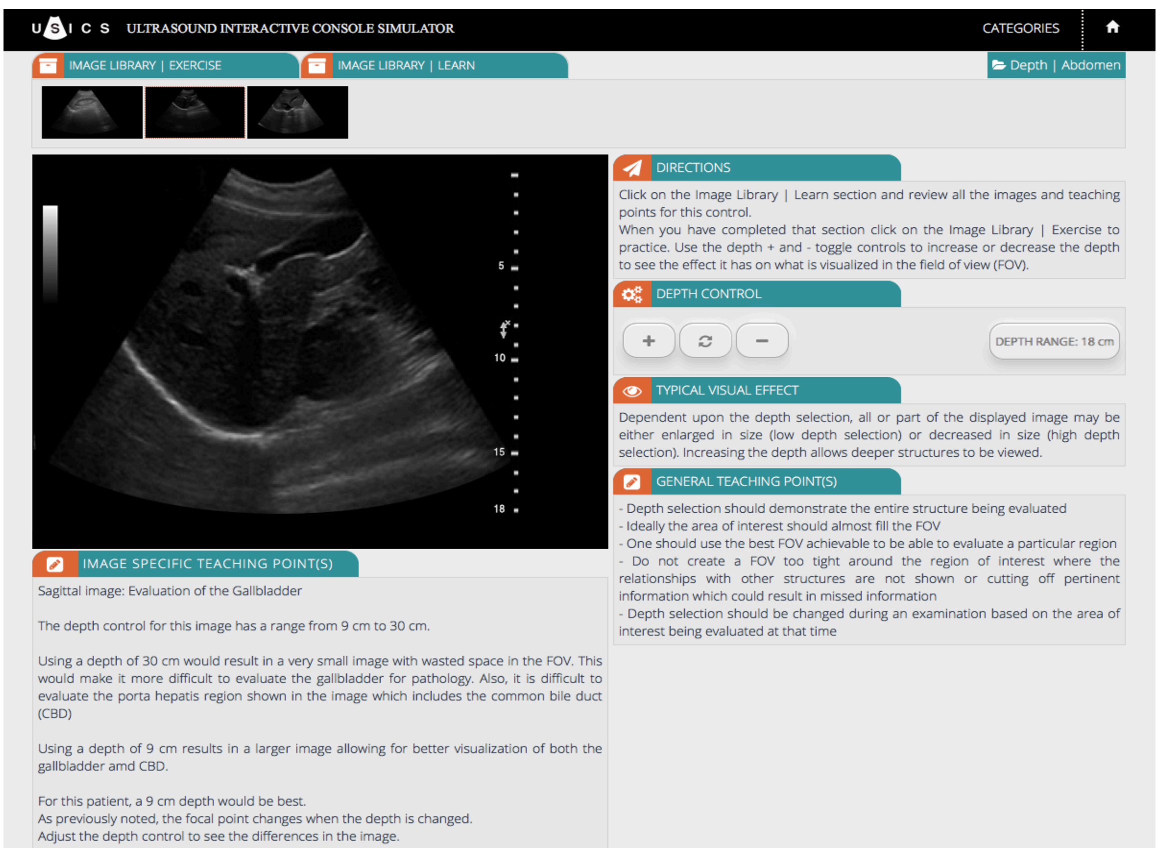



Figure 17: USICS - Learning Page (Depth Case)

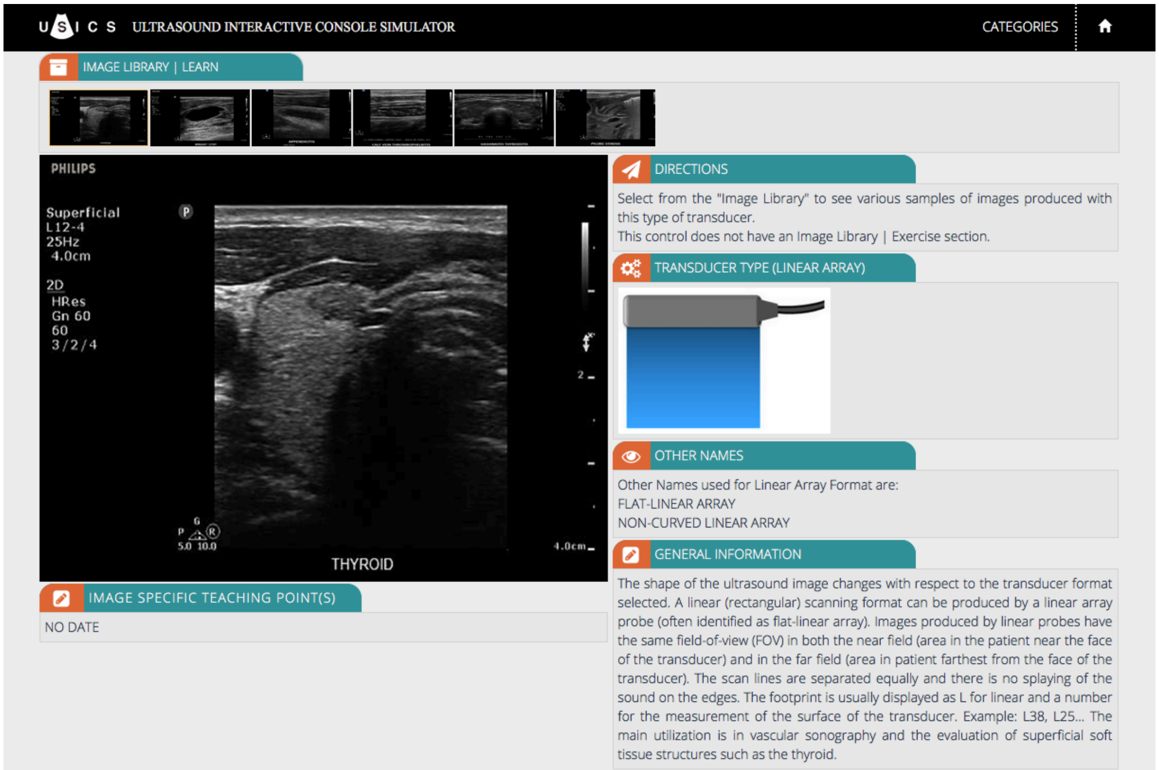



Figure 18: USICS - Learning Page (Transducer Formats Case)

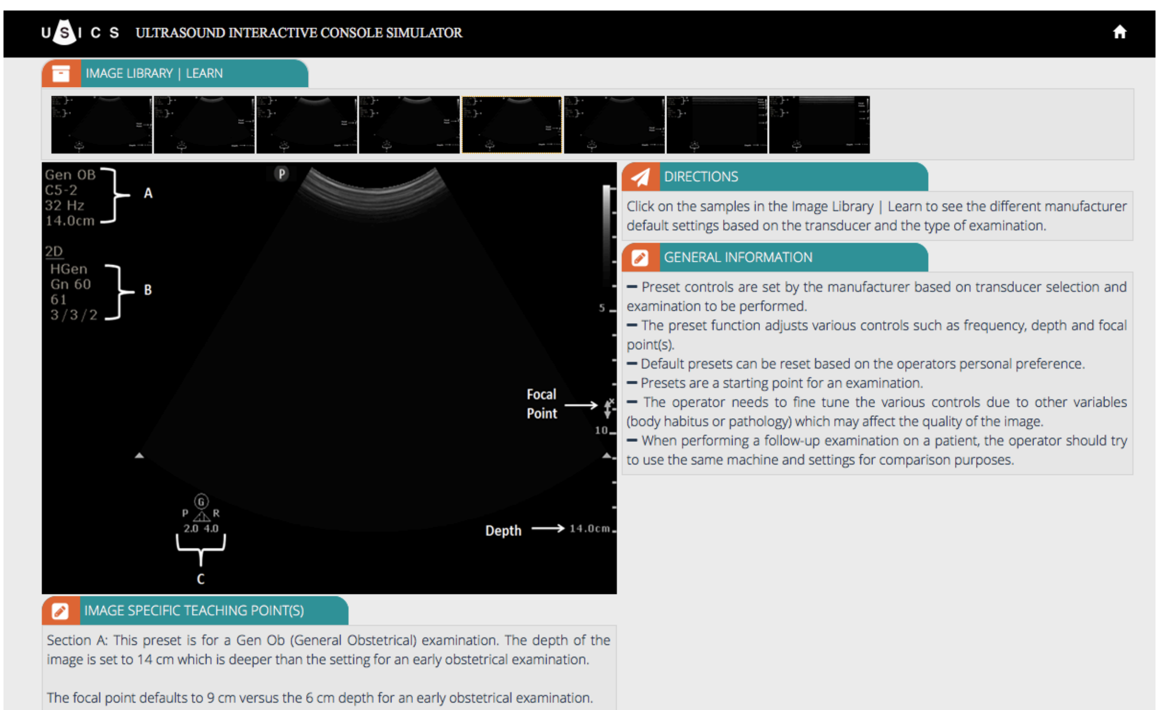



Figure 19: USICS - Learning Page (Preset Case)

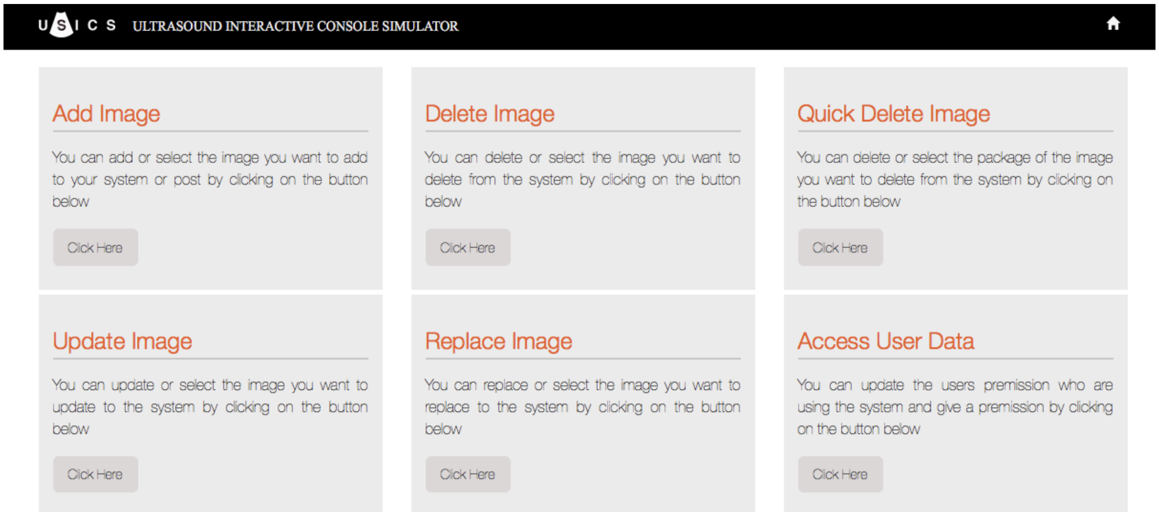



Figure 20: USICS - Control Panel

### 3.2.5 Flowchart of the USICS Access

The approach used in this simulator system in replicating the ultrasound machine is a unique in that, rather than focusing on how to scan, it allows the students to give more emphasis on its features and the ability of the machine. The possibility of that is shown by the friendly interface that USICS dose.

#### 3.2.5.1 Users interface flowchart

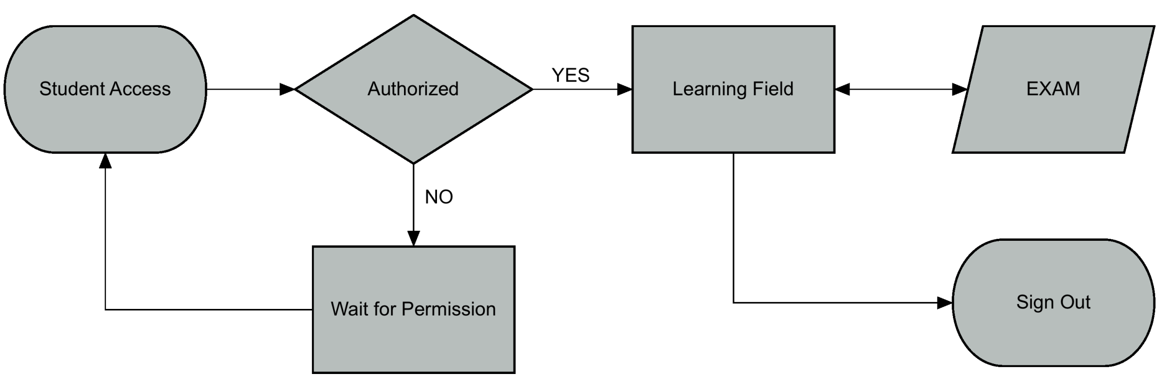



Figure 21: Users interface flowchart

For the users to be allowed to use the USICS, they have to go through the entire registration process then wait for authorization. The authorization of using the system was contingent on the acceptance of the registration. After authorization the users were enabled to use the friendly interface to go through the learning field, engage in practices, learn the concept of all tasks and cover all the requirements of their courses. After completion of the learning process, their ability to use the actual system is tested. The system was also used an assessment tools where the users are given score that explain if they are ready to use the actual system. They can sign out anytime they need. It doesn't require them to finish the task in specific time.

### 3.2.5.2 Admin interface flowchart

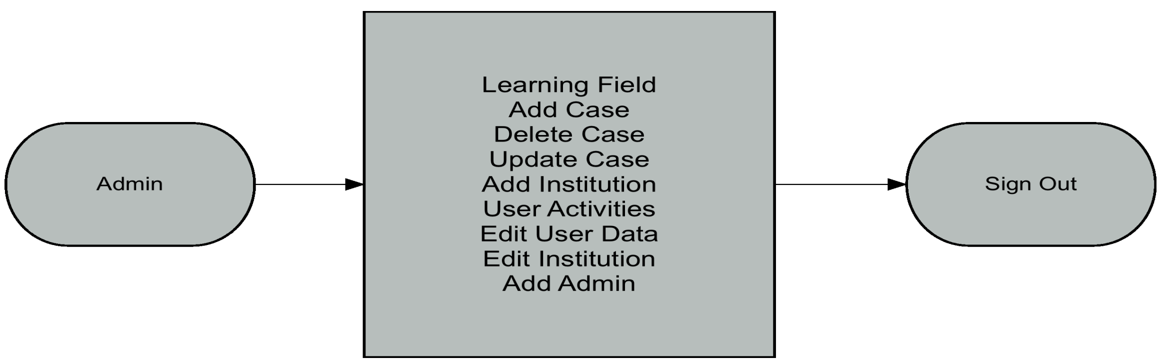



Figure 22: Admin interface flowchart

The system's admin has a unique interface that enables him/her to process all tools and generate the learning field. The admin has the power to add, delete and update cases, authorize different types of users, go through the activities of the users, edit the data of users and faculties, and give a full access to new admins. The can also access and sign out of the system at their own will.

### 3.2.6 Data collection

The study's core objective was to main develop an easy to use online interface by the name Ultrasound Interactive Console Simulator (USICS) which is available at www.shrp.rutgers.com/USICS so as to facilitate distance healthcare education. The study also aimed to evaluate the achievement of USICS's objectives.

Face, Content and Construct Validity Tests was evaluated by using a pool of domain (Medical Sonography) experts. The population for this design was on domain experts of 25 years and older currently teaching the course in Diagnostic Medical Sonography Department at Rutgers University and other different sites.

Comparative Effectiveness Assessment Test was a pre-test and post-test experiment conducted on a population of students. The population for this design was on students of 18 years and older currently studying in Diagnostic Medical Sonography Department at Rutgers University.

#### Image data collection

A free public imaging library was used in the collection of data for this study by the medical imaging science department at Rutgers University. The data collected was stored in a digital format on the main server computer at Rutgers University in password-protected database. Access to this data was limited to the principal investigator. These strict security measures were put in place to ensure that the data was safe and secure. The database will be securely housed in 65 Bergan St, Newark, NJ, 07101.

### 3.2.7 Study Variables

#### 3.2.7.1 Data Variables Used for Analysis

**Simulator similarity**

This variable will be measured on a continuous measurements scale with a range of 1 to 5. Calculating the average of questions 1 to 15 from the questionnaire will derive the score. Response choices on the questionnaire will be coded as: 1: Strongly Disagree; 2: Disagree; 3: Neither; 4: Agree; and 5: Strongly Agree. Thus, smaller scores indicate a perception that the simulator similarity is of less similarity while larger scores indicate a perception that the simulator similarity is of better similarity.

**Construct validity**

This variable will be measured on a continuous measurements scale with a range of 1 to 5. Calculating the average of questions 16 from the questionnaire will derive the score. Response choices on the questionnaire will be coded as: 1: Strongly Disagree; 2: Disagree; 3: Neither; 4: Agree; and 5: Strongly Agree. Thus, smaller scores indicate a perception that the construct validity is of less validity while larger scores indicate a perception that the construct validity is of better validity.

**Content effectiveness**

This variable will be measured on a continuous measurements scale with a range of 1 to 5. Calculating the average of questions 17 from the questionnaire will derive the score. Response choices on the questionnaire will be coded as: 1: Strongly Disagree; 2:

Disagree; 3: Neither; 4: Agree; and 5: Strongly Agree. Thus, smaller scores indicate a perception that the content effectiveness is of less effectiveness while larger scores indicate a perception that the content effectiveness is of better effectiveness.

**Supplementation of the need**

This variable will be measured on a continuous measurements scale with a range of 1 to 5. Calculating the average of questions 18 from the questionnaire will derive the score. Response choices on the questionnaire will be coded as: 1: Strongly Disagree; 2: Disagree; 3: Neither; 4: Agree; and 5: Strongly Agree. Thus, smaller scores indicate a perception that the supplementation of the need is of less supplementation while larger scores indicate a perception that the supplementation of the need is of better supplementation.

**Communication and learning**

This variable will be measured on a continuous measurements score with a range of 0 to 100. Calculating the scores for the pre-test and post-test experimental that are provided by instructors. Hence, that would derive the score for both tests.

### 3.2.8 Outcomes of USICS and Other Ultrasound Scanning Machine

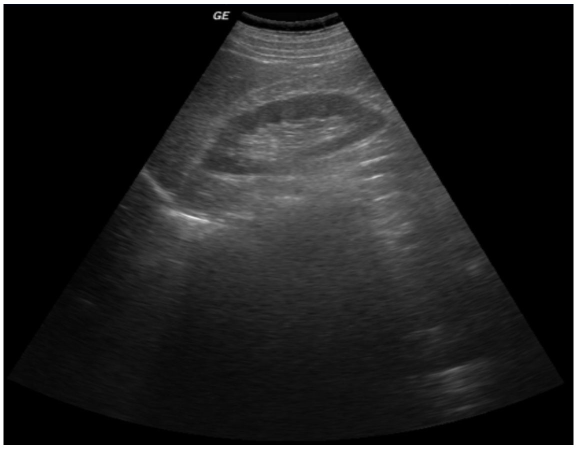


Figure 23: A - Real Ultrasound Machine
Depth Control - 30 cm

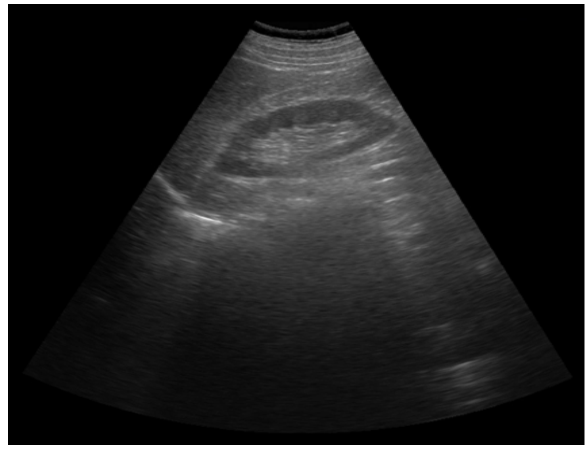


Figure 23: B - USICS
Depth Control - 30 cm

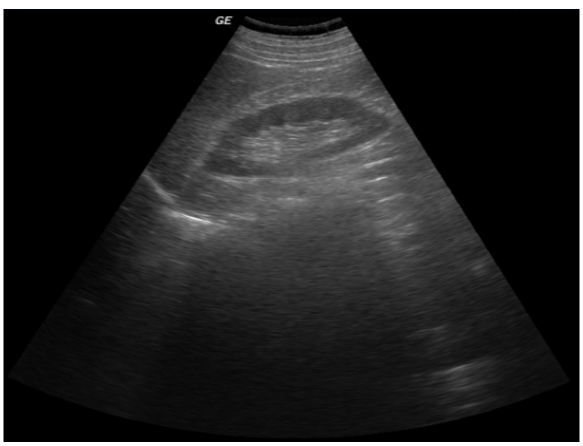


Figure 24: A - Real Ultrasound Machine
Depth Control – 26 cm

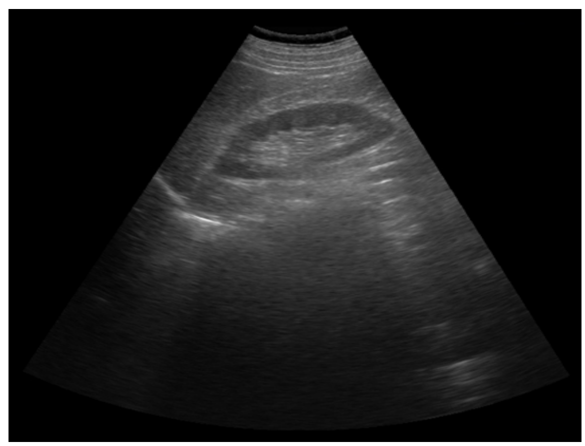


Figure 24: B - USICS
Depth Control – 26 cm

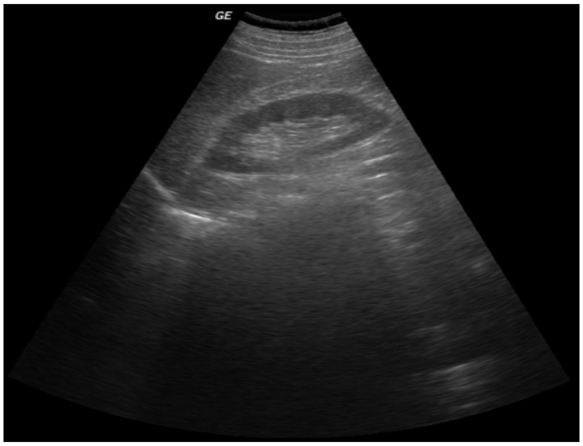



Figure 25: A - Real Ultrasound Machine
Depth Control - 22 cm

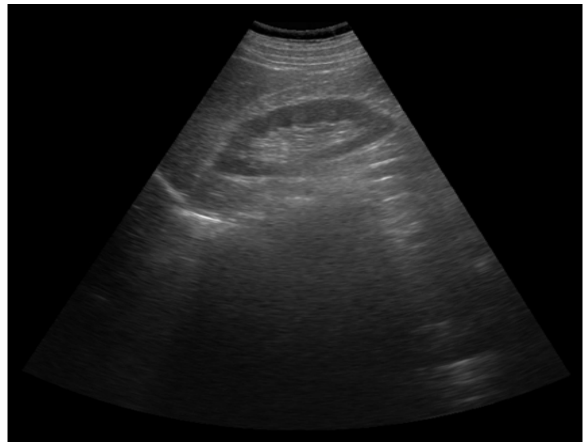


Figure 25: B - USICS
Depth Control – 22 cm

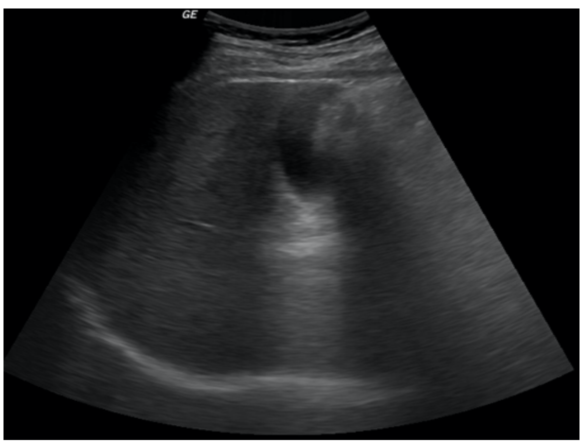



Figure 26: A - Real Ultrasound Machine
Focal Control – 1.75 cm

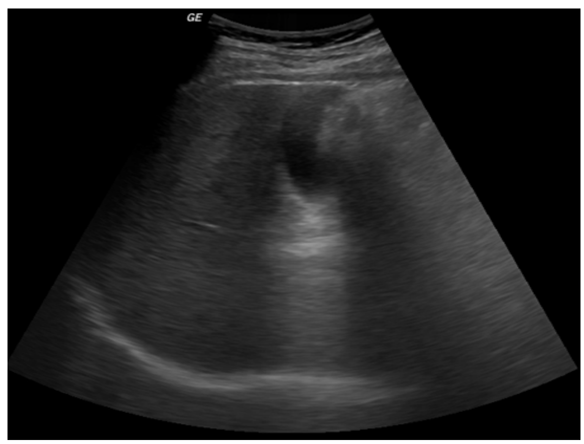



Figure 26: B - USICS
Focal Control -1.75 cm

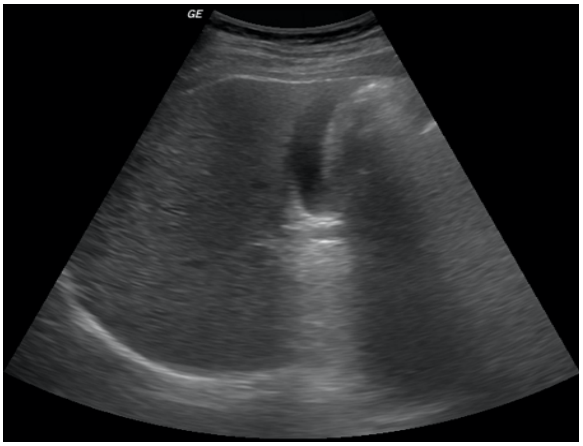


Figure 27: A - Real Ultrasound Machine
Focal Control – 8 cm

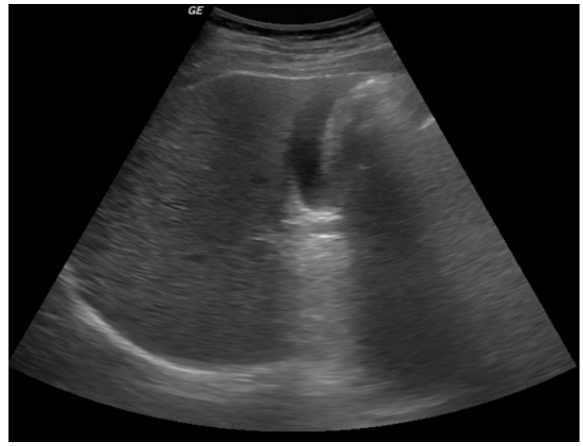


Figure 27: B - USICS
Focal Control – 8 cm

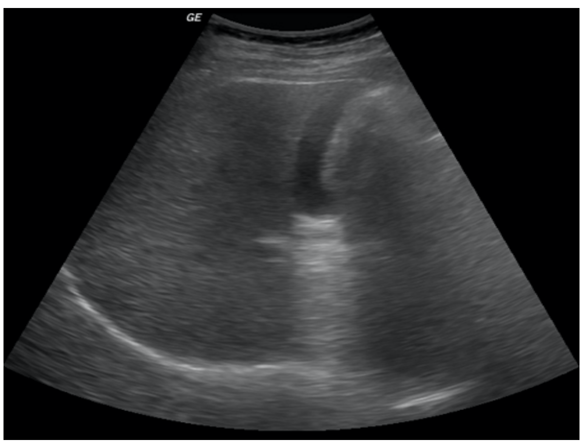


Figure 28: A - Real Ultrasound Machine
Focal Control -14.5 cm

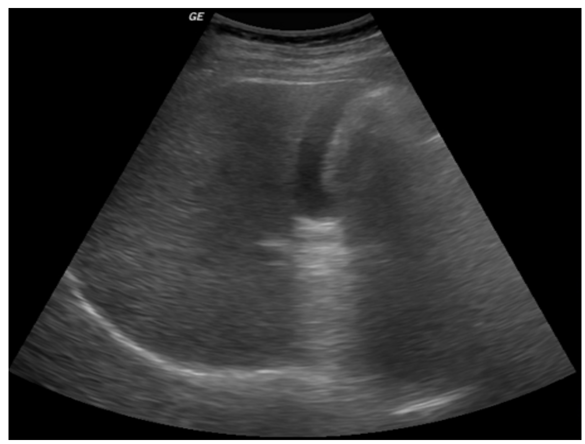


Figure 28: B - USICS
Focal Control – 14.5 cm

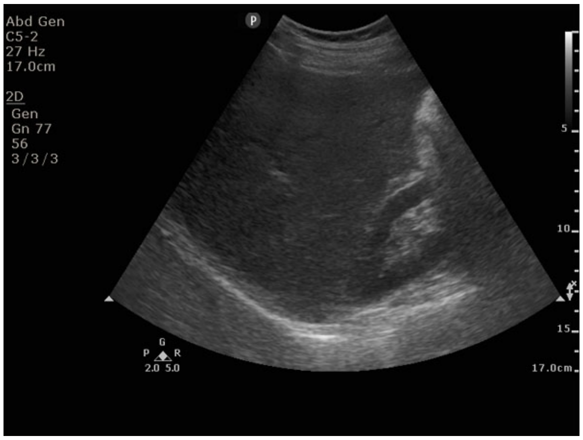



Figure 29: A - Real Ultrasound Machine
TGC Control - Near Gain

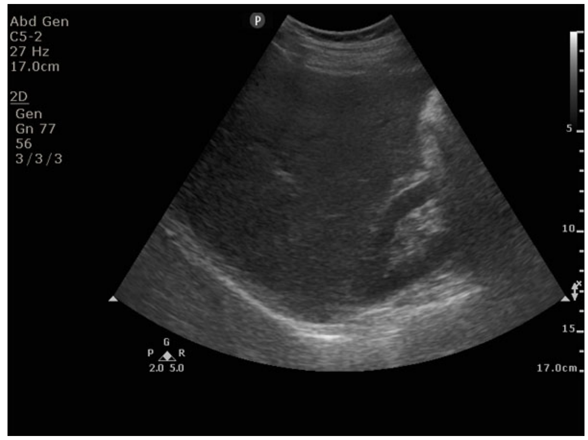



Figure 29: B - USICS
TGC Key - Near Gain

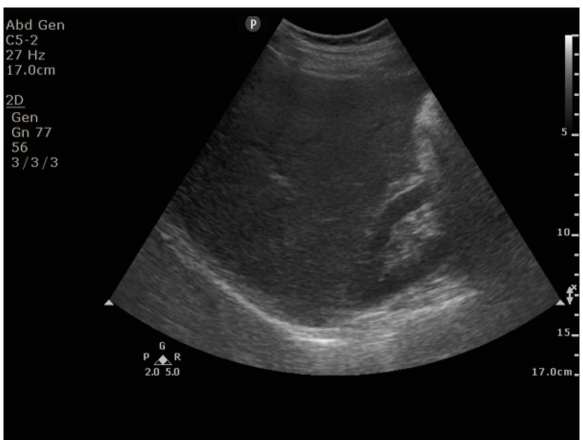



Figure 30: A - Real Ultrasound Machine
TGC Key - Med Gain

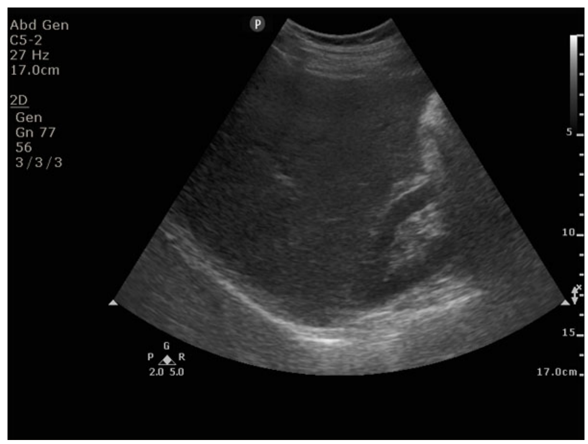
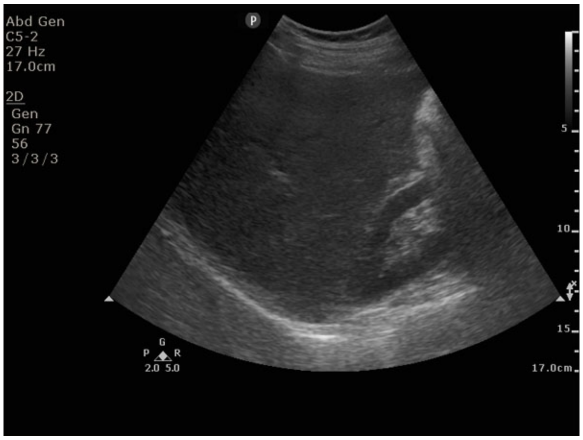



Figure 30: USICS
TGC Key - Med Gain



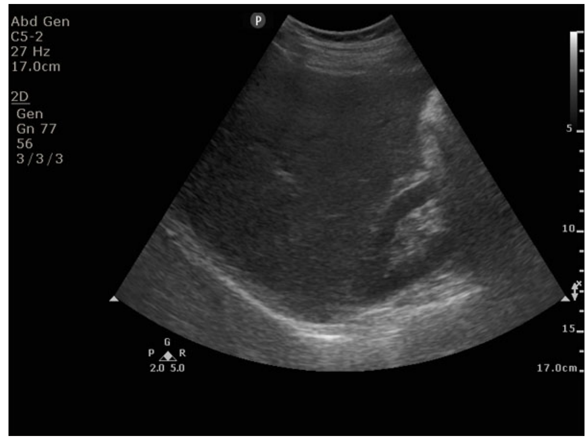
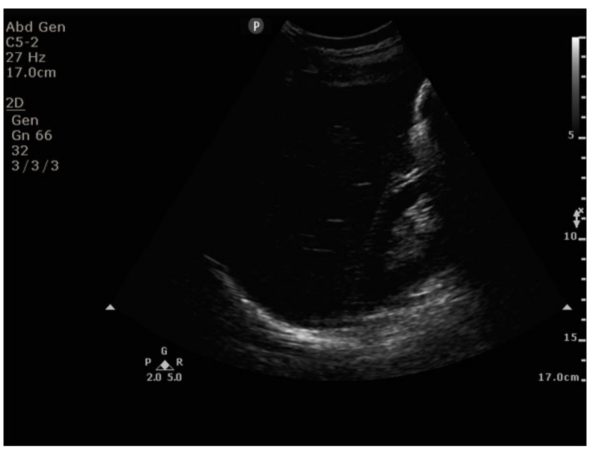




Figure 31: A - Real Ultrasound Machine
TGC Key - Far Gain

Figure 31: B - USICS
TGC Key - Far Gain



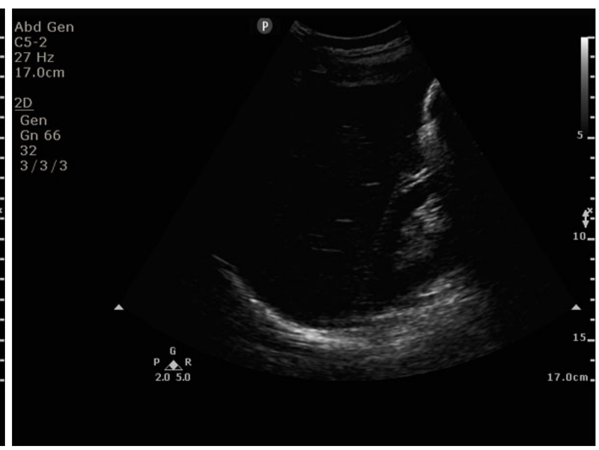




Figure 32: A - Real Ultrasound Machine
Dynamic Range Key – 32db

Figure 32: B - USICS
Dynamic Range Key – 32db

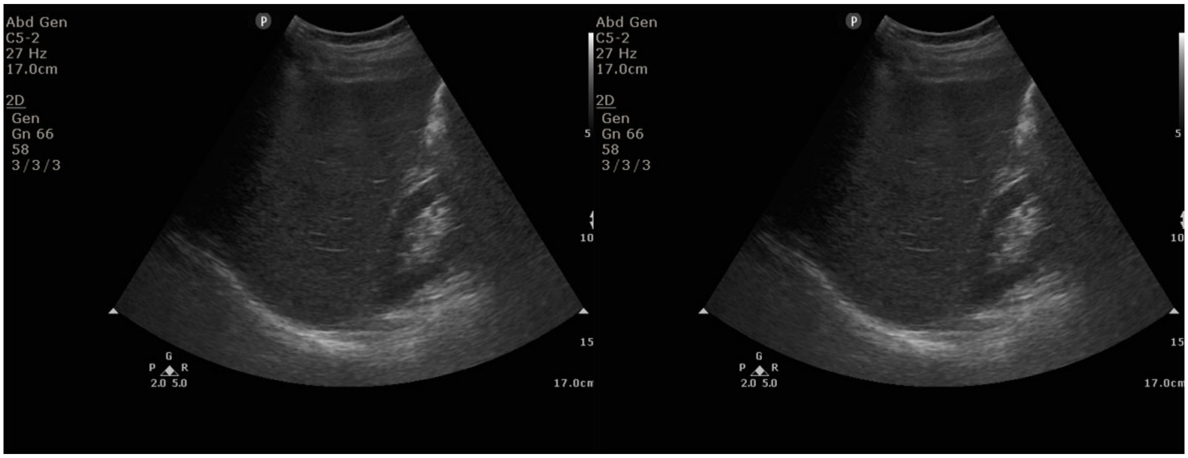



Figure 33: A - Real Ultrasound Machine
Dynamic Range Key – 58db

Figure 33: B - USICS
Dynamic Range Key – 58db

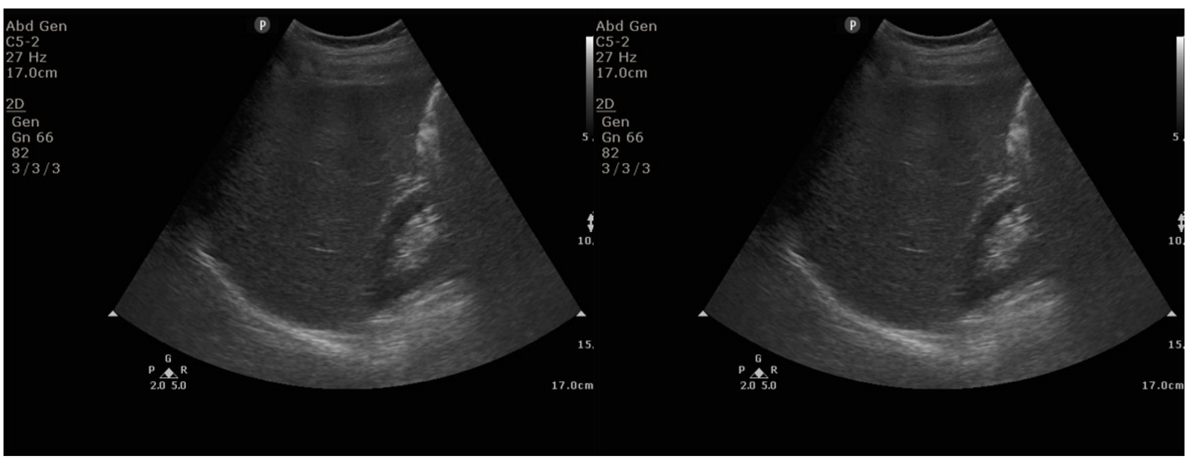



Figure 34: A - Real Ultrasound Machine
Dynamic Range Key – 82db

Figure 34: B - USICS
Dynamic Range Key – 82db

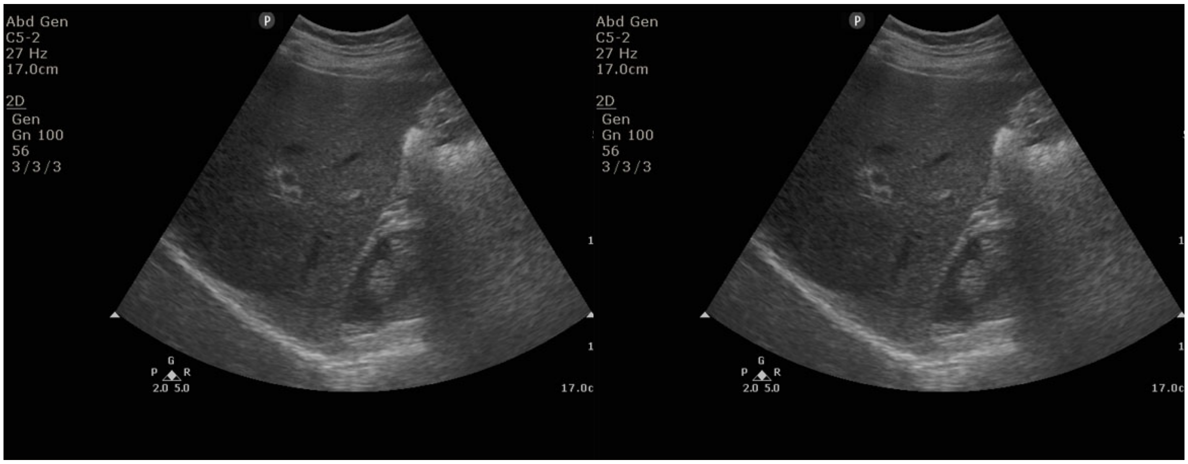



Figure 35: A - Real Ultrasound Machine
Overall Gain Key – Near Gain

Figure 35: B - USICS
Overall Gain Key – Near Gain

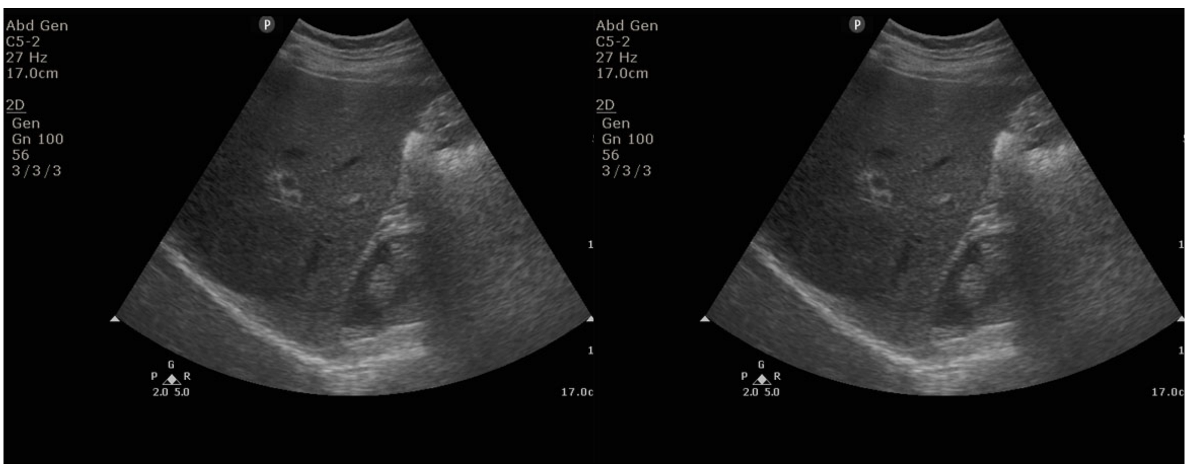



Figure 36: A - Real Ultrasound Machine
Overall Gain Key – Mid Gain

Figure 36: B - USICS
Overall Gain Key – Mid Gain


Figure 37: A - Real Ultrasound Machine
Overall Gain Key – Far Gain


Figure 37: B - USICS
Overall Gain Key – Far Gain


Figure 38: A - Real Ultrasound Machine
Sector Key – Narrow


Figure 38: B - USICS
Sector Key – Narrow

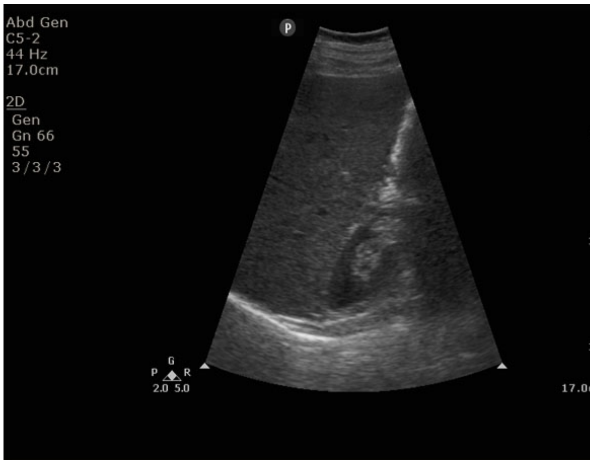



Figure 39: A - Real Ultrasound Machine
Sector Key – Mid

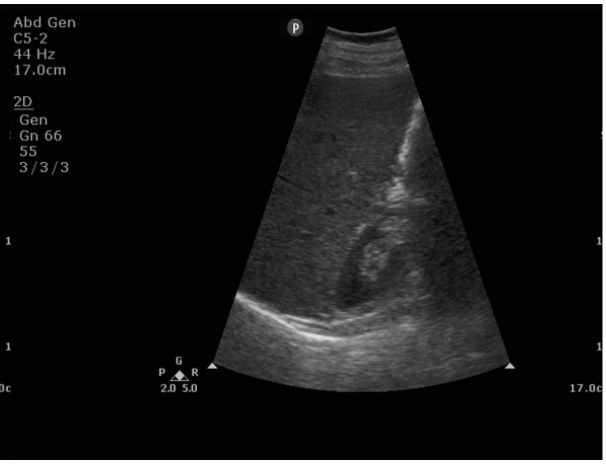



Figure 39: B - USICS
Sector Key – Mid


Figure 40: A - Real Ultrasound Machine
Sector Key – Wide

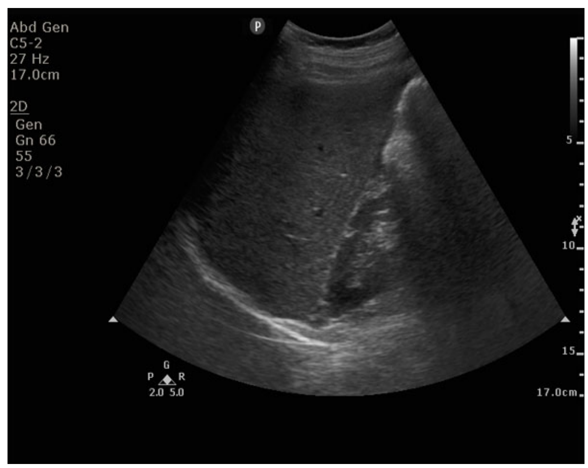



Figure 40: B - USICS
Sector Key – Wide

### 3.2.9 Appropriate Design for the Evaluation

There are two appropriate designs for the evaluations have been taken on this study. First design and method was a questionnaire that will be conducted in the PhD dissertation. After collection of the data, Cronbach's alpha test is the right statistic analysis that will be conducted for the questionnaire. The questionnaire was used to investigate a myriad of objectives that are discussed below.

- To design a user-friendly web-based or stand-alone simulation system (operable on any operating system platform) for mimicking the look and functions of Philip Clear Vue Ultrasound Machine for use in Online Education and Training.

- To assess the similarity between Ultrasound Interactive Console Simulator (USICS) and the Philip Clear Vue Ultrasound Machine for the results of operations performed for the modification of Sector Width control.

- To assess the similarity between Ultrasound Interactive Console Simulator (USICS) and the Philip Clear Vue Ultrasound Machine for the results of operations performed for the modification of Depth control.

- To assess the similarity between Ultrasound Interactive Console Simulator (USICS) and the Philip Clear Vue Ultrasound Machine for the results of operations performed for the modification of Focal Zone control.

- To assess the similarity between Ultrasound Interactive Console Simulator (USICS) and the Philip Clear Vue Ultrasound Machine for the results of operations performed for the modification of Output Power control.

- To assess the similarity between Ultrasound Interactive Console Simulator (USICS) and the Philip Clear Vue Ultrasound Machine for the results of operations performed for the modification of Dynamic Range control.

- To assess the similarity between Ultrasound Interactive Console Simulator (USICS) and the Philip Clear Vue Ultrasound Machine for the results of operations performed for the modification of Time Gain Compensation control.

- To assess the similarity between Ultrasound Interactive Console Simulator (USICS) and the Philip Clear Vue Ultrasound Machine for the results of operations performed for the modification of Overall Gain control.

- To assess the similarity between Ultrasound Interactive Console Simulator (USICS) and the Philip Clear Vue Ultrasound Machine for the results of operations performed for the modification of Transducer Frequency control.

- To examine the content effectiveness of USICS.

- To examine the construct validity of USICS.

- To delve into the assertion that USICS is supplementing the need to conduct training in a real-life clinical setting.

On the other hand, the second design and method is using Paired T-Test to compare the two populations as a nonparametric procedure versus its parametric counterpart. This method will evaluate the comparative effectiveness in the learning case of using Ultrasound Interactive Console Simulator (USICS). Here is the objective that I focused on it in the second method:

- To evaluate the comparative effectiveness in the learning case and measure the difference in the scores in using the real system and the simulator system.

### 3.2.10 Statistical Methodology

The following methods will be used to investigate the variables as appropriate.

- Cronbach's alpha
- Paired T-Test

### 3.2.11 Statistical Analysis

All calculations was done with SAS® Release 3.4 (Basic Edition) running on a Mac operating system. All invalid data will be testified and a reason given for why the data is considered invalid.

The first research data was collected through the questionnaire that provided on volunteers' domain experts. Data will be categorized as appropriate to investigate research objectives. Cronbach's alpha (α) is the most common measure of internal consistency ("reliability") to provide a measure of the internal consistency of a test or scale; it is expressed as a number between 0 and 1.

George and Mallery (2003 p. 231) provide the following rules of thumb:

| | |
|---|---|
| = 0.9 | Excellent |
| >= 0.8 | Good |
| >= 0.7 | Acceptable |
| >= 0.6 | Questionable |
| >= 0.5 | Poor |
| <= 0.5 | Unacceptable |

The second research data was as a secondary data from the result test through pre-post test through students who study ultrasound course by instructors. Paired sample t-test is used for the pretest and post test experiments and it is a statistical technique that is used to compare two population means in the case of two samples that are correlated. Paired sample t-test is used in “before-after” studies, or when the samples are the matched pairs, or when it is a case-control study.

# CHAPTER 4 RESULTS AND DISCUSSION

## 4.1 Introduction

After giving an explanation about the existing system, a description of the endeavors that were embarked on to make the new simulator system more affordable and efficient in the giving students a better comprehension about the concepts of various medical given. As a corollary, it is important to investigate system can be used to support and improve the adoption of web-based distance education.

## 4.2 Study Finding

### 4.2.1 Evaluation of Questionnaire

The questionnaire consists of eighteen statements where they were requested to share their opinion regarding the system using a Likert scale. The Likert scale that gave participants the option to: Strongly Agree; Agree; Neutral; Disagree and Strongly disagree with the questions. The Cronbach's alpha (α) is the most common measure of internal consistency (“reliability”) to provide a measure of the internal consistency of a test or scale; it is expressed as a number between 0 and 1.

First, I set up a simple hypothesis test that postulates there is no difference between the satisfaction scores of any of the attributes. The null hypothesis is Ho: and the research, or alternate hypothesis is Ha:

Then:

$H1_0$: The images generated by Ultrasound Interactive Console Simulator (USICS) are not similar to images produced by an Ultrasound Machine for Sector Width control in Wide Angle.

$H1_a$: The images generated by Ultrasound Interactive Console Simulator (USICS) are similar to images produced by an Ultrasound Machine for Sector Width control in Wide Angle.

$H2_0$: The images generated by Ultrasound Interactive Console Simulator (USICS) are not similar to images produced by an Ultrasound Machine for Sector Width control in Medium Angle.

$H2_a$: The images generated by Ultrasound Interactive Console Simulator (USICS) are similar to images produced by an Ultrasound Machine for Sector Width control in Medium Angle.

$H3_0$: The images generated by Ultrasound Interactive Console Simulator (USICS) are not similar to images produced by an Ultrasound Machine for Sector Width control in Narrow Angle.

$H3_a$: The images generated by Ultrasound Interactive Console Simulator (USICS) are similar to images produced by an Ultrasound Machine for Sector Width control in Narrow Angle.

$H4_0$: The images generated by Ultrasound Interactive Console Simulator (USICS) are not similar to images produced by an Ultrasound Machine for Depth control in increasing capability.

$H4_a$: The images generated by Ultrasound Interactive Console Simulator (USICS) are similar to images produced by an Ultrasound Machine for Depth control in increasing capability.

$H5_0$: The images generated by Ultrasound Interactive Console Simulator (USICS) are not similar to images produced by an Ultrasound Machine for Depth control in decreasing capability.

$H5_a$: The images generated by Ultrasound Interactive Console Simulator (USICS) are similar to images produced by an Ultrasound Machine for Depth control in decreasing capability.

$H6_0$: The images generated by Ultrasound Interactive Console Simulator (USICS) are not similar to images produced by an Ultrasound Machine for Focus control in increasing capability.

$H6_a$: The images generated by Ultrasound Interactive Console Simulator (USICS) are similar to images produced by an Ultrasound Machine for Focus control in increasing capability.

$H7_0$: The images generated by Ultrasound Interactive Console Simulator (USICS) are not similar to images produced by an Ultrasound Machine for Focus control in decreasing capability.

$H7_a$: The images generated by Ultrasound Interactive Console Simulator (USICS) are similar to images produced by an Ultrasound Machine for Focus control in decreasing capability.

$H8_0$: The images generated by Ultrasound Interactive Console Simulator (USICS) are not similar to images produced by an Ultrasound Machine for Output Power control in increasing capability.

$H8_a$: The images generated by Ultrasound Interactive Console Simulator (USICS) are similar to images produced by an Ultrasound Machine for Output Power control in increasing capability.

$H9_0$: The images generated by Ultrasound Interactive Console Simulator (USICS) are not similar to images produced by an Ultrasound Machine for Output Power control in decreasing capability.

$H9_a$: The images generated by Ultrasound Interactive Console Simulator (USICS) are similar to images produced by an Ultrasound Machine for Output Power control in decreasing capability.

$H10_0$: The images generated by Ultrasound Interactive Console Simulator (USICS) are not similar to images produced by an Ultrasound Machine for Dynamic Range control in increasing capability.

$H10_a$: The images generated by Ultrasound Interactive Console Simulator (USICS) are similar to images produced by an Ultrasound Machine for Dynamic Range control in increasing capability.

$H11_0$: The images generated by Ultrasound Interactive Console Simulator (USICS) are not similar to images produced by an Ultrasound Machine for Dynamic Range control in decreasing capability.

$H11_a$: The images generated by Ultrasound Interactive Console Simulator (USICS) are similar to images produced by an Ultrasound Machine for Dynamic Range control in decreasing capability.

$H12_0$: The images generated by Ultrasound Interactive Console Simulator (USICS) are not similar to images produced by an Ultrasound Machine for Transducer Frequency control in increasing capability.

$H12_a$: The images generated by Ultrasound Interactive Console Simulator (USICS) are similar to images produced by an Ultrasound Machine for Transducer Frequency control in increasing capability.

$H13_0$: The images generated by Ultrasound Interactive Console Simulator (USICS) are not similar to images produced by an Ultrasound Machine for Transducer Frequency control in decreasing capability.

$H13_a$: The images generated by Ultrasound Interactive Console Simulator (USICS) are similar to images produced by an Ultrasound Machine for Transducer Frequency control in decreasing capability.

$H14_0$: The images generated by Ultrasound Interactive Console Simulator (USICS) are not similar to images produced by an Ultrasound Machine for Time Gain Compensation control.

$H14_a$: The images generated by Ultrasound Interactive Console Simulator (USICS) are similar to images produced by an Ultrasound Machine for Time Gain Compensation control.

$H15_0$: The images generated by Ultrasound Interactive Console Simulator (USICS) are not similar to images produced by an Ultrasound Machine for Overall Gain control.

$H15_a$: The images generated by Ultrasound Interactive Console Simulator (USICS) are similar to images produced by an Ultrasound Machine for Overall Gain control.

$H16_0$: The contents provided for developing the skills and knowledge needed to perform in lab-sessions is not helpful.

$H16_a$: The contents provided for developing the skills and knowledge needed to perform in lab-sessions is helpful.

$H17_0$: The functionality and usability provided is not mimicking the Philips Clear Vue ultrasound machine.

$H17_a$: The functionality and usability provided is mimicking the Philips Clear Vue ultrasound machine.

$H18_0$: USICS is not a supplement that would beneficial to conducting training in a real-life clinical setting.

$H18_a$: USICS is a supplement that would beneficial to conducting training in a real-life clinical setting.

I am assuming that there is no statistically significant difference between the means in the null hypothesis (Ho). When I employ the Cronbach's alpha (α) test statistic, I am testing the validity of this hypothesis. Under the Cronbach's alpha (α) output, the test results can be found and as shown below.

**Scale: ALL VARIABLES**

**Case Processing Summary**

| | | N | % |
|---|---|---|---|
| Cases | Valid | 15 | 100.0 |
| | Excluded[a] | 0 | .0 |
| | Total | 15 | 100.0 |

a. Listwise deletion based on all variables in the procedure.

**Reliability Statistics**

| Cronbach's Alpha | Cronbach's Alpha Based on Standardized Items | N of Items |
|---|---|---|
| .953 | .954 | 18 |

Table 8: Evaluation of the questionnaire - Cronbach's alpha (α) output

In the case processing summary, I had 15 valid cases and 0 excluded that give me a total of 15. In the Reliability Statistics, I am looking for something like greater than 0.70. Hence, the questionnaire was employed to measure the goals and objectives, which consisted of 18 questions. The scale had a high level of internal consistency, as determined by a Cronbach's alpha of 0.953.

### 4.2.2 Evaluation of Pre-Test and Post-Test Experiments

Data were collected as secondary data from Medical Sonography Department at Rutgers University. The data collected were from 13 students who study Ultrasound course at two different times. The instructor administered the data collection.

*Pre-Assessment*

In the pre-assessment section, participants have their hands-on lab session before using Ultrasound Interactive Console Simulator (USICS). They have to optimize three different images from Ultrasound Scanning Machine called Philip Clear Vue. The main controls that students have been tested on to optimize an image was:

- Depth Setting
- Focus
- Time Gain Compensation (TGC)
- Overall Gain

Table 9 summarized the score results for the image 1 on Liver and instructors conducted the results.

| IMAGE 1 - Liver | | | | | |
|---|---|---|---|---|---|
| Student | Depth | Focal | Overall Gain | TGC | Total |
| 1 | 0/25 | 12.5/25 | 12.5/25 | 12.5/25 | 37.5 |
| 2 | 0/25 | 0/25 | 12.5/25 | 12.5/25 | 25 |
| 3 | 12.5/25 | 12.5/25 | 0/25 | 0/25 | 25 |
| 4 | 0/25 | 0/25 | 0/25 | 12.5/25 | 12.5 |
| 5 | 12.5/25 | 12.5/25 | 0/25 | 12.5/25 | 37.5 |
| 6 | 12.5/25 | 0/25 | 0/25 | 0/25 | 12.5 |
| 7 | 0/25 | 12.5/25 | 12.5/25 | 12.5/25 | 37.5 |
| 8 | 0/25 | 0/25 | 12.5/25 | 0/25 | 12.5 |
| 9 | 12.5/25 | 0/25 | 12.5/25 | 0/25 | 25 |
| 10 | 12.5/25 | 0/25 | 12.5/25 | 0/25 | 25 |
| 11 | 12.5/25 | 12.5/25 | 12.5/25 | 0/25 | 37.5 |
| 12 | 12.5/25 | 12.5/25 | 12.5/25 | 12.5/25 | 50 |
| 13 | 12.5/25 | 0/25 | 12.5/25 | 12.5/25 | 37.5 |

Table 9: score results for the image 1 on Liver

Table 10 summarized the score results for the image 2 on Gallbladder and instructors conducted the results.

| IMAGE 2 - Gallbladder | | | | | |
|---|---|---|---|---|---|
| Student | Depth | Focal | Overall Gain | TGC | Total |
| 1 | 12.5/25 | 12.5/25 | 12.5/25 | 12.5/25 | 50 |
| 2 | 12.5/25 | 12.5/25 | 12.5/25 | 12.5/25 | 50 |
| 3 | 0/25 | 12.5/25 | 0/25 | 0/25 | 12.5 |
| 4 | 12.5/25 | 12.5/25 | 12.5/25 | 0/25 | 37.5 |
| 5 | 12.5/25 | 0/25 | 0/25 | 0/25 | 12.5 |
| 6 | 0/25 | 0/25 | 12.5/25 | 12.5/25 | 25 |
| 7 | 12.5/25 | 0/25 | 12.5/25 | 0/25 | 25 |
| 8 | 12.5/25 | 12.5/25 | 0/25 | 12.5/25 | 37.5 |
| 9 | 12.5/25 | 12.5/25 | 0/25 | 0/25 | 25 |
| 10 | 0/25 | 12.5/25 | 0/25 | 0/25 | 12.5 |
| 11 | 12.5/25 | 12.5/25 | 0/25 | 0/25 | 25 |
| 12 | 0/25 | 0/25 | 12.5/25 | 12.5/25 | 25 |
| 13 | 12.5/25 | 12.5/25 | 0/25 | 12.5/25 | 37.5 |

Table 10: score results for the image 2 on Gallbladder

Table 11 summarized the score results for the image 3 on Common Bile Duct and instructors conducted the results.

| IMAGE 3 - COMMON BILE DUCT | | | | | |
|---|---|---|---|---|---|
| Student | Depth | Focal | Overall Gain | TGC | Total |
| 1 | 12.5/25 | 0/25 | 12.5/25 | 0/25 | 25 |
| 2 | 12.5/25 | 12.5/25 | 12.5/25 | 12.5/25 | 50 |
| 3 | 12.5/25 | 0/25 | 0/25 | 12.5/25 | 25 |
| 4 | 12.5/25 | 0/25 | 0/25 | 12.5/25 | 25 |
| 5 | 0/25 | 0/25 | 0/25 | 0/25 | 0 |
| 6 | 0/25 | 12.5/25 | 0/25 | 0/25 | 12.5 |
| 7 | 12.5/25 | 0/25 | 12.5/25 | 12.5/25 | 37.5 |
| 8 | 12.5/25 | 0/25 | 0/25 | 0/25 | 12.5 |
| 9 | 12.5/25 | 0/25 | 12.5/25 | 12.5/25 | 37.5 |
| 10 | 0/25 | 0/25 | 12.5/25 | 0/25 | 12.5 |
| 11 | 12.5/25 | 12.5/25 | 0/25 | 0/25 | 25 |
| 12 | 0/25 | 12.5/25 | 12.5/25 | 12.5/25 | 37.5 |
| 13 | 12.5/25 | 0/25 | 12.5/25 | 12.5/25 | 37.5 |

Table 11: score results for the image 3 on Common Bile Duct

*Post-Assessment*

In the post-assessment section, participants have their hands-on lab session after using Ultrasound Interactive Console Simulator (USICS). They have to optimize three different images from Ultrasound Scanning Machine called Philip Clear Vue. The main controls that students have been tested on to optimize an image was:

- Depth Setting
- Focus
- Time Gain Compensation (TGC)
- Overall Gain

Table 12 summarized the score results for the image 1 on Liver and instructors conducted the results.

| IMAGE 1 - LIVER | | | | | |
|---|---|---|---|---|---|
| Student | Depth | Focal | Overall Gain | TGC | Total |
| 1 | 25 | 12.5 | 25 | 25 | 87.5 |
| 2 | 25 | 0 | 25 | 12.5 | 62.5 |
| 3 | 12.5 | 25 | 25 | 25 | 87.5 |
| 4 | 25 | 25 | 25 | 25 | 100 |
| 5 | 25 | 12.5 | 25 | 25 | 87.5 |
| 6 | 12.5 | 25 | 25 | 25 | 87.5 |
| 7 | 25 | 12.5 | 25 | 25 | 87.5 |
| 8 | 0 | 25 | 12.5 | 25 | 62.5 |
| 9 | 12.5 | 25 | 25 | 25 | 87.5 |
| 10 | 12.5 | 25 | 25 | 25 | 87.5 |
| 11 | 25 | 12.5 | 25 | 25 | 87.5 |
| 12 | 25 | 0 | 12.5 | 25 | 62.5 |
| 13 | 12.5 | 25 | 25 | 12.5 | 75 |

Table 12: score results for the image 1 on Liver

Table 13 summarized the score results for the image 2 on Gallbladder and instructors conducted the results.

| IMAGE 2 - GALLBLADDER | | | | | |
|---|---|---|---|---|---|
| Student | Depth | Focal | Overall Gain | TGC | Total |
| 1 | 25 | 12.5 | 25 | 12.5 | 75 |
| 2 | 25 | 25 | 12.5 | 25 | 87.5 |
| 3 | 25 | 12.5 | 25 | 25 | 87.5 |
| 4 | 12.5 | 12.5 | 25 | 25 | 75 |
| 5 | 25 | 25 | 25 | 0 | 75 |
| 6 | 25 | 25 | 12.5 | 12.5 | 75 |
| 7 | 25 | 25 | 25 | 25 | 100 |
| 8 | 12.5 | 12.5 | 0 | 25 | 50 |
| 9 | 12.5 | 12.5 | 25 | 25 | 75 |
| 10 | 25 | 12.5 | 25 | 25 | 87.5 |
| 11 | 12.5 | 0 | 25 | 25 | 62.5 |
| 12 | 25 | 0 | 12.5 | 12.5 | 50 |
| 13 | 12.5 | 12.5 | 25 | 25 | 75 |

Table 13: score results for the image 2 on Gallbladder

Table 14 summarized the score results for the image 3 on Common Bile Duct and instructors conducted the results.

| IMAGE 3 - COMMON BILE DUCT | | | | | |
|---|---|---|---|---|---|
| Student | Depth | Focal | Overall Gain | TGC | Total |
| 1 | 25 | 25 | 25 | 25 | 100 |
| 2 | 12.5 | 25 | 12.5 | 25 | 75 |
| 3 | 12.5 | 25 | 25 | 25 | 87.5 |
| 4 | 25 | 25 | 25 | 25 | 100 |
| 5 | 25 | 25 | 25 | 25 | 100 |
| 6 | 25 | 25 | 25 | 25 | 100 |
| 7 | 12.5 | 0 | 25 | 25 | 62.5 |
| 8 | 12.5 | 25 | 25 | 25 | 87.5 |
| 9 | 12.5 | 25 | 12.5 | 12.5 | 62.5 |
| 10 | 25 | 25 | 12.5 | 25 | 87.5 |
| 11 | 12.5 | 0 | 25 | 25 | 62.5 |
| 12 | 25 | 12.5 | 12.5 | 12.5 | 62.5 |
| 13 | 12.5 | 25 | 12.5 | 12.5 | 62.5 |

Table 14: score results for the image 3 on Common Bile Duct

Paired sample t-test is used for the pretest and posttest experiments. Paired sample t-test is a statistical technique that is used to compare two population means in the case of two samples that are correlated. Paired sample t-test is used in “before-after” studies, or when the samples are the matched pairs, or when it is a case-control study.

First, I set up a simple hypothesis test that postulates there are difference in the scores in using the real system and the simulator system.

Second, I define the independent and dependent variables for this design. Hence, independent variable is Pretest score (before the training) and Posttest score (after the training) and the dependent variable is learning achievement score measured on two conditions.

Under Paired sample t-test outputs for all three images, the test results can be found and as shown below in Tables 1, 2 and 3. To test the hypothesis that is the pretest for Image1 (M=28.85, SD=11.84), Image2 (M=28.85, SD=12.98), Image3 (M=25.96, SD=13.94) and posttest for Image1 (M=81.73, SD=12.10), Image2 (M=75.00, SD=14.43) and Image3 (M=80.77, SD=16.63) were equal; a dependent sample t-test was performed.

**Paired Samples Statistics**

| | | Mean | N | Std. Deviation | Std. Error Mean |
|---|---|---|---|---|---|
| Pair 1 | PreTest | 28.8462 | 13 | 11.84164 | 3.28428 |
| | PostTest | 81.7308 | 13 | 12.09272 | 3.35392 |

**Paired Samples Test**

| | | Paired Differences | | | | | t | df | Sig. (2-tailed) |
|---|---|---|---|---|---|---|---|---|---|
| | | Mean | Std. Deviation | Std. Error Mean | 95% Confidence Interval of the Difference | | | | |
| | | | | | Lower | Upper | | | |
| Pair 1 | PreTest - PostTest | -52.88462 | 18.50805 | 5.13321 | -64.06892 | -41.70031 | -10.302 | 12 | .000 |

Table 15: Paired T-test for the Image 1 – Liver

**Paired Samples Statistics**

| | | Mean | N | Std. Deviation | Std. Error Mean |
|---|---|---|---|---|---|
| Pair 1 | PreTest | 28.8462 | 13 | 12.89442 | 3.57627 |
| | PostTest | 75.0000 | 13 | 14.43376 | 4.00320 |

**Paired Samples Test**

| | | Paired Differences | | | | | t | df | Sig. (2-tailed) |
|---|---|---|---|---|---|---|---|---|---|
| | | Mean | Std. Deviation | Std. Error Mean | 95% Confidence Interval of the Difference | | | | |
| | | | | | Lower | Upper | | | |
| Pair 1 | PreTest - PostTest | -46.15385 | 20.65630 | 5.72903 | -58.63632 | -33.67137 | -8.056 | 12 | .000 |

Table 16: Paired T-test for the Image 2 – Gallbladder

**Paired Samples Statistics**

| | | Mean | N | Std. Deviation | Std. Error Mean |
|---|---|---|---|---|---|
| Pair 1 | PreTest | 25.9615 | 13 | 13.93954 | 3.86613 |
| | PostTest | 80.7692 | 13 | 16.62655 | 4.61138 |

**Paired Samples Test**

| | | Paired Differences | | | | | t | df | Sig. (2-tailed) |
|---|---|---|---|---|---|---|---|---|---|
| | | Mean | Std. Deviation | Std. Error Mean | 95% Confidence Interval of the Difference | | | | |
| | | | | | Lower | Upper | | | |
| Pair 1 | PreTest - PostTest | -54.80769 | 28.20058 | 7.82143 | -71.84913 | -37.76626 | -7.007 | 12 | .000 |

Table 17: Paired T-test for the Image 3 – Common Bile Duct

As shown in Tables 1, 2 and 3, the differences in the scores in using the Philip Clear Vue machine and the USICS for all three images are statistically significant. Thus, there is strong evidence ($p < 0.000$) that the learning achievement score on two conditions (pretest and posttest) has been improved. Therefore, posttest's mean was statistically significantly higher than the pretest's mean for all three images test that might conclude that the USICS had a real, positive, effect on learning achievement score.

### 4.3 Limitations of Study

There are several factors that impinged on the ability of participants to take part in this study.

1- The simulator is compared at present only with the Philips Clear Vue Ultrasound Scanner (which does have all the required features of any Ultrasound Scanner) and not on all commercially available Scanners.
2- The validity tests were conducted only with participants in the RBHS Sonography program and not with students or users of such Scanners elsewhere.
3- This is a pilot study with a limited sample size and future studies will recruit a larger population for more definitive results.

# CHAPTER 5 SUMMARY AND CONCLUSION

## 5.1 Summary

In summary, the overall goals of this project was to build a positive role of web-based distance learning in medical education and this study has made fundamental contributions in field of healthcare education and Ultrasound Interactive Console Simulator has led to the accomplishment of its goals. Participants who took part in the study articulated their immense satisfaction towards online education. The methods that I conducted in this study was to delve into possibility to design and implement a simulation system, which mimics the look and operations of an Ultrasound Scanning Machine as well as other factors that include the results of operations performed on the simulation system are similar to that of the Ultrasound Scanning Machine. In addition, the learning's efficiency factor was most important goal when this project was implemented.

*Objectives:*

The development of simulator system was done to aid in the investigation of these goals and objectives of this study to facilitate the achievement:

- The similarity to other ultrasound machines such as Philips Clear Vue.
- The construct validity of the simulator system.
- The content effectiveness of the simulator system.
- The easiness of usage.
- The effectiveness of learning factor.

*Hypothesis:*

- It is possible to design and implement such Ultrasound Interactive Console Simulator (USICS), which mimics the look and the operations for other ultrasound machines such as of Philips Clear Vue machine.
- The results of operations performed by the USICS are similar to the other ultrasound machines such as the Philips Clear Vue machine.
- There are no variations in the content effectiveness and construct validity between the simulator system (USICS) and the Philips Clear Vue machine.
- The implementation of USICS is a supplement the need to conduct training in a real-life clinical setting.
- There is a comparative effectiveness in the learning factor through Ultrasound Interactive Console Simulator (USICS).

## 5.2 Conclusions

Based on the findings in this study, each of the research objectives are presented below and concluded:

*First objective:*

It is to investigate the similarity between Ultrasound Interactive Console Simulator (USICS) and Philips Clear Vue machine for the results of operations performed for the modification of Time Gain Compensation control, overall gain control, Focal Zone control, and Depth control. The hypothesis of the measurements using 15 domain experts were collected for this study and based on the 15 domain experts, Ultrasound Interactive

Console Simulator is giving the same effect and is similar to the real ultrasound-scanning machine.

*Second objective:*

It is to examine the content effectiveness and construct validity of Ultrasound Interactive Console Simulator (USICS). The hypothesis of the measurements using 15 domain experts were collected for this study and based on the 15 domain experts, the content effectiveness and construct validity are improving the students' performance and scanning skills.

*Third objective:*

It is to delve into the assertion that USICS is supplementing the need to conduct training in a real-life clinical setting. The hypothesis of the measurements using 15 domain experts were collected for this study and based on the 15 domain experts, using USICS, as a second hand is a significant and improving the training in real-life clinical setting.

*Fourth objective:*

It is to evaluate the comparative effectiveness in the learning factor through Ultrasound Interactive Console Simulator (USICS). The hypothesis of the measurements using Pretest and Posttest Experiments were collected for this study and based on this experiments test, there are differences in the scores in using the real system and the simulator system. The hypothesis was significance and the related conclusion drawn from the study was that there is a significant increase in learning achievement scores from the pretest to the posttest.

As discussed above, USICS has been proven that web based distance education has an immense potential capability to enable medical trainer wield the ability conduct scanning procedures using an actual ultrasound machine. The use of Ultrasound Interactive Console Simulator (USICS) is particularly beneficial to students who need more practice prior to conduction the real-life experiment. The study established that the results of operations performed on Ultrasound Interactive Console Simulator (USICS) are similar to that of the Ultrasound Scanning Machine such as Philips Clear Vue. In addition, the content effectiveness and construct validity are improving the students' performance in class and the test as I see in the result chapter. USICS could supplement the need to conduct training in a real-life clinical setting. As shown in this study the comparative effectiveness in the learning and the practice has been improved by the USICS efficacy.

Web-based distance education essentially provides effective and cost-effective mechanisms for the collection, storage, and retrieval of pertinent data. The platforms provided by web-based distance education are continuously and easily accessible to large masses of people across expansive geographic regions. Online programs that facilitate screening help many healthcare professionals to sharpen their skills and this ultimately improves their performance in real-life clinical situations. Consequently, the study proven that it is possible to design and implement USICS, which mimics the look and operations of an Ultrasound Scanning Machine.

It is imperative to monitor the individuals who can access information and data in these portals or web applications. It has become apparent that web based distance education is more efficient than the conventional paper based system in the provision of these features. The features of the Internet are designed in a manner that can ease flexibility among students in terms of accelerating the appraisal and documentation of educational goals. It is possible to improve the quality of education through distance learning. Improvement of healthcare education leads to improvement of services in the healthcare sector.

It has been acknowledged that adoption of contemporary technology in healthcare should happen in a multifaceted diffusion process and the barriers that impede adoption cannot be all handled using one tactic.

The use of the Internet is immensely beneficial in the improvement the computer utility of instruments simulation. This is because Web-based distance education can be propagated to a huge number of individuals across a wide geographic region in a manner that is time and cost friendly. Individuals can browse through the Internet where they can be presented with information of the tools and procedures they need to know rather than attending a real-life clinical room.

**5.3 Recommendation and Future direction**

The Ultrasound Interactive Console Simulator (USICS) has been used in this dissertation as a medical imaging platform. The system's unique architecture has been designed on the basis of the concept of Simulation as a service. The architecture wields the ability to manage a variety of simulation applications with a great sense of agility and flexibility. Its workflow resembles that of a bridge in terms of job-orientation in that it facilitates the connection of a variety of intricate simulation applications that have different level users. The architecture can be used in different the field of education research and training.

The Rutgers University students in medical imaging science department have put the USICS to use this year. The status used when keeping the system architecture can be described as relatively stable. In class, the results of appraisal and assessment output can be used in the adjustment of content in different lectures. So as to come up with appropriate questions of evaluation, the performance of students in on-line pre/post tests can be used. Each purpose of assessment should have a specific set of evaluation questions based on several teaching/learning. In conclusion, the medical imaging education concept inventory can be established based on the evaluation questions that are pertinent to the basic concepts.

The user-friendly interface of simulation scripts used to instruct students how simulation jobs are conducted are designed using Web language such as PHP, JavaScript JQuery and HTML. Although this project's structure and basic functions has been designed and executed, as web based distance education, it can still be improved in the as time progresses. There is still a lot of work to be done in the future.

First, the development process has not been subjected to a strict quality control since all the development has been done in the academic environment. With the exception of the fact that the education platform has been implemented and tested by students, more time is still needed in order to complete this instrument's other sections. Nonetheless, the initial version has been utilized multiple times from my website but there isn't any feedback that has been collected.

Second, on the subject of the education platform, sometimes the study and students' objectives do not always correspond with each other as some conflicts are occasionally identified. On the basis of the outcome of the practice, when there is a conflict in the objectives, the interest of students is quickly lost. As a result, it is of paramount importance to establish objectives that are common to the students and my project. My product can only grow if my objectives are aligned with the interests of the students. Furthermore, I should endeavor to inspire their interests through the provision of contents that are highly attractive and interactive. For instance, the feeling of success among certain students can be realized by posing some challenges to them. It is also imperative to make them aware of the benefits of my products, so as to enhance their cooperation in future as I proceed with my study. Another consideration that needs to be made is security, though my development is particularly designed as network application that enhances education and research, I am obliged to observe safety and surety in the storage of information and data.

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**Appendix 1:**

**Questionnaires for Evaluating the Efficacy of Ultrasound Interactive Console Simulator (USCIS)**

**Participant's experience of USICS application**

1. **The images generated by the USICS are similar to images produced by an Ultrasound Machine for the following controls and/or settings:**

| Control Setting(s) | Strongly Disagree | Disagree | Neither | Agree | Strongly Agree |
|---|---|---|---|---|---|
| Sector Width (Wide Angle) | | | | | |
| Sector Width (Medium Angle) | | | | | |
| Sector Width (Narrow Angle) | | | | | |
| Depth Control (Increase Capability) | | | | | |
| Depth Control (Decrease Capability) | | | | | |
| Focus Control (Increase Capability) | | | | | |
| Focus Control (Decrease Capability) | | | | | |
| Output Power (Increase Capability) | | | | | |
| Output Power (Decrease Capability) | | | | | |
| Dynamic Range (Increase Capability) | | | | | |
| Dynamic Range (Decrease Capability) | | | | | |
| Transducer Frequency (Increase Capability) | | | | | |
| Transducer Frequency (Decrease Capability) | | | | | |
| Time Gain Compensation (TGC) | | | | | |
| Overall Gain | | | | | |

2. **The contents provided for developing the skills and knowledge needed to perform in lab-session is helpful resources.**
    - o Strongly Disagree
    - o Disagree
    - o Neutral
    - o Agree
    - o Strongly Agree

3. **The functionality and usability provided is mimicking the other ultrasound machines.**
    - o Strongly Disagree
    - o Disagree
    - o Neutral
    - o Agree
    - o Strongly Agree

4. **USCIS is a supplement the need to conduct training in a real-life clinical setting.**
    - o Strongly Disagree
    - o Disagree
    - o Neutral
    - o Agree
    - o Strongly Agree

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**DHHS Federal Wide Assurance Identifier:** FWA00003913
**IRB Chair Person:** Robert Fechtner
**IRB Director:** Carlotta Rodriguez
**Effective Date:** 3/14/2016

# eIRB Notice of Closure for Study # CR00003908

## STUDY PROFILE

| | |
|---|---|
| **Study ID:** | Pro20150002509 |
| **Title:** | Design and Implementation of an Ultrasound Interactive Console Simulation System for Medical E-Learning Scenarios |
| **Principal Investigator:** | Salem Albagmi |
| **Co-Investigator(s):** | Syed Haque |
| **Sponsor:** | Rutgers, the State University of New Jersey |

## CURRENT SUBMISSION STATUS

| | | | |
|---|---|---|---|
| **Submission Type:** | Continuation( CR00003908 ) | | |
| **Report type:** | Final Report | **Study Status:** | Study is completed (all enrollment, treatment, data collection, follow-up, and data analysis are complete.) |
| **Closure Date:** | 3/14/2016 | **Review Type:** | Exempt |

**ALL APPROVED INVESTIGATOR(S) MUST COMPLY WITH THE FOLLOWING:**

1. **Unanticipated Problems**: Unanticipated problems involving risk to subjects or others must be reported to the IRB Office (45 CFR 46, 21 CFR 312, 812) as required, in the appropriate time as specified in the attachment online at: http://rbhs.rutgers.edu /hsweb

2. **STUDY RECORDS:** Protocols and all amendments must be kept in a secure place by the principal investigator for a period of at least six (6) years after completion of the study.

3. **CONSENT FORM:** Documentation of informed consent has been waived by the IRB in accordance with 45 CFR 46.117. The IRB has reviewed and approved the consent process and consent letter described in this protocol as required by 45 CFR 46 and 21 CFR 50, 56, (if FDA regulated research). Only the versions of the documents included in the approved process may be used; each subject must receive a copy of the approved document(s).

4. **Removal of Original Research Data:** All original research data and materials belongs to the University but should ordinarily be maintained by the research unit of origin at the University, or by the School department. Original research data and materials can be removed from the University only when the chair and dean determines that it is impractical for the investigator to make copies of the materials. For additional information, please see the University policy on Removal of Original Research Data and Materials from the University at: http://vpr.rutgers.edu/

5. The Investigator(s) did not participate in the review, discussion, or vote of this protocol.

6. **CLOSURE:** Study is completed (all enrollment, treatment, data collection, follow-up, and data analysis are complete.) . The study is being closed at the request of the principal investigator.