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Utilization of Focus Groups to Design Curricula to Teach 3D/4D Technology

Dustin Reinholtz
University of Wisconsin-Milwaukee

UTILIZATION OF FOCUS GROUPS TO DESIGN CURRICULA TO TEACH 3D/4D TECHNOLOGY

by

Dustin Reinholtz

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ABSTRACT

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Dustin Reinholtz

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Diagnostic medical sonography is a tool utilized daily in the medical field. Currently there is a trend of moving from 2D technologies to newer, advanced 3D/4D technologies. The issue involved with adding 3D/4D technology to the echocardiography exam is how to best teach the sonographers how to become comfortable with using the newer technology. The aim of this study was to use focus groups and grounded theory as tools for curriculum development to teach cardiac sonographers 3D/4D technology to calculate left ventricular volume. The setting for this study was an academic medical center in which eight cardiac sonographers were recruited to learn how to utilize 3D technology to calculate left ventricular volumes. The sonographers were asked to participate in two focus groups, online learning modules, hands-on practice sessions, and a final hands-on session with a data set to test the effectiveness of the final educational material. The methodology utilized for this study was qualitative, with audio taped interviews in focus groups and videotaped hands-on observation of 3D phantom scanning. Grounded theory was utilized to evaluate the data collected and to develop curricula to teach sonographers how to measure left ventricular volumes. Results indicate that in order to have successful implementation of a curriculum into the laboratory, specific educational materials and hands-on practice sessions should be provided to enhance learning and understanding of 3D technology. Sonographers participating in this study defined barriers to learning 3D technology as not enough time, positioning of equipment in examination rooms, too many different uses of 3D technology, and 3D technology “experience gap.” Findings indicate that focus groups serve as a mechanism for identifying barriers to learning and designing an effective curriculum for teaching sonographers how to measure left ventricular volumes.

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Introduction

Diagnostic medical sonography (DMS) is considered to be a low-cost, noninvasive, portable technology with a high level of reproducibility and accurate results (Iino, Shiraishi, Ichihashi, Hoshina, & Momoi, 2006). As new technology is developed, new utilization applications of the technology are implemented. This is easier said than done, as it takes time to learn how to best utilize new technologies. This study utilized qualitative methods of audio taped focus group interviews, participation observation and grounded theory for developing a curriculum for implementing three dimensional (3D) technologies for evaluation of left ventricular (LV) function.

The rationale for the addition of 3D technology for evaluation of LV function is that the 3D technology allows for increased test reproducibility among sonographers and interpreting physicians (Chuang et al. 1999, Nitkin et al. 2006, Sugeng, Weinert, & Lang, 2003). The 2D method of measuring left ventricular volume is limited because both ventricular geometry and image positioning are assumed (Iino et al., 2006). 3D/4D programs remove both of these assumptions. This produces an easier-to-perform test with a higher degree of accuracy and better reproducibility; however implementation into clinical practice is difficult.

Literature Review

Use of Focus Groups for Curriculum Development

In 2010 Mitchell, Willey, Baker, Kohn, and Hendricks showed that 3D technology is not simple to learn, and that teaching a single application for the technology along with medical director support may assist with implementation.

Strategies for implementation include on-line learning modules, application specialist presentations, continuing education courses, and focus groups. In 2010 Mitchell et al. utilized hybrid learning to teach working sonographers imaging protocols for attaining images of the thyroid, coronal views of the female pelvis, and renal imaging. This group found that sonographers still felt frustrated at the end of the educational experience and felt that future directives to teach working sonographers 3D/4D technology should focus on one specific application that is the most utilized function in the clinic.

In the discipline of echocardiography one focused 3D application would be to evaluate LV function (Lang et al., 2012). Lang et al. (2012) reported that one of the most important contributions of 3D echocardiography is the assessment of LV function. 3D echocardiography allows for the assessment of LV ejection fraction and function independent of geometrical assumptions (Lang et al., 2012). In this article, the authors describe the rationale for utilization of 3D echocardiography and steps for image acquisition and reconstruction. However, implantation of this technology and mastering the skill still needs to be developed.

Focus groups have been utilized to gather critical information regarding the development of curricula. One study pointed out that focus groups provide "…stimulating exchange of ideas, experiences, and attitudes about a specific topic" (Kooker, Shoultz, Sloat, & Trotter, 1998, p. 283). Another study showed that members of its focus groups pointed out shortcomings of the curricula resulting in a better curriculum (Rizzolo et al., 2006). Research conducted by Rizzolo et al. (2006) demonstrated that focus groups can be utilized as part of the process in developing an anatomy course, specifically to give students a chance to reflect on how they study and learn anatomy, and to better understand how to organize the course. The authors note that during the sessions, students pointed out shortcomings of the program and where improvements could be made. Students were first put through a pilot study using light-box exercises for radiology, holograms for tomography, interactive web-based activities, and a computer program to manipulate visible human images. Surveys and questionnaires were used after each exercise to determine the students' perception and the efficacy of the test activities. Two 1.5 hour focus groups were conducted to learn the attitudes towards the programs. Through these focus groups the authors learned that their redesigned anatomy course needed a balance between self-study and group discussion.

When evaluating how to develop curricula for working adults, one can use the work of Rizzolo et al. (2006) to design learning modules that will present information in a variety of ways and incorporated problem based learning. Rizzolo's work indicated, through student responses, that student's desired practice and self assessments. When working with adult learners, as described in the previous work of Kooker, Shoultz, Sloat, & Trotter, 1998, and Rizzolo et al., 2006, it is important to incorporate teaching strategies appropriate for adults. Thus, what follows next is a review of Knowles' Adult Learning Theory.

Adult Learning Theory

Knowles' Adult Learning Theory is based on six principles that must be considered for optimal learning to occur: 1) a need to know, 2) a responsibility for one's own learning, 3) the role of experience as a resource in one's learning, 4) a readiness or applicability of the information to one's life situation, 5) motivation to learn, and 6) problem-centered learning with real-life problems (Mitchell & Courtney, 2005; Knowles, 1980). When designing curricula, it is important for the educator to facilitate principles 1 and 2. Throughout the initial focus group, the educator should place a high degree of importance on the participants needing to know the information and that it is the participants' responsibility to learn when asking questions. By phrasing follow-up questions with "why would this be important to you" or "what benefit will learning this have for you" the participants will begin to take ownership of acquiring new information presented to them. All other principles should be addressed as the study focuses on a particular group of individuals and is tailored around this group's specific work place specialty.

In Mitchell and Courtney's (2005) study adult family members of intensive care unit (ICU) patients were recruited to assist with gathering information to develop a brochure that would explain to families how patients would be transferred from the ICU into the general ward. The major finding in the study was that the information was informative and useful, but only to a certain extent. It was reported that family members would prefer information to be individualized to their situation (Mitchell & Courtney 2005). The finding supports Knowles' principle four and is something to consider when designing curricula for adult learners.

Gallagher (1996) also used the Knowles' Adult Learning Theory when teaching human immunodeficiency virus (HIV) education to people living with HIV and showed that programs like this can be successful through the utilization of Adult Learning Theory and the use of interactive, problem based learning. It is the opinion of many that computer-based educational programs play a role in supplementing traditional teaching methods (Habbal & Harris, 1995; Cahill & Leonard, 1997). In addition to that sentiment, others believe that online educational programs can provide revolutionary ways to present anatomical knowledge (Rosse, 1995; Brinkley & Rosse, 1997). For example, Kim, Brinkley, and Rosse (2003) conducted a survey involving 40 online anatomy web resources which determined the most important components of a good online educational resource and to introduce criteria by which online resources could be judged. These criteria included four categories: site background information, content components, interactivity features, and user interface design components

(Kim, Brinkley, & Rosse, 2003). The average score of the 40 reviewed websites was determined to be 3.3 out of 10, as determined by a survey matrix, which led the authors to determine that the design features of the website are not very important to the user. The order and depth of content is more important to the user and should include specifically stated goals and have a defined level of achievement (Kim et al., 2003). These are important concepts to keep in mind during the development of the curricula for adult learners. Another strategy for working with adult learners is the use of hybrid learning theory.

Hybrid Learning Theory

Hybrid learning theory is the use of both online and face to face teaching methods to deliver educational content. Mitchell, Willey, Baker, Kohn, & Hendricks, 2010 utilized hybrid learning theory to teach working sonographers how to perform 3D imaging of the thyroid, female pelvis and kidney. In their work they noted that while the hybrid theory worked well for delivery of the content, mastering the skill was still challenging. T0 be successful in mastering 3D technology, there still needed to be a formal practical experience. Other disciplines, such as education, have utilized hybrid learning modules for use in teacher upgrade programs. Chatterjea (2004) suggested that any educational program for practicing professionals should be designed so that the learner receives exactly what they need. In reviewing the needs for implementation of new curricula, one needs to consider the addition of not only online hybrid learning modules, but the also the use of practical practice sessions to master the psychomotor skill of using the technology.

Simulated practice theory

Simulation based training has been studied by many authors; Johnsson, Kjellberg, and Lagerstrom (2005) evaluated nursing students' work technique after proficiency training in patient transfer methods during undergraduate education. The aim of this study was to see if nursing students improved their patient transfer technique after practice on simulated patients. Johnsson et al. (2005) found that providing proficiency training versus only on-the-job training facilitated the practice of transfer techniques and the perception of simulated patients. Others in the discipline of medicine have also used simulation as a means of mastering proficiency of a skill (Jeffires et al., 2011; Black, Nestel, Kneebone, & Wolfe, 2010; Dawson, Meyer, Lee, & Pevec, 2007). Jeffries et al. (2011) utilized a deliberate practice model and simulation-based curriculum to teach advanced practice nursing students' cardiovascular assessment skills. The students obtained cardiovascular assessment skills through an interactive process which was also designed to be self paced. Black et al. (2010) utilized a simulated patient in an operating room setting to evaluate surgeon operating skills. The authors found that the use of simulation was a successful teaching strategy to prepare surgeons to perform carotid endartectomy. Dawson et al. (2007) also reported the advantages in utilizing simulators for endovascular surgical training to improve performance in learning sessions. This study used a training program that provided a didactic portion, table top procedure demonstrations, and computer-based training modules and simulation proved to be a successful training method.

Based on the aforementioned literature review, curricula to learn new skills for working professionals should be designed taking into account simulated practice, hybrid learning and adult learning theory.

Research Methodology

Procedures

The study took place at “MidWestern Hospital” in the echocardiography laboratory and assigned conference rooms for the focus groups. All labs were conducted on a Philips IE 33 Ultrasound machine. The study took place over an eight month time period. Flyers offering the opportunity to participate in the study were posted in the echocardiography laboratory. Interested participants were informed to contact one of the primary investigators and the PI set up a meeting to discuss the study and obtain a signed information form.

Research Question

The research question for this study was, “Can Focus Groups Be Utilized to Design Curricula to Teach Working Sonographers 3D/4D Technology?” It has been shown that focus groups can provide vast amounts of information on any number of topics especially with creating new curricula or redesigning old curricula (Kooker et al., 1998 and Rizzolo et al., 2006). For the purposes of this study, working professionals who use sonography (diagnostic medical sonographers) were given the opportunity to participate in a focus group and hybrid learning course on the use of 3D sonographic technology for evaluation of LV function.

Research Design

This study utilized the qualitative methods of audio taped open-ended questions asked in a focus group, pretest for baseline knowledge, online modules with post-tests, participant observation during practice sessions scanning a balloon phantom (to simulate a left ventricle), videotaping of hand movements during the competency session of phantom scanning, a second focus group, post-course survey and a final practice session with a data set utilizing the flash cards made (Appendix G) as a tool to assist with memory of how to perform a LV function volume acquisition and reconstruction.

A qualitative study is any study that produces results which were not derived from a statistical method. Qualitative studies most often will focus on the social sciences and can include topics such as behaviors, feelings, and cultural phenomena (Corbin & Strauss, 1998). Utilizing focus groups provides an effective way to gather information on a specific topic within the social sciences. Focus groups are effective because they consist of small groups with individuals having a vested interested on the topic being discussed. In addition to small group sizes, asking open-ended questions induces participants to share as many thoughts and feelings as possible, providing researchers with vast amounts of information. It is because of the focus group method of gathering data, that grounded theory is most applicable to this study. Grounded theory is theory derived from data and will yield from that data an emerging theory that correlates closely to the core problem. The core problem will also reveal itself through the research process and the emerging theory can be used to solve the problem.

The theories derived from a grounded theory approach are understood by researcher and "layman" alike, since the theory is derived from the data that the "layman" is heavily involved in, and is an important tenet of grounded theory (Glaser & Strauss, 1967). Using a qualitative method like grounded theory, interpretation of the data was conducted in a manner that facilitated the discovery of concepts and relationships exclusive to the raw data gathered through the focus groups. This data collection allowed for further categorization into theoretical schemes to generate a theory specific to its supposed uses (Glaser & Strauss, 1967). The theoretical framework that grounded theory constructs also provides a theory that stands up to refutation because the theory is inextricably linked to the raw data collected.

Other authors have used variations of formal grounded theory to study group and individual experiences. McCreaddie et al. (2010) and used a constructivist grounded theory approach in a study of drug users and nurses in a pain management setting. This method measures how the phenomenon and experience of the event are constructed by the individual. This variation of grounded theory focuses on social interactions and is not appropriate for the current study which does not have a social interaction component.

Holtslander (2007) also utilized constructivist grounded theory to study the experience and processes of hope for older women who were caregivers to a spouse with cancer. In this study, Holtslander (2007) developed a theory of how their hope experience may be understood to allow for nurses to be able to understand this phenomenon. Through nurses understanding this experience, the professional nurse can provide guidance for maintaining hope for these individuals and get through their bereavement time period. Holtslander (2007) utilized the qualitative methods of open-ended, in-depth audio-taped interviews, hope diaries, transcribed verbatim and analyzed this data with constant comparative analysis. Holtslander's 2007 study, also utilized the social context to define her grounded theory.

Since this research question focused on how focus groups could be used to teach working sonographers 3D technology and develop curricula, a systematic approach to grounded theory, as espoused by Strauss and Corbin (1990, 1998) was utilized. In this study data collection consisted of focus group interviews, development of online modules and post-tests, hands-on phantom imaging, a follow-up focus group and a final assessment using the note cards developed to assist the sonographer with using the technology in the clinical lab.

Data collection

Data collection included audio-taping two focus groups, on-line learning module post-tests two phantom scanning sessions (one video recording of hand movements), on-line post-course surveys and a final written observatory note on a data set to record EDV, ESV, stroke volume (SV) and ejection fraction. An online learning curriculum was created based on these themes and included three modules, each module with a post-test. Module one was designed to teach 3D instrumentation and focused on the participant's ability to learn/define new terminology (i.e. voxel; x, y, and z axis; MPR, i-slice, report terminology), describe post processing functions, and state which report data were to be captured routinely. The goal of module one was to show the participant new terms associated with 3D technology and how others are using this technology. The post-module test helped demonstrate the use of the new terminology and manipulation of controls associated with different images. Module one addressed the third (knowledge) and sixth (3D technology "gap") themes that emerged from the first focus group. The aim of the second module was image acquisition using the X-2 and X-5 transducers. Here the participants were to learn how to obtain a volume to assess LV function from the apical 4C view, to evaluate the quality of a data set, and why it is good practice to take a minimum of two data acquisitions. Module two addressed the first (lack of time) and second (repetitive practice/number of machines and positioning of equipment) themes. Module three was developed to teach volume assessment of LV function on the Philips IE 33 system with Q-Lab. The module demonstrated how to select which volume set to use, how to select and measure the diastolic and systolic frame, and how to asses those measurements. The post-test for module 3 required measurement of a data set stored on the machine, a work sheet to complete three measurements of EDV, ESV and stroke volume (SV) and an answer sheet based on what the expert measured. Themes one (lack of time), four (want to use 3D technology), and five (too many different uses of 3D technology) were addressed during this module. At the completion of the study the audio-taped focus groups and video recorded hand movements were destroyed.

This study utilized focus groups to establish the baseline knowledge of participants and to learn what barriers existed regarding learning and using new technology. The information was used to design a hybrid learning course to teach 3D technology. Because there is a unique combination of adult learners and online education methods being utilized, the educational curriculum needs to be designed incorporating both the cognitive and social/environmental perspectives which impact learning and allow for planned, non-threatening practice sessions (Mann, 2002). In regards to the cognitive aspect, the current study provided a means to acquire a baseline of knowledge established through an initial focus group. The initial focus group was conducted by the primary investigators. At the initial focus group, a series of open ended questions were asked. Questions asked are listed in Table 1 (Appendix A). The focus group was audio tape recorded and the responses were transcribed. Each participant was assigned a pseudonym.

The primary investigator asked the question and recorded responses until saturation was reached. Saturation, as defined by Creswell (2007, p. 80), is the point at which no new information is discovered that furthers the understanding of a category. As saturation became evident, the primary investigator would ask similar questions hoping to reveal any possible new and insightful information. During the initial focus group, the participants were asked the questions in Table 1 and the answers provided by participants were used to create the content included in the learning modules. Participants were asked each of the 10 questions exactly as written in Table 1, and if necessary were asked again with slightly different wording in hopes that the participant would answer with as much detail as possible. Many of the questions in Table 1 have a correlation with one or more of Knowles' six principles. An example of this is seen with the first and last questions in Table 1. The first question is aimed at gaining an understanding of how the participants currently use the new technology. The last question is intended to have the participants explain how, after this study, they can imagine using this technology. This combination of questions incorporates principles one (this technology is coming and you the sonographers will be asked to use it) and two (the sonographers will be required to learn it). This process assisted with deciding what areas of sonography to elaborate on and to determine the baseline level of knowledge to meet all participants' needs.

After all participants had completed the online modules, hands-on practice sessions were scheduled. The hands-on portion of the study was conducted using the Philips IE 33 system. This system provided a semi-automated analysis of true LV volumes by generating full 3D borders of the myocardium. A balloon filled with water was utilized to simulate the LV for the volumetric measurements. 50 ccs of liquid was added to the balloon and the participant used the Philips IE 33 system to create an image and measure the volume of the balloon. The balloon was tied by a thread and fixed in position within a water bath. A catheter attached to a 60 cc syringe was connected to the balloon. The balloon was filled with 50 cc of fluid to simulate end-diastolic volume (EDV), and during acquisition of the image fluid was withdrawn from the balloon to obtain an end systolic volume (ESV). The balloon was positioned within the water bath to simulate imaging the LV from the apical four chamber view. The phantom bath was constructed in a manner to allow for simulation of an apical window. Pictures of the phantom model can be seen in Appendix D.

The sonographers obtained the volume in two orthogonal planes (simulating imaging the LV in the apical two chamber and apical four chamber views) displayed on the ultrasound machine monitor. All data sets were manipulated to calculate an EDV, ESV and ejection fraction on the Philips IE 33 system. During the practice sessions, participants were encouraged to ask questions and utilize their handouts from the on-line modules to acquire the desired images and reconstruct the data set obtained. Table 4 (Appendix E) provides a summary of the participants' activities in the on-line modules and post-tests. After completing an on-line learning module regarding 3D technology for the evaluation of LV function, sonographer participants were asked to participate in a hands-on scanning session with a LV volume phantom. Sonographers were then asked to obtain 3D data sets of the LV phantom and then reconstruct the data sets in the form of a competency after multiple practice sessions. After the completion of the competency, participants were again asked to participate in a focus group to discuss the learning experience and how they think 3D assessment of LV function can be added into the routine 2D exam for LV function.

One final hands-on assessment was completed after the second focus group with note cards made based on input from the final focus group. After the final hands-on assessment the participant measured the EDV, ESV, SV and EF on a pre-recorded data set.

These notes for each participant were again entered into the Ethnograph software and the meta-matrix. After the last focus group, participants completed a post-course survey. The post-course survey was reviewed along with the focus group data, post-learning module tests, and competency tests to evaluate the positive or negative aspects regarding how the course was conducted and also whether or not the information presented was adequate. The results from all surveys and focus groups were then evaluated to determine whether a good, or bad, continuing education experience was had by the participants.

Sample Selection

Inclusion criteria for this study were practicing sonographers in the "MidWestern Hospital" (pseudonym) echocardiography laboratory. After obtaining exempt status from the institutional review boards, participants were recruited and signed a study information form. Exclusion criteria were anyone who was not a "MidWestern Hospital" echocardiography laboratory sonographers.

Data Analysis

All data collected from the focus groups and practical sessions were coded and entered into entered into The Ethnograph v5.0™ software for Windows® (Qualis Research; Amherst, Massachusetts 1998). Data were coded utilizing open coding (typed data in The Ethnograph v5.0™ software, project files were coded line by line), axial coding (data linked back to categories), selective coding (coding of the core variable) and then the codes were grouped into concepts (Creswell, 2007, pg. 160). Throughout the process of coding, the primary investigator utilized the process of “constantly comparing” concepts against concepts until categories emerged (Creswell, 2007, p. 160: Strauss & Corbin, 1990). Categories were then utilized to generate theoretical codes. Theoretical codes integrate the theory by interweaving the concepts into a hypothesis that explain the concern of the participants. This process can be seen in Table 2 (Appendix B). Scientific rigor was evaluated through fit, relevance, workability and modifiability. The term fit refers to how closely a concept maps to its incidents, relevance refers to how closely the findings relate to the participants concerns. Workability explains how the theory works and modifiability refers to how transferrable the new theory can stretch when new data is compared to old data. The data collected was analyzed with the mindset that it contains the main concern or problem. Levy (2006) demonstrated that it is only after the data is collected and analyzed that the true problem can be discovered and subsequently answered. Data from the focus groups, hands-on assessment, and online learning module post-test scores were entered into a meta-matrix, a tool which allows researchers to recognize and following emerging themes coming from large amounts of collected data. Data were coded, concepts noted and categories formed. After the themes emerged, a meta-matrix was developed and utilized to track themes from the focus groups to the practical sessions to the post-test learning module and post-course surveys for each participant. A meta-matrix is essentially a chart, and in this chart the results from all activities can be coded, tracked, and associated with each participant's pseudonym. Since this study utilized focus groups, hands-on practical sessions, post-test scores and post-course surveys, this method allowed for an easy way to track data across activities for each source of data used (Polit & Beck, 2008).

Results

Themes that emerged were; 1) lack of time, 2) repetitive practice needed/number of machines, 3) knowledge, and 4) the "want" to use 3D technology. Themes that emerged from the first focus group were; 1) lack of time, 2) repetitive practice/number of machines and positioning of equipment in examination rooms, 3) knowledge, 4) want to use 3D technology, 5) too many different uses of 3D technology, and 6) the 3D technology "experience gap".

Lack of Time. This theme referred to the perception of the sonographers that there was barely enough time to perform the exam protocol as it was without adding anything additional. The sonographers felt a "time crunch" and did not perceive anyway 3D technology could be added without giving them more time to complete the exam.

Repetitive practice needed/number of machines. This theme referred to the perceived barrier to learning and having adequate time to practice the use of the new technology. Sonographers felt that they were most comfortable with one machine and that machine was often in the transesophageal echocardiography room and not available for them to use to practice their new knowledge on. Without the “swapping:” of this machine, it would be difficult to continue to practice this new knowledge.

Knowledge. The third theme, knowledge, was defined as an understanding of how the technology worked and the steps that were required to acquire the data set and the steps that were involved in reconstructing the data set.

Want to use 3D technology. The final theme that emerged from the data was the “want“ to use 3D technology. This theme referred to how the participant’s saw themselves using the new skill in the lab. While sonographers stated they wanted to learn the new technology and they were participating in this study to learn this technology, they still had concerns about how it would be worked into their already full protocol.

Results of the final assessment with measurement of a test data set for EDV, ESV, SV, and EF demonstrated a range of values. The data set utilized had been previously measured by an expert in the field. The expert values were EDV = 107.1 mL, ESV = 43.10 mL, SV = 64.10 mL and EF = 59.5%. The measurement values for the participants ranged from 97.3 – 133.9 for the EDV, 38.7-62.7 mL for the ESV, 38.0-88.8 mL for the SV and 37.7 – 66.3% for the EF (see Appendix E).

Discussion

Through the multi-step process of focus groups, hands-on evaluation, and online course, three sets of themes emerged and evolved into a final, fourth set of themes. The themes that emerged from the initial focus group were; lack of time, positioning of equipment in examination rooms, sonographers have a "want" to use 3D technology, too many different uses of 3D technology, and the 3D technology "experience gap". The hands-on event gave us two themes. First, not remembering steps for obtaining/saving images, and second, an apparent hesitation at the touch screen interface. Upon completion of the hands-on event and an online course a final focus group was conducted which produced three themes; varying comfort level, long protocol, and again the "want" or potential uses for 3D. The previous sets of themes evolved into a final list of four themes; lack of time, repetitive practice/number of machines available, knowledge base, and a "want" to use 3D technology. This final list of themes ultimately lead to the emerging theory that simulation based practice is necessary to learn 3D/4D technology and supports the findings of Issenberg et al. (2002) that curricula grounded in deliberate practice are a positive teaching strategy.

"Deliberate practice is an evidence-based teaching method grounded in information processing and behavioral theories of skill acquisition and maintenance" (Jeffries et al., 2011, p. 316; Ericsson, 2004; Ericsson & Charness, 1994; Ericsson, Krampe & Tesch-Romer, 1993.). As mentioned before the main aim of the first focus group was to find the baseline knowledge of the participants in regards to their individual experiences with 3D technology. This step agrees with Ericsson's (2004), p. S71 opinion; "…but extensive experience does not invariably lead people to become experts." Extended periods of functional practice/activities are needed, in addition to experience, in order for an individual to become an expert in their respective field. For this study online learning modules were developed that were, as Ericsson (2006, p. 693) says "…activities that had been specifically designed to improve performance, which we call 'deliberate practice'." To further validate the use of focus groups, online learning modules, and hands-on activities we can see from Ericsson (2004) those tasks are to be outside the normal range of expected performance and reproducible performance is necessary. Both the online and hands-on activities provided a standard that each participant needed to achieve and also provided instant feedback allowing for reproducibility. "The goal in assimilation learning context is a constant skill, knowledge, or professional improvement, not just maintenance of the status quo" (Jeffries et al., 2011, p. 316).

In this study, the problem was the fear of having a lack of time to complete a task, this was illustrated by one participant who said "I do not see how we are ever going to have time to do this (use 3D/4D) unless there is a complete restructure to our schedule" and "if we allowed the sonographers to do a more focused exam, we might have more time then to do the 3D"**.** This quote demonstrates the participant's desire for improvement by stating that the sonographer needs more time for their exams for the incorporation of 3D into the exam to become a reality. However, the sonographer does not want to be seen as lacking motivation to learn a new skill and hence the second quote, "…if we are allowed to perform a more focused exam…" then we will be able to incorporate the new skill. Interview responses also demonstrated that there might be a fear of failure. While sonographers verbalized that they wanted to learn a new skill and signed up to participate in this course, not all completed the actual deliberate practice of measuring the data test sets and recording their results. But in the focus groups all expressed an interest in participating to learn the new skill.

According to Jeffries et al. 2011, features of deliberate practice that contribute to simulation-based health care education are 1) high motivation, good concentration, 2) well defined learning objective or task at appropriate learning level, 3) focused repetitive practice that leads to precise educational measurement, 4) informative feedback, 5) trainee monitoring with corrective strategies, 6) evaluation to master a skill, 7) moving on to another task, 8) baseline testing (in this study, the focus group served as a tool to establish baseline knowledge), 9) focused learning objectives sequenced, 10) deliberate skill practice sessions, 11) developing a minimum mastery of skills (i.e. department objectives), 12) formal evaluation of the skill, and 13) advancing to the next skill (i.e. performing additional 3D exams beyond LV function) (Jeffries et al., 2011). For this study the first feature (high motivation, good concentration) was addressed by recruiting participants. At the initial focus group, all participants answered questions and discussed barriers they felt existed and served to impede learning this sill. Feature two (well defined learning objective or task at appropriate learning level) was addressed by taking the information obtained at the first focus group and developing online learning modules for the sonographers to learn how to acquire a volume data set and to learn to reconstruct a 3D volume of the left ventricle. Features four (informative feedback), five (trainee monitoring with corrective strategies), six (evaluation to master a skill), and eight (baseline testing) were addressed through post-test evaluations, competency evaluation, and a post course survey. Responses from the participants' post course survey were, "good balance with didactic and hands-on" and "…I think we should have practiced more on people…" These statements demonstrate that participants liked the integration of hands-on learning with the more traditional online courses, but also wanted to go a step further and utilize live models which afford the participant with a more realistic practice session. Our participants also said "…just learning one or two things was very helpful" indicating that working on a limited skill set, in this case LV function, was beneficial to them and is expressed by Ericsson (2004, p. S74): "the first step of the expert-performance approach involves establishing representative tasks that define the essence of the domain". This was also reiterated in the post course survey responses. Most participants indicated that they could explain how to use 3D technology to calculate an ejection fraction and could perform the task themselves.

The first theme, lack of time, has been relevant in many papers specifically Dawson et al. (2007) and Krueger et al. (2004). These papers showed a "time crisis" specific to learning in the health sciences. The latter paper claims there is decreased time for teaching with an increase demand for clinical hours. Krueger et al. (2004) goes on to state that online, simulation based learning is a dynamic method that can bridge this gap.

We have seen, through our second theme, that the number of machines and the amount of repetitive practice, can impact the role of the sonographer's knowledge of protocol requirements relative to a particular machine. Dawson et al. (2007) showed that more practice runs on their simulator improved the residents' performance. Issenberg et al. (2002, p. 227) show "that simulation technology and deliberate, repetitive practice resulted in a large and significant improvement…" among their study participants when recognizing simulated heart sounds.

Knowledge, our third theme, can be improved if simulation based training is incorporated. Birch et al. (2007) demonstrated through a combination of lecture based and simulation based teaching and pre- and post-training assessments, that those participants who were part of the combined lecture/simulation training had longer retention of knowledge. Knowledge retention is an important aspect of continued adult learning, as Jeffries et al. (2011, p. 321) states that one of the goals in simulated learning is constant improvement upon one's knowledge base.

Our final theme, the "want" to use 3D technology, is based in part on responses from participants in this study. From the initial focus group, participants in this study could envision how they could use 3D technology in their work as is demonstrated by this statement "…want to believe this will replace CT and MRIs". The sonographer's vision for the capabilities of 3D technology have improved, but there is still an inability to fully envision the full capacity of 3D technology due to the lack of time component as it pertains to learning the full functionality of this technology. Responses from the first and final focus group including; "[*sic*] one good data set and it is comparable to an MRI and CT…" indicate that the participants could see 3D technology replacing such tests as cardiac cath [*sic*], MRI, and CAT scans. Anwar and Nosir (2008) also indicated that these same technologies may someday be replaced by 3D/4D sonography technology.

Deliberate practice theory, as defined by Jeffries et al. (2011, p. 316) is "an evidence-based teaching method grounded in information and behavioral theories of skill acquisition and maintenance." The goal of deliberate practice, combined with interactive simulation, is a constant improvement of skills and knowledge until the skill or subject has been mastered. Once a level of mastery has been obtained or new technologies have been introduced to the field in question, a new or improved method of skill improvement must be administered. The sonographers in this study had obtained such a level of mastery upon completion of schooling and licensing/certification. With the development of 3D/4D technology a new level of mastery is now needed, and with the time constraints and the fast paced nature of DMS, a new method of teaching new technologies is needed. The aim of this study was to develop this new method of teaching stemming from the use of focus groups.

There are five steps to the development and successful implementation of 3D/4D technology. First, to gather a baseline of knowledge within the group a focus group needs to be conducted to collect the necessary feedback. This is a vital step and sets the tone for subsequent steps. Taking themes from this focus group and using them to develop an on-line learning curriculum is the second step. This is followed by the third step, scheduled deliberate practice sessions on both phantoms and models. Phantoms provide participants a chance to manipulate data sets in 3D/4D as they are not used to seeing these images, but the introduction of live models will afford a more realistic simulation of the exam and the resulting data set. The fourth step would be to add additional learning modules for other possible exams. The focus of this study was LV function, but other exams such as evaluation of mitral valve pathology could be added to the curriculum. The fifth and final step is to validate the value of planned educational activities to integrate 3D/4D technology into the lab.

In reviewing our data, the results show that for the EDV there is a range of 97.3 mL to 133.9 mL in the final assessment. One explanation for this range is that while our participants were taught how to use the software to acquire a data set and make the EDV measurements, specific instruction for what makes a good measurement was not presented. Mor-Avi et al. (2008) noted that real-time 3D echocardiography LV volumes are underestimated in patients because the software cannot differentiate between the myocardium and the trabeculea. Participants noticed this issue making comments such as "…I see the endocardium well, but it just does not track…I have a lot of issues with the tracking". Going forward, another module should be added focusing on where to place the calipers to result in a more accurate tracking of the endocardium. Shimada & Shiota (2011) performed a meta-analysis to compare the accuracy of LV volume and function measurements with MRI. Conclusions from this work indicate that understanding how measurements are made is an important step in improving accuracy of 3D echocardiography. As with our study, Mor-Avi et al. (2008) found up to a 30% difference in estimated volumes between the inner and outer rims when 3D EDV was tracked by tracing the inner versus outer border. Most of our study was founded on practice with a balloon phantom and could be the cause of this study's differences in volumes.

The ESV range was 38.7 mL to 62.7 mL. As noted above, the difference in our results may be tied to the lack of providing instructional material on caliper placement. Based on the work of Mor-Avi et al. (2008), Hascoët et al. (2010) and Thavendiranathan et al. (2012) the importance of caliper placement for reproducible results cannot be stressed enough. Providing a dedicated module on caliper placement is needed and recommended for future course development.

The estimated EF range was 37.7 mL to 66.3 mL. This has been reported by other to be the most accurate of the 3D echocardiography measurements. This study only had six participants (out of eight) complete this portion of the study and the actual measurements were 62.2%, 37.7%, 60.2%, 66.2%, 61.7%, and 66.3%. The majority were within 6% of the expert value. The participant with the lowest percent measurement was unable to partake in any of the balloon phantom activities, not receiving as much feedback as the participants who did participate. For this individual, the discrepancy may be related to a lack of "deliberate practice" and supports the theory that deliberate practice sessions are needed to fully teach sonographers how to utilize 3D technology to construct LV volumes.

Based on the finding of this study, focus groups can be used as a tool for designing learning experiences to teach working sonographers how to implement 3D technology to calculate LV volumes and ejection fractions. When designing an education module to teach sonographers how to utilize 3D technology to calculate LV volumes and ejection fraction Jeffries et al. (2011), 13 features of deliberate practice theory should be integrated into the design of the learning experiences. Based on this study a recommended educational program might be as illustrated in Table 7 (Appendix G).

Conclusion

Focus groups can be used to understand the base knowledge of a group of people allowing for the creation of an educational program tailored to working sonographers learning 3D/4D technology protocols. Focus groups are vital to the success of a curriculum in two ways; first, it shows that the participant's input is important and secondly, it gives the participants a chance to help improve the way they work every day. Once the step of information gathering has been completed, building a challenging, engaging, and interactive simulation training course keeps the participants involved. Most importantly, the participants shape the way the curriculum should be taught specific to their needs.

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Appendix A: Focus Group Questions

Do you currently utilize 3D/4D technology within your daily practice as a sonographer? (If Yes, what are some examples of how you use this technology)
What is your comfort level of obtaining the volume sweep?
How would you define what a “volume sweep” is?
After you obtain a volume data set, what happens, what do you do with the data?
How comfortable are you with manipulating the volume data set to see certain structures?
What is meant by the terms x-axis, y-axis, z-axis? How would you define or explain these terms to someone?
How comfortable are you with reconstructing a data set? What would make you more comfortable or confident in using this technology?
Do you want to learn more about how 3D/4D works?
Are there specific applications you are interested in learning about? What do you think about utilizing 3D imaging to assess ejection fraction? What do you know about this application? Do you know how to do this?
What are your thoughts about future uses of 3D/4D technology and the sonographer’s role in applying this technology?

These are the questions that were asked to the participants during each focus group.

Appendix B: Themes Emerging From Data Collection/Analysis

Theme	Meaning
Lack of Time	Dawson et al. (2007) and Krueger et al. (2004) all relevant papers include a “time crisis” specific to the health sciences. As Krueger et al. claims there is decreased time for teaching with an increase demand for clinical hours. On-line, simulation based learning is a dynamic method of learning that can bridge this gap.
Repetitive Practice/# of Machines/Positioning of equipment in examination rooms	The number of different types of machines can play a role in the sonographer’s knowledge of the protocol requirements relative to that particular machine. Regardless of the number of different machines sonographers need to spend more “practice” time, Dawson et al. showed that more practice runs on their simulator improved residents’ performance.
Knowledge	Birch et al. (2007) demonstrated through a combination of lecture based and simulation based teaching, pre- and post-training assessments. That those who were part of the combined lecture/simulation training had longer retention of knowledge.
Want to Use 3D Technology	All sonographers could envision how they could use 3D technology in their work. Although the sonographers’ vision for the capabilities of 3D technology may have improved since the start of this there still is an inability to fully envision it’s uses due to the lack of time component in regards to learning the full functionality of this technology.
Too many different uses of 3D technology	Without total knowledge 3D technology the number of uses and time required to learn them seems daunting, overwhelming, and maybe that there are too many uses/advantages
The 3D Technology “experience gap”	There is a sizable gap in the individual experiences of each sonographer with 3D technology in all areas. Sum up/combine connotative meaning for previous 4 themes as to why there is a gap.

This table includes the themes that emerged from the data collection and analysis. Also included is an explanation for each theme.

Appendix C: On-line and Post-test Score Summary

Sonographer	Module 2 Pretest Score	Module 3 % within expert measurement (avg. measurement, mL)	Final % within expert measurement (avg. measurement, mL)
01	80%	EDV-1.59 (137.24) ESV-1.16 (60.88) SV-5.93 (76.36)	EDV-4.92 (108.80) ESV-12.32 (43.60) SV-0.18 (60.30)
02	100%	0	0
03	80%	0	0
04	100%	EDV-1.77 (132.00) ESV-4.41 (60.00) SV-38.5 (78.00)	EDV-0.92 (109.00) ESV-10.07 (41.20) SV-1.96 (67.80)
05	100%	EDV-25.02 (146.60) ESV-4.46 (67.34) SV-38.5 (76.10)	EDV-9.79 (133.90) ESV-24.24 (45.10) SV-0.52 (88.80)
06	40%	0	0
07	0	0	0
08	0	0	0

This table shows the margin within the expert's measurement the participant came within. In parentheses is the participants' average measurement. *0 indicates participant did not complete that portion.

Appendix D: Comparison of Actual Measurements Made on Module 3 Post-test

LV-EDV (mL)	118.6 – 143.6 (n=5) Expert Value = 130.8
LV-ESV (mL)	48.6-67.34 (n=5) Expert Value = 54.2
SV (mL)	69.7-78 (n=4) Expert Value = 76.5

8 participants were recruited to participate in this study. 5 out of 8 completed the measurements for EDV and ESV. One of the 5 did not know how to record the stroke volume.

Appendix E: Comparison of Actual Measurements Made with Note Cards After Competency Assessment

LV-EDV (mL)	97.3- 133.9 (n=6) Expert Value = 107.1
LV-ESV (mL)	38.7 – 62.7 (n=6) Expert Value = 43.10
SV (mL)	38.0 – 88.8 (n=6) Expert Value = 64.10
EF (mL)	37.7 – 66.3 (n=6) Expert Value = 59.50

6 out of 8 participants completed the final assessment with note cards. Two subjects were not available to complete the final assessment with note cards.

Appendix F: Recommended Educational Program

Feature as stated in Jeffries 2011p. 312	Educational Activity
High motivation, good concentration/Baseline testing/Focused learning objectives sequenced	Utilize a focus group to discern what the sonographer's base knowledge is and what skills the sonographer feels they need help with. Also, utilize the focus group to note what barriers the sonographer feel exist to learning this new technology/skill. Utilize this information to develop didactic learning modules. Require a post-test at the end of each learning module to affirm mastery of didactic knowledge to be successful with utilizing the new technology.
Well defined learning objective or task at appropriate learning level	Develop and write well-defined learning objectives for the educational program and utilize the information gained in the focus group to develop the objectives
Focused repetitive practice that leads to precise educational measurement	Invite an application specialist to perform a one day training session where each sonographer will be allowed 30 minutes to obtain a volume acquisition on a human model and work with an expert. Obtain a data set on this day that can be used for future training with measurements saved as performed by the expert. Have sonographers deliberately measure this data set 5-10 times each quarter and record data on the group's measurements. Utilize this information to share and discuss how measurements should be made at quality assurance meetings.
Informative feedback/Trainee monitoring with corrective strategies/Evaluation to master a skill/Developing a minimum mastery of skills	Review data acquisition sets and measurements at QA meetings to provide feedback. Also, after the initial training, schedule deliberate practice sessions at least once per quarter for sonographers to scan human models to practice their skills. Record data sets and measurements at these times to be utilized in QA meetings as a means of instruction and feedback. Decide as a group at the QA meetings when the group is consistent and all have reproducible data, then decide on the next skill to learn.
Moving on to another task/Advancing to the next skill	Decide as a team at a focus group what the next skill should be. This should be based on department need and the same steps for learning should be followed as stated above.

This table shows the steps for successful implementation of the curriculum and an explanation of each step.

Appendix G: Recruitment Flyer

UW Milwaukee IRB Approval 1/19/2011 IRB#11.205

Appendix C: Flyer

Invitation To Participate In A Research Study To Learn How To Reconstruct 3D Ultrasound Images With On-Line And Face – To – Face Learning Modules

Title of Study: Utilization of Focus Groups to Design Curricula to Teach 3D/4D Technology

Study Investigators: Carol Mitchell, Peter Rahko, Nancy Bell, Dustin Reinholtz

You are invited to participate in a research study about how on-learning and face-to-face learning sessions can teach working sonographers how to acquire and reconstruct 3D ultrasound images.

If you decide to participate,your involvement would require you to be interviewed, observed, participate in on-line learning modules with a pre and post-test, and complete a post-course survey. The interview will be audio recorded and the observed scanning sessions will be video recorded. The video recording will consist of imaging your hands scanning a phantom and pushing the ultrasound machine buttons. Your participation will consist of approximately two 2-hour focus group meetings, four on-line learning module (each which may take up to 30 minutes to complete), 2-5 30 minute scanning sessions, where you will scan an ultrasound phantom to practice acquiring and reconstructing a data set on the ultrasound system.

The information gathered from the questionnaires used in this study is about your educational experience as a sonographer taking this course and if the course format was helpful in assisting you to learn this new technology. The questionnaires seek to gain information about your learning experience in this course and your ideas about 3D technology for use in echocardiography. The information gained from the observation data is to look at the practice (tasks you perform) as a sonographer to reconstruct 3D data sets. The information gained from this study will provide insight as to how to teach and possibly implement new technology in the work environment.

If you are interested in participating in this study, please contact Carol Mitchell.

Carol Mitchell PhD, RDMS, RDCS, RVT, RT(R), FASE

457 Enderis Hall

University of Wisconsin Milwaukee

414-229-2230 / mitchelc@uwm.edu

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This is a picture of the recruitment flyer inviting members of the lab to join this research project.

Appendix H: Consent Form

"Can Focus Groups Be Utilized To Design Curricula To Teach Working Sonographers 3D/4D Technology?**"**

Primary Investigator: Carol Mitchell PhD, RDMS, RDCS, RVT, RT(R), FASE
Primary Investigator: Dr. Peter Rahko, MD, FACC, FASE
Key Personnel: Nancy Bell, RN, RVT, RDCS, Dustin Reinholtz

Consent Form

INVITATION:

You are invited to participate in a research study to evaluate the potential of utilizing focus groups to design curricula to teach working sonographers 3d/4d technology. We are trying to determine if focus groups can be used as a tool to construct curriculum for learning how to acquire and reconstruct 3D/4D data sets. You are being invited to be a subject to be interviewed and participate in a curriculum developed based on the responses at the focus group interview. Participation in this study is completely voluntary and involves attendance at two focus group meetings, completion of on-line learning modules, participation in 2-5 scanning sessions and completion of a post-course survey. After the data has been collected, the data will be analyzed and the learning process described. Approximately 5-10 subjects will participate in this study.

WHAT IS THE PURPOSE OF THE VOLUNTARY RESEARCH STUDY FOR THE SCHOOL OF DIAGNOSTIC MEDICAL SONOGRAPHY?

The purpose of the voluntary research study is to answer the question of "Can Focus Groups Be Utilized To Design Curricula To Teach Working Sonographers 3D/4D Technology?"
This data will be utilized to write and describe how focus groups can be a tool for curriculum development.

WHAT WILL MY PARTICIATION INVOLVE?

If you decide to participate in this study, you will participate as a subject to be interviewed, observed, participate in on-line learning modules with a pre and post-test, and complete a post-course survey. The interview will be audio recorded and the observed scanning sessions will be video recorded. The video recording will consist of imaging your hands scanning a phantom and pushing the ultrasound machine buttons. Your participation will consist of approximately two 2-hour focus group meetings, four on-line learning module (each which may take up to 30 minutes to complete), 2-5 30 minute scanning sessions, where you will scan an ultrasound phantom to practice acquiring and reconstructing a data set on the ultrasound system.

HOW WILL I BENEFIT?

As a sonographer you will have the opportunity observe and learn how 3D data sets are acquired and reconstructed with the heart.

ARE THERE ANY COSTS?

There are not costs associated with this study.

ARE THERE ANY RISKS?

The risks associated with your participation are as follows:

You will be audio recorded during the focus group and video recorded during the observed scanning sessions. Your scores on the pre-test, post-test and responses on the post-course survey will be analyzed. You may feel uncomfortable answering these questions or being observed when scanning. The audio and video recordings will be destroyed after the data has been transcribed and analyzed. Your identity will be protected by only recording data attributed to your pseudonym and your responses will be de-identified. There is potential for a breach of confidentiality, however all efforts will be made to keep your identity confidential by the use of the pseudonym.

ARE THERE ANY ALTERNATIVES?

You do not have to participate in this study. The alternative to participating in this study is simply not to participate, which will not affect your employment.

WILL I RECEIVE COMPENSATION FOR PARTICIPATING?

You will not receive any compensation for participating in this study

IF I DECIDE TO START THE STUDY, CAN I CHANGE MY MIND?

Your decision to participate in this study is entirely voluntary. You may choose not to participate. If you do decide to participate, you may change your mind at any time without penalty or loss of benefits that you had prior to the study. You will be told of any new and significant findings that may affect your willingness to continue. Your decision of whether or not to participate in this study will not affect your employment or the quality of your medical care at this institution.

WHAT IF I HAVE QUESTIONS?

If you have questions about the research study, please contact Carol Mitchell at 414-229-2230. If you have any questions about your rights as a research subject, contact UWHC Patient Relations Representative at 608-263-8009.

<u>Authorization to Participate in the research study</u>:

I have read the information in this consent form. The purpose of the research, the study procedures, the possible risks and discomforts as well as potential benefits have been explained to me. Alternatively my participation in the study have been discussed. All my questions have been answered. My signature below indicates my willingness to participate in this study.

____ ________________________

Signature of Subject **Date**

I have explained the purpose of the research, the study procedures, identifying those that are investigational, the possible risk and discomforts as well as potential benefits and have answered any questions regarding the study to the best of my ability.

____ ________________________

Signature of Investigator or Person Obtaining Consent **Date**

This is the each participant was required to read and sign before participating in the research project.

Appendix I: Course Survey Tool

Question 1

I feel that I could explain how 3D technology can be used to calculate an ejection fraction of the LV.

#		1	2	3	4	5
1	1=Strongly Disagree, 2=Disagree, 3=Neutral, 4=Agree, 5=Strongly Agree	◯	◯	◯	◯	◯

Question 2

I feel that I could tell someone how to reconstruct a 3D volume set to calculate a 3D ejection fraction

#		1	2	3	4	5
1	1=Strongly Disagree, 2=Disagree, 3=Neutral, 4=Agree, 5=Strongly Agree	◯	◯	◯	◯	◯

Question 3

I feel that I could explain how to acquire a 3D volume of the heart that can be used to calculate an ejection fraction of the LV.

#		1	2	3	4	5
1	1=Strongly Disagree, 2=Disagree, 3=Neutral, 4=Agree, 5=Strongly Agree	◯	◯	◯	◯	◯

Question 4

I feel that I am ready to obtain a 3D volume data set on all patients to calculate an ejection fraction of the LV starting tomorrow.

#		1	2	3	4	5
1	1=Strongly Disagree, 2=Disagree, 3=Neutral, 4=Agree, 5=Strongly Agree	◯	◯	◯	◯	◯

Question 5

I feel that I am ready to obtain a 3D volume data set on all patients to calculate an ejection fraction of the LV starting after one week of more practice.

#		1	2	3	4	5
1	1=Strongly Disagree, 2=Disagree, 3=Neutral, 4=Agree, 5=Strongly Agree	◯	◯	◯	◯	◯

Question 6

I feel that I am ready to obtain a 3D volume data set on all patients to calculate an ejection fraction of the LV starting after one more month of practice.

#		1	2	3	4	5
1		◯	◯	◯	◯	◯

Question 7

I feel that I cannot perform a 3D volume set on a patient to obtain an ejection fraction.

#		1	2	3	4	5
1	1=Strongly Disagree, 2=Disagree, 3=Neutral, 4=Agree, 5=Strongly Agree	◯	◯	◯	◯	◯

Question 8

I feel that I can reconstruct a 3D volume set on a patient to obtain an ejection fraction.

#		1	2	3	4	5
1	1=Strongly Disagree, 2=Disagree, 3=Neutral, 4=Agree, 5=Strongly Agree	◯	◯	◯	◯	◯

Question 9

I feel that I can reconstruct a 3D volume set on a patient to obtain an ejection fraction, and implement this into practice starting tomorrow.

#		1	2	3	4	5
1	1=Strongly Disagree, 2=Disagree, 3=Neutral, 4=Agree, 5=Strongly Agree	◯	◯	◯	◯	◯

Question 10

I feel that I can reconstruct a 3D volume set on a patient to obtain an ejection fraction, and implement this into practice starting after one more week of practice.

#		1	2	3	4	5
1	1=Strongly Disagree, 2=Disagree, 3=Neutral, 4=Agree, 5=Strongly Agree	◯	◯	◯	◯	◯

Question 11

I feel that I can reconstruct a 3D volume set on a patient to obtain an ejection fraction, and implement this into practice starting after one more month of practice.

#		1	2	3	4	5
1	1=Strongly Disagree, 2=Disagree, 3=Neutral, 4=Agree, 5=Strongly Agree	◯	◯	◯	◯	◯

Question 12

Comments reagarding what you liked about this experience:

Question 13

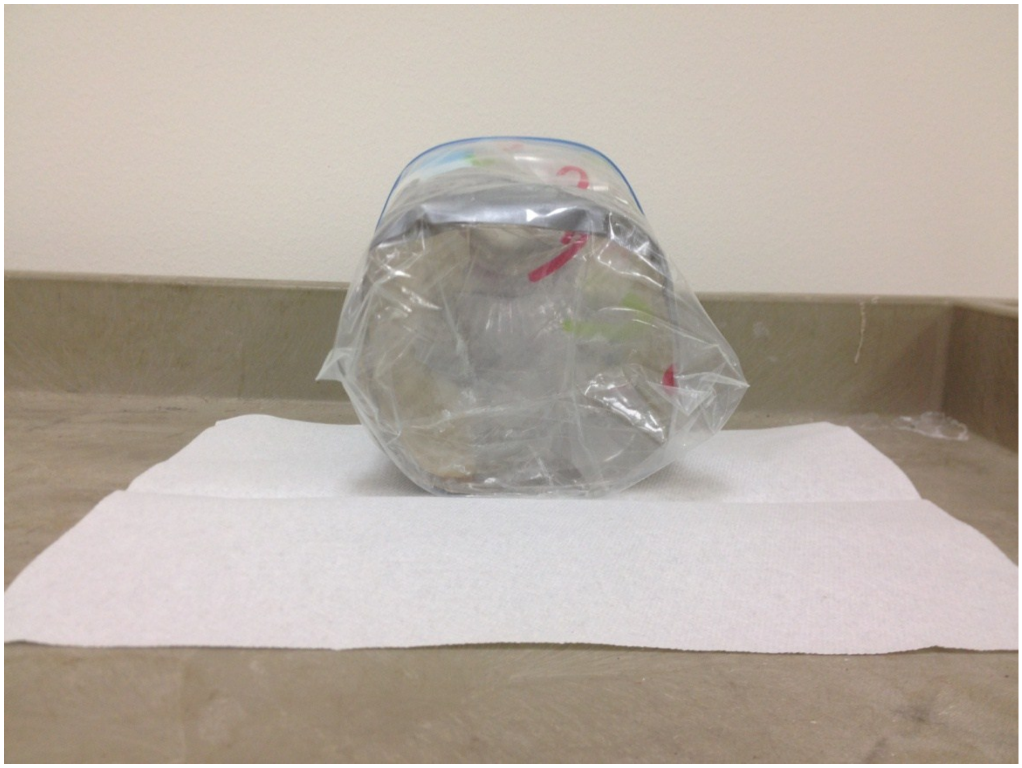
Comments regarding what could have made this experience better for you to learn 3D technology:

Save

Submit

This is the form that the participants filled out at the end of the course.

Appendix J: Phantom Bath Setup

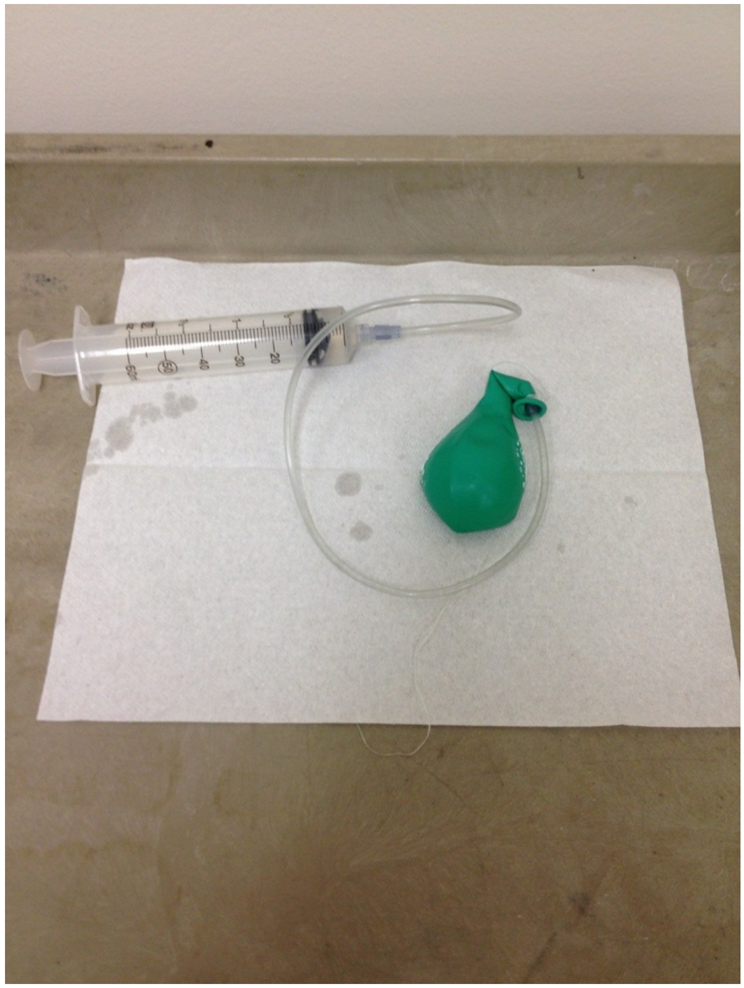


Bottom of the vessel used to house the balloon suspended in water.

Side of the vessel used to house the balloon suspended in water.

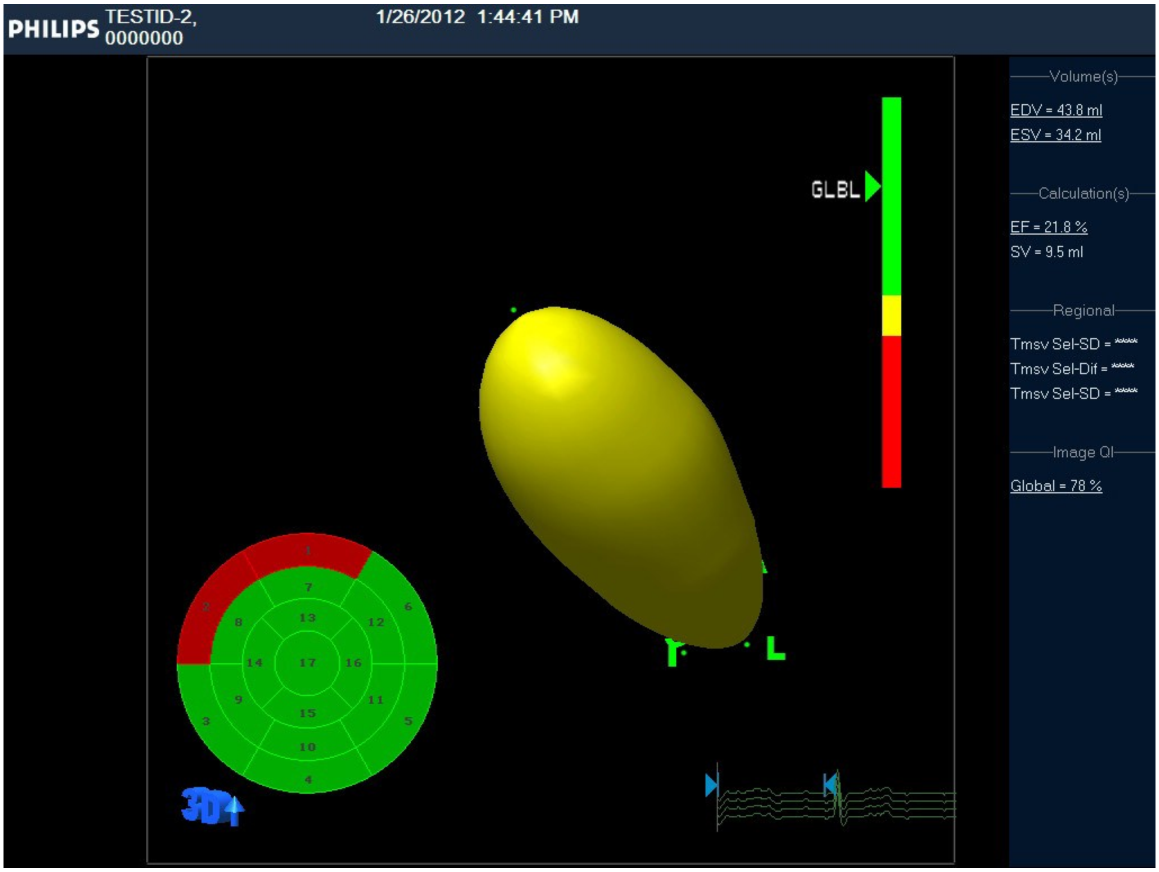
Top of the vessel used to house the balloon suspended in water.

Syringe used to fill the balloon with water.



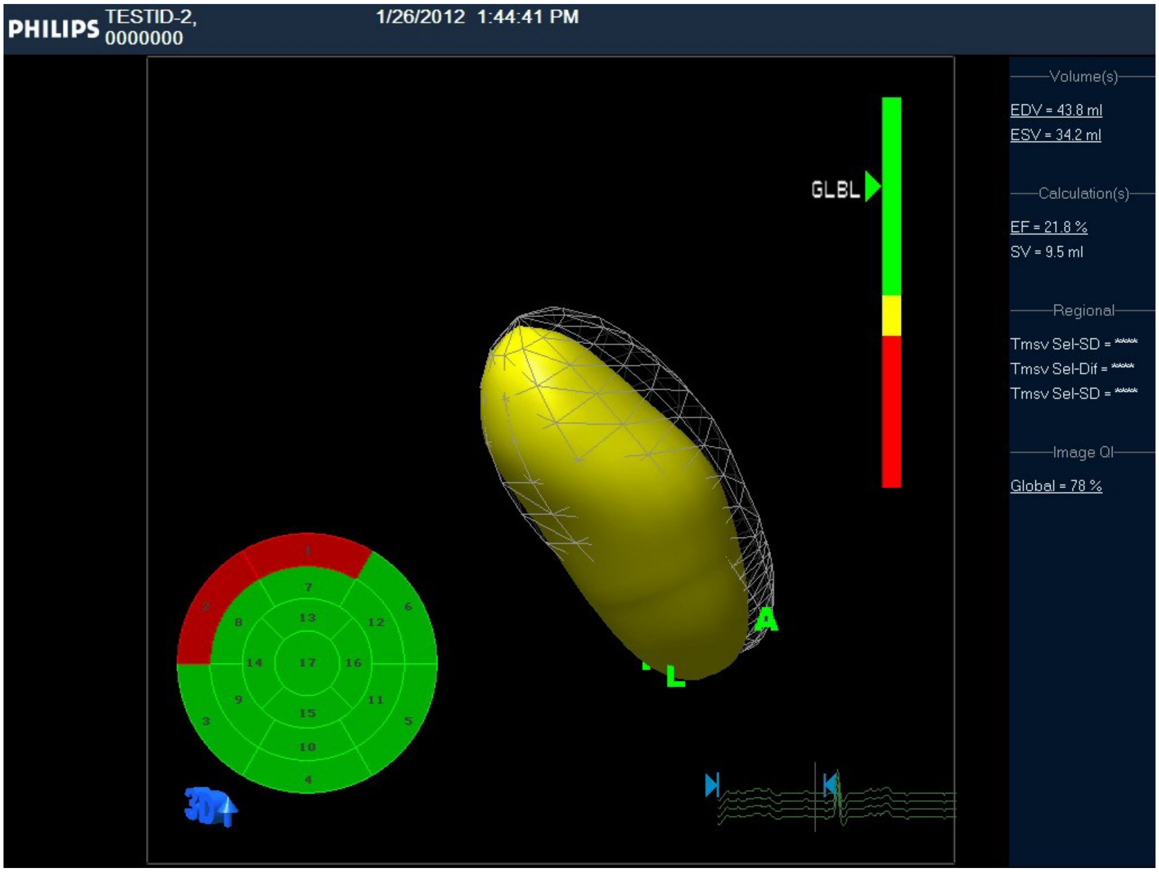
Syringe attached to the balloon before being inserted into vessel.

Appendix K: Balloon Phantom Image – EDV



Screen shot of the Phillips IE33 during a scan of the end diastolic volume phantom balloon.

Appendix L: Balloon Phantom Image – ESV



Screen shot of the Phillips IE33 during a scan of the end systolic volume phantom balloon.

Appendix M: In House Assistance Note Cards

3D Acquisition

1. Select "Full Volume"
2. If using the X-5 matrix transducer select the 4 beat acquisition option
    1. The X-3 transducer defaults to this setting
3. Have patient old their breath
4. Obtain two 4 beat clips at the time of acquisition
    1. Select review
    2. Select "Image" on the left touch screen
    3. Select volume display only
5. If you like the data set, select "Save 3D Clip"

LV Function Analysis

1. Select "Review"
2. Select "Image" tab
3. Select "Volume Display Only"
4. Select "Save 3D Clip" on RT touch
5. LV Volume Ejection Fraction
    1. Select "Q LAB" (left touch screen)
    2. Select "3DQ Advanced" (left touch screen)
6. Adjust, green, red, and blue lines. Yellow arrow (Red – long axis 4c, Green – long axis 2c, Blue – set just inferior (below) MV (do not include MV), direct yellow arrow towards septum and RV (tips for adjusting lines)
7. Set EDV points (LT, RT, Apex)
8. Use keyboard arrows and arrow to ESV frame (set points LT, RT, apex)
9. Select sequence analysis on left side panel
10. Allow sequence analysis to run
11. Pick "3D View"
12. On left side panel select "Show Report Page"

Hit play on movie to see mesh

Images to Obtain

1. Autocrop volume review without reference lines
2. Loop of quad screen with Left Ventricle (LV) shell
    1. Demonstrates Ejection Fraction (EF)
    2. Select “play” button to see mesh
3. Loop of enlarged LV shell with reference mesh
4. Loop of i-slice view with borders
5. Loop of i-slice view without borders
6. Click on show report pages
    1. Still image Global Function Report

Send 3D data set to TomTech work station for future measurements if needed

Images to Obtain - Steps

1. Enlarged LV shell image with mesh
    1. Click “Hide Waveforms” on left of screen
    2. Click “Show Ref Mesh” on left of screen
    3. Select “play” button to see mesh
2. i-slice view
    1. Click “i-slice view” on left of screen
    2. Acquire a loop with the borders demonstrated
    3. Acquire a loop with borders hidden
        1. Select “hide borders” on left side of screen
        2. Show report page
            1. i-slice – setup – unclick “show GR[Y] in i-slice”
    4. Global Function Report
        1. Still image

Information found on the note cards used by participants at the last scanning session.