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The Effectiveness, Efficiency, and Appeal of Pediatric Echocardiography Protocol Training for First Year Pediatric Cardiology Fellows

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THE EFFECTIVENESS, EFFICIENCY, AND APPEAL OF PEDIATRIC ECHOCARDIOGRAPHY PROTOCOL TRAINING FOR FIRST YEAR PEDIATRIC CARDIOLOGY FELLOWS

by

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ABSTRACT

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Echocardiography training for pediatric cardiology fellows is complex and academic hospitals strive to provide high-quality training using limited resources. The purpose of this embedded single case study design was to evaluate the effectiveness, efficiency, and appeal of a newly developed 10-day echocardiography protocol learning module for first year pediatric cardiology fellows. Using blended learning methods that included didactic lectures, online learning activities, and interactive games, the learning module was the first step in the process of training pediatric cardiology fellows to perform echocardiograms independently with limited supervision during their first year of fellowship. At the end of the 10-day module, the cardiology fellows successfully learned the pediatric echocardiography protocol and were able to begin applying their new knowledge in the echocardiography laboratory. Results from the qualitative evaluation confirmed that the learning module was effective, efficient, and appealing.

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Problem and Target Population

Midwestern Hospital accepts 3-4 pediatric cardiology fellows each year. The fellowship begins on July 1st of each year and continues for three years. First year fellows are given a block rotation calendar that includes rotations in echocardiography, electrophysiology, floor service, cardiac catheterization laboratory, and research. The first rotation month for all first year fellows includes a general hospital orientation, cardiac critical care boot camp, and echocardiography. The echocardiography rotation is two weeks in length and the fellows take call during this time. Taking call does not permit them to be in the echocardiography lab on post call days. This equates to approximately 10 days (or less) of echocardiography training during their first echocardiography rotation. Therefore, focused instructional methods are needed to optimize the training rotation.

Pediatric cardiology training is intensive and needs to be covered in a very short time. Pediatric cardiology fellows not only need to learn massive amounts of information, but they also need to learn various skills and techniques in the areas of echocardiography, cardiac catheterization, and electrophysiology (Abdulla, 2000). In addition, all of this education takes place in a real-world hospital setting where they must simultaneously provide patient care within time and resource constraints. According to the 2015 results and data from the *National Resident Matching Program,* there are currently only 57 pediatric cardiology programs in the United States, which placed 137 pediatric fellows last year, with most programs accepting 1-3 new fellows ("The Match National Resident Matching Program, 2015,"). With no formal pediatric cardiology fellowship curricula available to teach didactic or skill-based competencies, fellowship programs are required to develop their own teaching strategies, often with little or no formal educational background or experience. With recent changes in health care funding,

institutions are also forced to provide quality training with fewer resources. Techniques and strategies to provide uniform instruction that are inexpensive and reproducible from year to year are needed to ensure quality education while taking some of the burden off of faculty who are often already overextended. The pediatric echocardiography lab at Midwestern Hospital experiences similar sets of challenges and continually works toward providing effective education in an efficient format.

Pediatric echocardiography requires physicians who are knowledgeable in obtaining and interpreting diagnostic ultrasound images. The ultimate goal of the first year of pediatric echocardiography training at Midwestern Hospital is to prepare the cardiology fellows to independently perform and interpret echocardiograms with limited support. While adult cardiologists mainly concentrate on acquired heart disease, pediatric cardiologists must be familiar with these cardiac pathologies as well as all forms of congenital heart disease. The core competencies of a pediatric cardiologist include the ability to perform and interpret a transthoracic echocardiogram (TTE) in children of all ages (Lai et al., 2006).

TTE performance is typically learned in the lab from skilled pediatric cardiologists and cardiac sonographers and includes topics such as ultrasound physics, knobology, image resolution techniques, protocol mastery, and hands-on scanning. These concepts are then applied to performing a complete 2-dimensional and Doppler assessment of cardiac hemodynamics and function as well as demonstrating the anatomic features of simple to complex congenital heart defects (Lai et al., 2006). When institution-dependent protocols are added to this instruction, it becomes clear that echocardiography cannot be effectively mastered without deliberate practice. Fellows in the program are expected to learn all of the information necessary to function as an entry-level sonographer with less than three months of dedicated training. With increased work

hour restrictions and fellows not permitted in the hospital on post call days, time is a significant limiting factor to achieving comprehensive training (Eric, Nair, Sibbald, Lee, & Dorian, 2015; Fletcher, Saint, & Mangrulkar, 2005; Jagannathan et al., 2009; Peets & Ayas, 2012). Lack of resources and time require creative solutions for developing and delivering quality educational programs. The following literature review highlights what has been offered in the area of pediatric echocardiography training for fellows and the gaps that remain for the specific population of learners.

Literature Review

Training in Pediatric Echocardiography

Formal curricula focused on training pediatric cardiology fellows in echocardiography is lacking (Maskatia, Altman, Morris, & Cabrera, 2013); however, the training recommendations for pediatric cardiology published by the American College of Cardiology Foundation, the American Heart Association, and the American Academy of Pediatrics are comprehensive (Sanders et al., 2005; Srivastava et al., 2015). Published recommendations outline the competencies and requirements to be met during a three-year pediatric cardiology rotation, but leave programming strategies to individual medical centers. Other than textbooks and continuing medical education courses, most publications about echocardiography training for physicians are focused on training non-cardiologists to quickly acquire limited diagnostic bedside images and do not address the complete diagnostic protocol requiring advanced echocardiography skills and knowledge on the part of the physician (Bahner, Hughes, & Royall, 2012; Breitkreutz et al., 2009; Eisen, Leung, Gallagher, & Kvetan, 2010; Fernandez et al., 2012; Price et al., 2008; Sekiguchi, Bhagra, Gajic, & Kashani, 2013; Sharma & Fletcher, 2014).

The term “boot camp” has been used to describe a short-term, intensive method for echocardiography training that is helpful for the initial introduction of cardiology fellows to the underlying concepts, methods, and skills required to perform cardiac ultrasound (Maskatia et al., 2013). While this is a useful method that is independent of standard patient scheduling and availability, the required resources are often not available to smaller programs. The role of electronic simulators has also been explored, but the technology is costly and not an option for most programs (Sidhu, Olubaniyi, Bhatnagar, Shuen, & Dubbins, 2012; Weidenbach et al., 2009). Finally, a subset of papers has focused on objective testing and assessment of competencies of trainees but do not address the methods for educational delivery (Hao et al., 2007; Nair et al., 2006).

While training in pediatric echocardiography is just one small piece of the training requirements for cardiology fellows, it is significant. Eventually, fellows will need to be able to synthesize information in a complex fashion; the Kolb model of experiencing, reflecting, thinking, and doing is a logical approach to internalizing and using new information. Continuing medical education programs have sought to provide teaching strategies that will promote changes in learner behaviors and have utilized Kolb’s Learning Styles Inventory (Armstrong & Parsa-Parsi, 2005). While these examples provide an overall view of approaches to physician education and offer useful applications of Kolb’s theory, they focus on educational programming as a whole and do not necessarily offer ideas on how to break down and prioritize the information required to implement programming. Many of the papers published on training in echocardiography focus on the ability of the student to perform and interpret an echocardiogram as quickly as possible but do not adequately address how to present the underlying knowledge

requirements; these papers generally cite the use of didactic lectures and independent learning through reading and assimilation.

The absence of curricula related to specific tasks and information may be attributed to the learning capacity of individuals who are in the field of medicine. They are usually highly motivated and self-disciplined, with vast knowledge and experience gained from their previous medical education. However, given the lack of resources and time available for fellow education, the most logical approach may be the use of short-term intensive learning opportunities similar to the "boot camp" principle, delivered through blended learning techniques that appeal to all learning preferences. For cardiology fellows to quickly move forward in their learning, they must be armed with a solid foundation of information and experience that is grounded in mastery of basic concepts and facts. Anecdotal experience has shown that those fellows who make an effort to learn the echocardiography protocol and the underlying ultrasound physics and techniques seem to perform higher quality TTEs more quickly. By learning in prescribed steps and building on previous concepts, the learners do not need to manage as many new tasks simultaneously, allowing them to focus on practicing the complex technical skills required to perform an echocardiogram.

Purpose Statement

The purpose of this case study was to assess the effectiveness, efficiency, and appeal of a newly developed pediatric echocardiography protocol learning module for first year cardiology fellows. Knowledge obtained by the cardiology fellows was assessed and interviews and surveys were conducted to evaluate the efficiency and appeal of the education delivery methods. The information gathered during the case study will be used to enhance the quality of the training module by "Examining whether certain program goals or objectives are being achieved at

desired levels" (Fitzpatrick, Sanders, & Worthen, 2011). What follows is a description of the integrated framework used to design an introductory pediatric echocardiography protocol learning module for pediatric cardiology fellows, which utilized concepts from various learning theories.

Theoretical Framework

Behaviorism

Learning has been defined by psychologists as a change in behavior (Merriam, Caffarella, & Baumgartner, 2012). Behaviorism, developed by John B. Watson, is comprised of three assumptions: learning is manifested by a change in behavior, learning is shaped by elements of the environment, and contiguity (the timing of events to form a bond) and reinforcement are important to explain the learning process (Merriam et al., 2012). The behaviorism philosophy is often applied in adult education in the areas of career and technical education and is often used for on-the-job training using the concepts of performance improvement, competency-based instruction, and accountability (Merriam et al., 2012). The question then becomes, how do we change the behavior of pediatric cardiology fellows as quickly as possible with limited resources? Potentially, a methodological approach would be more efficient than relying on independent learning.

Bloom's Taxonomy

Bloom's taxonomy discusses four types of knowledge: factual, conceptual, procedural, and metacognitive (Anderson, Krathwohl, & Bloom, 2001). All of these knowledge types are important for students to acquire and apply in various situations. Two goals of education include promoting retention of information and promoting transfer or use of information (Anderson et al., 2001). Ultimately, pediatric cardiology fellows need to move beyond memorizing facts and

be able to apply their new knowledge in meaningful ways to diagnose and treat patients with congenital heart disease. Bloom's taxonomy describes six levels of cognitive processes used for retention and transfer. These include: remember, understand, apply, analyze, evaluate, and create (Anderson et al., 2001).

Remember – retrieve information

Understand – construct meaning from instruction

Apply – use a procedure in a given situation

Analyze – break down information and determine relationships or purpose

Evaluate – use criteria and standards to make judgments

Create – form coherence out of elements or reorganize them into a new structure

This learning module was designed to primarily address the areas of remembering, understanding, applying, and analyzing. Once mastered, the acquired pediatric echocardiography knowledge would provide the framework for the next steps of learning: evaluating and creating. By addressing the above concepts in the new pediatric cardiology fellow echocardiography educational module, the goal was to accelerate the learning process while ensuring a complete review of the required information. The next consideration was how to deliver the instruction.

Instructional-Design Theory

This research project did not focus on what to teach pediatric cardiology fellows as this has already been covered in detail by clinical experts (Srivastava et al., 2015). Instead, the focus was on "how to teach," and the framework was based on instructional-design theory (Reigeluth,

1999). According to Reigeluth (1999), instruction should provide clear information, thoughtful practice, informative feedback, and strong intrinsic or extrinsic motivation. Instructional-design also focuses on the means to attain learning goals, the methods used to support learning, and the detailed components of these methods (Reigeluth, 1999). Instruction should also include two major aspects: instructional conditions and desired instructional outcomes. Instructional conditions are concerned with the nature of the content, the learner, the learning environment, and the development constraints of the instruction, which include time and money for planning and developing. Reigeluth describes the desired instructional outcomes in terms of effectiveness, efficiency, and appeal (Reigeluth, 1999). These outcomes were especially interesting for pediatric cardiology fellow educational planning and delivery in the institution due to restricted resources and time. These constraints also called for a creative mode of delivery. Thus, components of the new pediatric echocardiography protocol learning module were developed based on the content, learner, and learning environment of Midwestern Hospital.

Blended Learning

Since the birth of the field of pediatric cardiology in the 1940s (Maskatia et al., 2013), technology has advanced, not only in the area of diagnostic imaging but also in the ability to deliver meaningful educational opportunities. With the advent of e-learning, various styles of educational programming have been successfully developed in diverse formats and using differing levels of technology. Initially, most courses were transferred to an exclusive e-learning format; however, this gave "rise to the realization that a single mode of instructional delivery may not provide sufficient choices, engagement, social contact, relevance, and context needed to facilitate successful learning and performance" (Singh, 2003). What followed was increased experimentation with blended learning models that incorporate various modes of delivery, an

approach that is now well established (Singh, 2003). Badrul Khan's framework of blended e-learning provides a guide to assist organizations in strategically developing effective and economical blended learning programs (Singh, 2003). Blended learning mixes various activities, including face-to-face didactic instruction, live e-learning, and self-paced learning. Information can be delivered via traditional instructor-led methods or via synchronous online conferencing, asynchronous self-paced learning, and on-the-job training (Singh, 2003). The design of the new pediatric echocardiography protocol learning module was based on a blended learning model, incorporating the use of various methods of instruction.

Face-to-face Lectures

Echocardiography protocols are highly institution dependent. As such, there are no formal educational materials available to teach them. Pediatric echocardiography is the most specialized and completing the protocol may require as many as 150-200 images depending on the pathology of the patient. Textbooks cover many topics related to echocardiography and are a valuable resource, but the only way to learn a protocol is by interpreting a written list of images or through observation. Neither of these are the most efficient method of learning, nor do they ensure consistent learning.

Shirley J. Farrah (Galbraith, 1998) states:

> Lecture is appropriate when the information to be transmitted is not readily available or is scattered among diverse sources and when an expert has current information immediately desired or needed by a large group of learners in a short period of time.

Having all of the fellows together for instruction may not only help with team building, but also ensures that they receive the same instruction, which has been a challenge with previous cohorts.

Higher levels of recall have also been demonstrated with learners who have an advanced level of education when lectures are incorporated into the instruction (Galbraith, 1998).

Gaming

Active learning is a preferred method of learning for adults and as a result, gaming approaches are often used to enhance retention of knowledge, promote problem-based learning, and increase the motivation of the learner (Royse & Newton, 2007). Research regarding the effectiveness of gaming as a learning strategy in the health sciences is varied and often not systematically reported; however, most studies conclude that gaming is perceived as a fun and interactive way to learn (Blakely, Skirton, Cooper, Allum, & Nelmes, 2009). Some studies also report higher long-term retention when game-based reinforcement of learning is used (Blakely et al., 2009). Use of methods to reinforce retention is an important consideration, as echocardiography rotations for each fellow may be separated by weeks to months.

The pediatric echocardiography protocol is technical and is essentially a list of images and measurements that are required for a complete assessment of cardiac structure and function. The content is dry and memorizing the order of images is specific. Pediatric cardiology fellows are often overwhelmed and confused and would rather focus on scanning with the idea that the specifics of the protocol will become clear in time. While this may be true in some cases, in order to make the most efficient use of face-to-face time with patients, one must ensure that the fellows are thoroughly prepared, with full understanding of the complete protocol.

John Keller's Attention, Relevance, Confidence, and Satisfaction (ARCS) model of motivation with games is well known in the field of instructional-design and each of these elements were addressed with the gaming activities included in the learning module (Kapp, 2012).

- Attention – varying the educational delivery method
- Relevance – modeling the results of learning new knowledge
- Confidence – creating opportunities for success in completing small milestones
- Satisfaction – providing opportunities to apply new knowledge

Gaming was incorporated via two distinct methods: during the face-to-face meetings and online. For the purposes of clarity, these activities were referred to as interactive games (face-to-face) and online activities throughout the study. The interactive games increased learner engagement, motivation, and teamwork in a non-threatening environment during didactic sessions, while the online activities provided unlimited access for practice outside of programmatic learning time.

In summary, the pediatric echocardiography protocol learning module was developed using Reigeluth's instructional-design theory and provided instructional conditions incorporating the blended learning techniques of face-to-face lectures, online activities, and interactive gaming. The desired instructional outcome was to create effective, efficient, and appealing education using Bloom's taxonomy of remembering, understanding, applying, and analyzing new information to ultimately change the behavior of the pediatric cardiology fellows (see Figure 1).

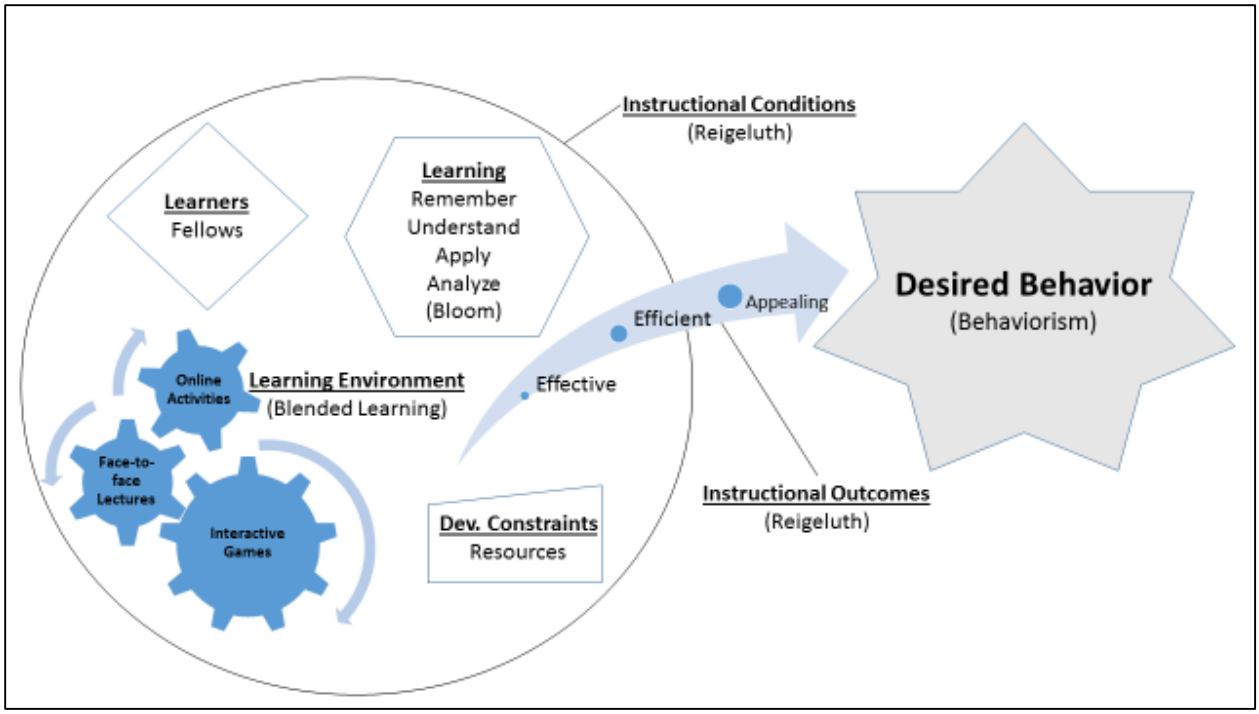

Figure 1. Elements of the pediatric echocardiography protocol learning module

Research Methodology

Procedures

Before the learning module was implemented, exempt status was obtained from the institutional review boards (IRB) at both Midwestern Hospital and the University of Wisconsin Milwaukee with a start date of July 9, 2015. The study began with an orientation meeting led by the instructor for the incoming first year pediatric cardiology fellows. Participants received an information sheet (see Appendix A for the study information sheet) informing them that data would be collected on the learning module for an educational research project. Informed consent was not required by either IRB. The fellows were provided with a general overview of the plan for the first rotation and given reading assignments that were to be completed before the rotation began. At the end of the orientation meeting, they were asked to complete an online pretest

covering the information to be mastered by the end of the first rotation. The pretest assessed the level of knowledge of the learners before participating in the protocol learning.

The pediatric echocardiography learning module consisted of 10 days of face-to-face learning. Information was presented using a variety of didactic lectures and reading assignments. Each morning, the fellows met with the instructor for 1.5 to 3 hours to cover the assigned material for the day, which was reinforced through the use of interactive games, a novel approach to learning for the pediatric cardiology fellowship program. A set of flashcards containing diagrams and ultrasound still images were provided to each fellow. These were used for the face-to-face activities as well as for independent study. The fellows were also assigned a login and password to the online learning domain owned by Midwestern Hospital. They had unlimited access to practice new concepts using a variety of online games and activities; however, the activities were only designed for practice and quantitative data was not collected. Following each daily meeting, the fellows were paired with an experienced cardiac sonographer for hands-on instruction with actual patients and training on the administrative protocols used by the echocardiography laboratory. At the conclusion of the rotation, the fellows took a posttest covering the same concepts and materials as the pretest and completed a simulation demonstration with the instructor. Scores achieved on these activities were collected and used to assess the effectiveness of the protocol learning module. During the following week the fellows completed a survey tool developed to assess the effectiveness, efficiency, and appeal of the learning module and within one month of module completion, follow-up interviews were conducted. These interviews included questions related to how the learners perceived different activities in the module and included topics related to the evaluation questions.

Research Questions

The aim of the echocardiography protocol learning module was to provide effective, efficient, and appealing learning activities, which were measured using a set of evaluation questions. The evaluation questions directly related to the goals and objectives of the module. These questions included the following:

- How effective was the pediatric echocardiography protocol learning module?
    - How well did the participants learn the pediatric echocardiography protocol?
    - Which activities made the protocol learning module effective?
- How efficient was the pediatric echocardiography protocol learning module?
    - How well did the participants demonstrate the pediatric echocardiography protocol by the end of the module?
    - Which of the protocol learning module activities accelerated learning?
- How appealing was the pediatric echocardiography protocol learning module?
    - Which of the protocol learning modules were the most appealing?
    - Which learners found the protocol learning module activities more appealing and what was their type of learning preference?

Evaluation Design

An embedded single case study design was utilized to evaluate the effectiveness, efficiency, and appeal of the new pediatric echocardiography protocol learning module. With this design, the researcher is not only able to validate the efficacy of the treatment but they are also able to understand the "why" and "how" of the situation (Fitzpatrick et al., 2011). Fitzpatrick et al. (2011) state that "An explanatory case study examines the context, studying it to explain and understand the workings of the program" (p. 405).

To assess the effectiveness of the module, an objectives-oriented evaluation approach was selected. The Tylerian evaluation approach consists of the following steps (Fitzpatrick et al., 2011, p. 155)

1. Establish broad goals or objectives
2. Classify the goals or objectives
3. Define objectives in behavioral terms
4. Find situations in which achievement of objectives can be shown
5. Develop or select measurement techniques
6. Collect performance data
7. Compare performance data with behaviorally stated objectives

To strengthen this approach, a logic model approach was also implemented. The use of logic models help to bridge the gap between the program activities and the stated objectives (Fitzpatrick et al., 2011). A logic model is used by planners to identify inputs, activities, outputs, and outcomes. The logic model included all of the components of the protocol learning module and how they contribute to the mid-term and long-term goals of echocardiography training (see Appendix B for a diagram of the logic model). The short-term goal of learning the pediatric echocardiography protocol was expected to be achieved by the end of the protocol learning module. Using this approach, the activities of the module were aligned with the desired objectives as well as the previously stated blended learning and instructional-design goals.

The case study evaluated the effectiveness, efficiency, and appeal of the new Midwestern Hospital pediatric echocardiography protocol learning module. It was important to know whether using instructional-design theory to design a comprehensive learning module augmented with an interactive gaming strategy would provide the means for pediatric cardiology fellows to

effectively acquire and demonstrate the pediatric echocardiography protocol in a simulated setting. To be efficient, mastery of the required protocol components was expected to be completed by the end of the module. The activities in the protocol education module were designed to accelerate the learning process with maximum appeal to motivate learners. This efficiency aspect of the module was also included in the assessment to guide development of future modules.

Sample Selection

Four cardiology fellows were accepted into the pediatric cardiology fellowship. One dropped out of the program before July 1st. One fellow was continuing her cardiology training at Midwestern Hospital after completion of an intensive care fellowship and was initially excluded based on the premise that there would be bias based on her previous experience with the sonographers. During the first session, it was found that this fellow did not have an unfair advantage and in fact had no more experience with the pediatric echocardiography protocol than the other two fellows from outside programs. Thus, the final cohort for the case study was three.

Data Collection

A formative (qualitative) evaluation method was selected to facilitate assessment of the effectiveness, efficiency, and appeal of the new pediatric echocardiography protocol learning module. The evaluation focused on process improvement, which serves "formative purposes, providing information to program providers or managers about how to change activities to improve the quality of the program delivery to make it more likely that objectives will be achieved" (Fitzpatrick et al. 2011, pp. 26-27).

In order to increase the validity of the evaluation data, multiple assessment tools, including pretest/posttests, surveys, observations, and interviews were used (Yin, 2012).

Collecting both quantitative data (impact on outcomes) and qualitative data (experience of intervention) allowed for analysis of the effectiveness of the module as well as the appeal; this is known as an embedded design (Creswell, 2013). The quantitative pretest/posttests, observations, and surveys were collected first, followed by qualitative interviews. This allowed the evaluator the opportunity to refine the interview questions to address unexpected data emerging from the surveys in order to gain a better understanding of the circumstances and influences surrounding the outcomes.

Pretest/posttest. Much of the information assessed in the pre- and posttests was general echocardiography content; however, questions regarding protocol information specific to Midwestern Hospital were also included. Pretest and posttest scores were compared to analyze attainment of knowledge. The effectiveness objective expected to be met by the end of the protocol learning module was a score of 90% on the protocol learning module posttest.

Demonstration simulation. The demonstration simulation was designed to assess learning as it relates to the performance of an echocardiogram. Performance of an echocardiogram on an actual patient was not required for this learning module. While the fellows were practicing on patients during the learning module, echocardiography is a skill that takes considerable time to master. The demonstration simulation only assessed the knowledge of the learner, not the ability to obtain diagnostic images. The demonstration simulation was performed using an ultrasound transducer prop. The fellow was asked to hold the transducer for each view and demonstrate probe movement while providing a narrative. The narrative included the names of standard pediatric echocardiography views in the correct order, patient positioning, transducer marker orientation, movement of the ultrasound plane, image acquisition length and appropriate anatomic landmarks. The demonstration simulation was graded using a rubric

developed to assess view order and narrative elements (see Appendix C for demonstration simulation rubric). This type of assessment is often used in qualitative nursing research and is commonly referred to as the think-aloud method or verbal protocol technique (Lundgrén-Laine & Salanterä, 2010). While the purpose of this study was not to assess the decision-making process of the learners in a real-world setting, this method made it possible to assess the depth of understanding of the echocardiography protocol and how it relates to imaging the heart. The effectiveness objective expected to be met by the end of the protocol learning module was a score of 80% on the demonstration simulation.

Survey tool. The survey tool design was based on a template developed by (Conceição, Strachota, & Schmidt, 2007). This tool was designed and validated to assess the effectiveness, efficiency, and appeal of online training materials. The tool was modified to include survey questions regarding all categories of learning, including didactic lectures, interactive group games, and online activities (see Appendix D for survey).

Interviews. After the data from the assessments and surveys were collected and initially reviewed, the interview questions were reviewed for appropriateness. Interviews were conducted using a standardized open-ended interview format (see Appendix E for interview protocol). Open-ended questions allowed the fellows to fully express their viewpoints and the use of structured questions reduced the potential for researcher bias (Turner III, 2010). Follow-up questions were asked at the discretion of the interviewer to help keep the fellow focused on the question (Turner III, 2010). The interviews were audiotaped for ease of data capture and transcription.

The data from each measuring tool was anonymized and the fellows were randomly assigned a code name. All data were stored electronically in a password protected file at Midwestern

Hospital or in a locked cabinet in the researcher's office. Data were not accessible by anyone other than the researcher.

Online questionnaire. To identify the learning preferences of the participants, they were also asked to complete an online questionnaire called the VARK® analysis. VARK® stands for visual, aural, read/write, and kinesthetic, representing basic learning preferences ("VARK A Guide to Learning Styles," 2014). Developed in 1987 by Neil Fleming, this questionnaire provides information on how participants prefer to take in and present information and was included in the evaluation process because it may reveal relationships between learning outcomes and potential rival explanations for the success or failure of the learning module ("VARK A Guide to Learning Styles," 2014) (see Appendix F for questionnaire sample). This information was also analyzed at the completion of the protocol learning to assess if learners with certain learning preferences found the module more appealing. While the sample size was too small for quantitative correlation, this information helped contribute to the perception of overall appeal by certain learners.

Each data collection instrument was designed with the evaluation questions in mind. As shown in Table 1, the questions included on each collection instrument (tests, survey, interview, and observation) were created to collect the required data to answer the research questions.

Table 1

Data Collection Instrument by Evaluation Question

Evaluation Question	Data Collection Instrument
How effective is the protocol learning module?	Learning module survey Interviews Pretest/Posttest Demonstration simulation observation rubric
How efficient is the protocol learning module?	Learning module survey Interviews
How appealing is the protocol learning module?	VARK® questionnaire Learning module survey Interviews

Data Analysis

Data from the pretest, posttest, survey, and demonstration simulation observation rubric were collected and tabulated. The interview responses were transcribed and manually coded until themes emerged that answered the research questions (Creswell, 2014). Pattern coding (second-level coding) was used to identify relationships and patterns within the case study (Rogers & Goodrick, 2010). Information from the open-ended questions in the survey were also added to the thematic analysis. Due to the small sample size, quantitative data analysis was not feasible; however, information from the quantitative instruments was used to support the themes found through the survey and interview processes.

Findings

Face-to-face lectures were mentioned consistently as the most effective, efficient, and appealing method of learning, while games were considered the most appealing way of reinforcing learning. Even though the fellows have been students for many years and have their own learning preferences, they all mentioned the benefit of forcing themselves to try new

learning activities. The online activities were overall the least useful for learning and some modifications were suggested to make them more effective. Even though they were listed as the least desirable learning method, the online methods were acknowledged as beneficial for reinforcement and for utilizing a different learning approach to gain the most benefit from the program as a whole. The following sections discuss the findings in relation to the research questions, as well as the different methodologies and theories used to design the pediatric echocardiography protocol learning module.

Effectiveness

The interview data was helpful in discovering how the fellows used each aspect of the module for their learning. Analysis of questions regarding how each of the blended learning activities contributed to learning revealed that all four targeted aspects of Bloom's taxonomy were reported. The didactic lectures and interactive games facilitated the cognitive processes of remembering, understanding, applying, and analyzing, while the online activities were primarily described in terms of remembering.

Survey questions also addressed the purposes for which the fellows used each activity for their individual learning. Each activity could be used for more than one purpose and if chosen by all three fellows, the highest score possible for each purpose was three. While the scores for each activity were not statistically significant, all of the activities were used for more than one learning purpose by more than one fellow. The most notable observation being that the face-to-face lectures were indicated as the only tool that was useful for clarification. Table 2 lists the scores for each activity.

Table 2

Purpose for Using Activities, n=3

Activity	Reinforce	Clarification	Practice	Review	Retention
Online Activities	2	0	2	3	1
Interactive Games	3	0	2	2	3
Face-to-Face Lectures	2	3	2	3	3

The face-to-face lectures were cited by all three fellows as the most effective of the learning activities because of the interactive nature of the instruction. They reported that the lectures provided opportunities for learning, understanding, and reinforcement while instilling confidence in the learners.

Interactive games were employed through various activities and the flashcards were utilized each day. Because the interactive games were interspersed within the face-to-face lectures, it was sometimes difficult to differentiate the two when analyzing the data. The interactive games were described as being effective for identifying gaps in knowledge, assessing understanding, and providing a variety of learning activities. Communicating, analyzing, and memorizing were accomplished via the games and the fellows reported using the flashcards for self-study as well. As the module progressed and the fellows were able to better identify images, methods of critical analysis were introduced. This was a valued form of learning as it provided an opportunity for them to apply their new knowledge in a simulated situation. One fellow said, "You are kind of training my brain how to think the next time I'm puzzled."

The responses to questions about the effectiveness of the online activities were inconsistent and each fellow offered unique feedback. Comments were received from each fellow. Fellow 1 stated, "Very helpful and fun at the same time, made me aware of my weaknesses," fellow 2 stated, "More reinforcement of what I had already learned," and fellow 3

stated, “I’m not sure I learned anything from doing them.” There were valid critiques of the online activities and it is recommended that a thorough analysis of these activities be conducted before the next implementation of this module. Some suggestions from Fellow 2 included, “It would have been more effective if it could have [had] longer lists to order” or “you could play the game multiple times and it would be new every single time.” The online activities also did not provide correct responses when a question was answered incorrectly. Fellow 3 stated that “It felt more like a quiz than a game.” This was an intentional design element as the online activities were developed to be a higher level of practice than the interactive games. The idea of offering different levels of problem solving, or scaffolding, was developed to control task elements “so that the learner can concentrate on and complete elements within his or her immediate capability” (Kapp, 2012, p. 67). Scaffolding may have been more effective if it had been built into the online activities as well. The limitations of the online activities were directly related to the functionality of the system as it was not designed specifically for game play but was adapted for the project. Future enhancements may require researching and selecting an alternative software program.

All three fellows mentioned scanning with the sonographers and how the pediatric echocardiography protocol learning module better prepared them for that experience. They reported having more confidence in directing their hands-on learning because they were familiar with the protocol order, anatomical landmarks, and what the required images should look like. Fellow 1 commented, “In the beginning I thought it would be more beneficial to touch the probe and go, but you really need that base and foundation” and Fellow 3 said, “Learning it well has helped me now when I’m on imaging because I feel like I get more scanning time.” This prior

knowledge allowed them to focus on the next steps of image acquisition and diagnosis, which was the desired change in behavior for this research project.

The quantitative data from the pretest and posttest showed a substantial increase in assessment scores and supported the fellow's responses that the pediatric echocardiography protocol learning module was effective. Pretest scores ranged from 46-58%, while posttest scores increased to 82-94%. All three fellows improved their test scores with only one not achieving the 90% goal for the posttest. English is a second language for this fellow and they commented during her interview on how this may have affected her testing performance. The demonstration simulation scores were much higher than the goal of 80%, ranging from 93-97%. Only minor errors were observed, consistent with those made by sonographers with a much higher level of experience. Individual assessment scores by fellow are listed in Table 3.

Table 3

Assessment Scores

	Assessment (Out of 50 Pts.)				Demonstration Simulation (Out of 120 Pts.)	
	Pretest		Posttest			
	Points	%	Points	%	Points	%
Fellow 1	24	48	41	82	115	96
Fellow 2	29	58	46	92	112	93
Fellow 3	23	46	47	94	116	97

The bulk of the survey questions were focused on the effectiveness, appeal, and overall satisfaction with the learning module activities. While quantitative analysis of these answers was also not possible, the distribution of responses is consistent with the previous examples from the interviews. Table 4 shows the breakdown of answers regarding effectiveness by each learning activity (Strongly Agree = most effective, Strongly Disagree = least effective). Face-to-face

lectures again received the highest scores for effectiveness followed by the interactive games and online activities.

Table 4

Effectiveness of Activities, Survey Data

	Total # of Questions	Strongly Agree	Agree	Neither Agree or Disagree	Disagree	Strongly Disagree
Online Activities	12	4	2	6	0	0
Interactive Games	12	8	2	2	0	0
Face-to-Face Lectures	12	12	0	0	0	0

Efficiency

Due to the narrow time frame assigned to the pediatric echocardiography protocol learning module, efficiency was important for success. As previously shown in Table 3, the assessment goals were met at the end of the 10-day module, which was an aggressive goal compared to previous cohorts. There were interview questions that specifically addressed the efficiency of the module and it was also mentioned during interviews on other topics discussed by the fellows.

The benefit of face-to-face interaction was mentioned as the most important theme related to efficiency of the pediatric echocardiography protocol learning module. Numerous comments were made stating that being able to discuss the different components of the module and receive immediate feedback actually solidified learning. This is consistent with findings by Pashler et al. who reported that subjects had a fivefold increase in retention when they were provided immediate feedback regarding errors made during learning lessons (Pashler, Rohrer, Cepeda, & Carpenter, 2007). The fellows explained how efficient the learning was during the interview: Fellow 1, “It’s easier for me to remember things when we are discussing them,”

Fellow 2, “It was really helpful at the beginning of each face-to-face session making one of us talk it through. While you’re waiting for whoever is talking, you are thinking about it yourself too,” and Fellow 3, “I think I would have learned it eventually but I do think it was helpful to have the group learning. I definitely feel like I remember it better than I would have if I would have just tried to go down the list and memorize.” This teaching strategy accelerated the learning process, which translated into a decrease in the amount of independent study time required to learn the material.

Another theme that emerged was that breaking down the material into smaller pieces and using multiple teaching methods contributed to the efficiency of learning the material. Robert Gagné proposed events or steps to include in a systematic instructional design process that share the behaviorist approach to learning. One of these steps is to organize and chunk content in a meaningful way while using a variety of media to address different learning preferences (Gagne, Wager, Golas, Keller, & Russell, 2005). Statements from the fellows included: Fellow 2, “I think it’s easier to master a whole bunch of small things and then put it together at the end,” and Fellow 1, “Everyone is a different learner and I think everyone uses some of the senses in different percentages. With these different modules it attacked all of the senses that someone might use.”

The confidence of success increased during the module and one fellow stated that when they initially received all of the content, they thought it would take a month to master, they ended by saying “but after that first week I felt much more confident.” When asked when they thought the material started to make sense, the fellows all felt they were comfortable with the new material at the end of each face-to-face meeting. There was a general consensus that they

were confident with many aspects of the protocol by the beginning of the second week, with none requiring more than the 10-day module to master the information.

Appeal

According to Reigeluth, in instructional outcomes, the "level of appeal is the extent to which the learners enjoy the instruction" (Reigeluth, 1999, p. 10). Consistent with the previous findings, the face-to-face lectures were considered the most appealing component of the learning module.

The use of multiple learning methods was mentioned frequently as a valuable aspect of the learning module. Repetition through various activities helped with retention and understanding while making the learning more appealing. Comments included statements such as, "It was repetitive but not repetitive in the same way each time" or "repetition in different ways so it didn't make it as boring." There were also many comments regarding the value of group work and how this was an unexpected benefit. The fellows enjoyed having a group learning experience as this allowed them to learn from their peers, compare learning techniques, and create a sense of community. Fellow 2 stated, "I really did like that it was done in a group, otherwise we are on rotation on our own." The survey data in Table 5 lists the responses regarding appeal of each learning component (Strongly Agree = most appealing, Strongly Disagree = least appealing).

Table 5

Appeal of Activities, Survey Data

	Total # of Questions	Strongly Agree	Agree	Neither Agree or Disagree	Disagree	Strongly Disagree
Online Activities	12	5	2	4	1	0
Interactive Games	12	6	4	2	0	0
Face-to-Face Lectures	12	12	0	0	0	0

The interactive games were also very appealing and the friendly competition was motivating. The fellows indicated that they would have liked to have played more games. Flashcards were used for many gaming activities including matching, ordering, and quizzing. Even though interaction was favored, the flashcards were also an appealing tool used by each of the fellows, whether in class or at home. One limitation with the online activities was the inability to order the entire protocol in one screen. This activity could be supplemented with additional sets of cards containing the entire protocol order. Learners could also start with smaller sections of the protocol online and work towards sorting the entire flashcard deck as the final goal.

Even though the online activities were not perceived as the most effective learning method, one fellow was surprised at how appealing they were. This fellow initially did not want to try the activities because they are not something they would consider due to lack of time; however, once they tried them they said, “Oh, that’s cool, I should have tried that earlier.”

They also agreed that individual preferences were often consistent with their VARK® analysis scores. The scores in Table 6 represent each mode of learning by fellow: visual, aural, read/write, and kinesthetic; with the higher scores representing preferred modes of learning. Based on these scores and feedback from the fellows, designing educational activities for various

learning preferences provided more opportunities for repetition and reinforcement while ensuring there was a preferred mode of learning available for each participant.

Table 6

VARK® Analysis Results by Fellow

	Visual	Aural	Read/Write	Kinesthetic
Fellow 1	0	12	1	15
Fellow 2	8	2	6	8
Fellow 3	9	3	7	6

Overall, the comments regarding the pediatric echocardiography protocol learning module were favorable and the participants liked the experience. None of the participants thought they would have been as successful without completing the learning module. Fellow 3 reported receiving feedback from the cardiologists regarding their progress, "They feel like the three of us have done more echos already than in previous years. I think that comes from being confident in what the protocol is, because if we didn't know it then I think [sonographers] wouldn't let us do as much." In addition, the sonographers were impressed with the knowledge that the fellows had gained in such a short time. Both fellows and sonographers felt this accelerated the learning process in the scanning lab as fellows were more able to effectively communicate their learning needs in order to streamline the hands-on learning process and focus on scanning skills instead of protocol learning.

Discussion and Implications

The results of this evaluation demonstrated the effectiveness, efficiency, and appeal of a new pediatric echocardiography protocol training module for first year cardiology fellows. By the end of the module, the fellows were able to demonstrate mastery of the protocol through the protocol demonstration observation and scored much higher than expected on posttests and

demonstrations. They also began applying their knowledge in real-time scanning situations. Unlike other published studies, this learning module focused on the underlying knowledge needed to successfully and efficiently learn the hands-on skill of pediatric echocardiography. While this is only a portion of the knowledge and skills needed to adequately perform and interpret pediatric echocardiograms, the goal was to help them achieve a depth of understanding of the pediatric echocardiography protocol that would directly impact the amount of time needed to successfully perform unsupervised echocardiograms. Other "boot camp" models have included didactic learning and hands-on scanning condensed into 3 full days but required significant resources including multiple medical staff members and more than 50 patient volunteers (Maskatia et al., 2013). Education on that scale is difficult to coordinate and hard to justify in smaller programs. The ability to perpetuate a program of that scope in a smaller program is also questionable. The program Midwestern Hospital was unique in that a learning module focused on the pediatric echocardiography protocol, incorporating multiple learning preferences and requiring very few resources, was successfully implemented. Vigorous assessments demonstrated high scores that can be attributed to the effectiveness of the education. Based on the overall success of this research project at Midwestern Hospital, it can be concluded that, when properly developed and delivered, the investment in a short-term learning module is worthwhile. Furthermore, because of the limited resources required to provide the instruction, this program can be reproduced with minimal effort. While the pediatric echocardiography protocol learning module focused primarily on learning the protocol, it is reasonable to assume that this concept could be successfully applied to other aspects of the pediatric fellow echocardiography training as well (e.g., Doppler principles and pathology). The next step of training, which was requested by the cardiology fellows, could be a focused hands-on module

with the instructor. This could be accomplished easily with access to a simulator; however, using live patient models would require a more creative approach and possibly more resources.

An important key to success of the pediatric echocardiography learning module was the use of interactive face-to-face lectures. Consistently mentioned as the most effective, efficient, and appealing component of the module, the fellows were able to complete all of the learning goals during these meetings. Considering that the face-to-face lectures only comprised approximately 20 hours of instruction over the course of 10 days, they were a sound investment of time and resources. More condensed echocardiography training programs have been reported but were focused on emergent diagnosis by non-cardiologists during cardiopulmonary resuscitation and would not be sufficient in the setting of congenital heart disease (Breitkreutz et al., 2009).

Interactive games were an important component of the face-to-face time and were also very appealing to the participants. While appeal is not usually mentioned as a consideration in medical education, interactive and online games were included to increase the motivation of the fellows, which potentially contributed to their success (Kapp, 2012). Use of games has not been previously reported in the literature pertaining to pediatric cardiology training and there is potential for more research in this area.

This study addressed the different learning preferences of the fellows (visual, aural, read/write, and kinesthetic) which has also not been previously reported. Other studies have referenced Kolb's learning styles of diverging, assimilating, converging, and accommodating (Armstrong & Parsa-Parsi, 2005; Maskatia et al., 2013). The use of blended learning was successful in this module as it reinforced concepts and information while including multiple learning preferences. This framework ensured that all of the targeted cognitive processes were

addressed within the instructional design while being effective, efficient, and appealing. Offering instructional activities that appeal to various learning preferences should continue to be considered when developing pediatric cardiology education. This multi-faceted approach helped to optimize the efficiency of learning, which is important to pediatric cardiology programs of all sizes. Although the online activities were less appealing than other components of the learning module, they were valued for reinforcement and practice. Opinions about the online activities seemed to be more preference-based and it is recommended that these activities are included in future modules. The online activities may need modification before the next implementation.

The success of this study provides possible options for filling the gaps in educational programming for pediatric cardiology fellowship programs. By using an effective, efficient, and appealing theoretical frame work, programs can develop short-term learning opportunities relatively easily even with limited resources. A focus on the instructional-design as it relates to the educational goals is recommended, as good instruction relies on careful preparation and planning. Grouping the material into smaller units that are focused on predetermined steps and delivered in the appropriate order, helps learners to effectively organize information and build on prior knowledge. If the goal is for pediatric cardiology fellows to evaluate and create quality pediatric echocardiograms, educational programming should first provide blended learning activities focusing on the steps of remembering, understanding, applying, and analyzing.

Limitations

This study was limited by the small sample size and the findings represent a small group of pediatric cardiology fellows at one site. In order for the findings to be generalizable, a larger study would need to be conducted across multiple institutions.

There were some limitations of online activities, specifically the lack of built-in scaffolding. Easier levels providing correct answers progressing to longer more complex problems would be helpful.

Although initial feedback was positive regarding the scanning progress of the fellows, the next step would be to measure their scanning competence as well. Learning and applying this information was not feasible in the time frame assigned to this project, and another scanning-focused study would need to be completed in order to assess their progress accurately.

Conclusion

The pediatric echocardiography protocol learning module was effective, efficient, and appealing. This blended learning approach to delivery of an education module supports the idea that when properly designed, small programs with limited resources can provide quality education for pediatric cardiology fellows. Future directions of study could include additional topics related to echocardiography such as Doppler principles, ultrasound physics, pathology, and hands-on scanning. In addition, a multi-institution study could help to determine if the module would be effective, efficient, and appealing at other institutions. While this case study was completed in the workplace, potential applications could also include sonographers in higher education programs to compare results when offered in different educational settings with other types of learners.

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Appendix A: Study Information Sheet

MIDWESTERN HOSPITAL

INSTITUTIONAL REVIEW BOARD

We are asking you to take part in a research study being done by Lynne Brown at Midwestern Hospital.

THE EFFECTIVENESS, EFFICIENCY, AND APPEAL OF PEDIATRIC ECHOCARDIOGRAPHY PROTOCOL TRAINING FOR FIRST YEAR CARDIOLOGY FELLOWS

You are being asked to take part in this survey because you are a cardiology fellow beginning the echocardiography rotation. If you choose to be in the study, you will complete a survey and an interview. The survey and interview will help us learn more about how efficient, effective, and appealing you find the pediatric echocardiography learning module. This module will consist of face-to-face lectures, interactive group activities and online learning modules. The survey will take about 20 minutes and the interview will take about 45 minutes to complete.

Participating in this study is optional and voluntary. You do not have to take this survey or be interviewed if you do not want to. The answers that you provide in the survey and interview may still be used if you stop the survey and do not finish. Any question you do not answer will not be collected.

You can skip questions that you do not want to answer or stop the survey or interview at any time. The survey and interview are anonymous, and no one will be able to link your answers back to you. Please do not include your name or other information that could be used to identify you in the survey responses. You must be at least 18 years old to participate in this research survey.

There are no direct benefits to you for taking this survey or participating in the interview. The information learned from this survey will help the researchers learn more about how to effectively provide fellow education in echocardiography.

The survey will be done online using the service Qualtrics. The information that you provide in the survey and interview will not be linked to your computer, email address, or other electronic identifiers. Information provided in this survey can only be kept as secure as any other online communication. The interview will be conducted with the instructor and your responses will be assigned a code number. The responses will be transcribed by the interviewer and stored electronically on an encrypted computer. All hard copies will be stored in a locked cabinet in the interviewer's office and securely destroyed when data analysis is complete.

If you have questions about this survey, contact Lynne Brown at (312)123-4567. If you have any questions about your rights as a research participant, wish to discuss problems, concerns, and

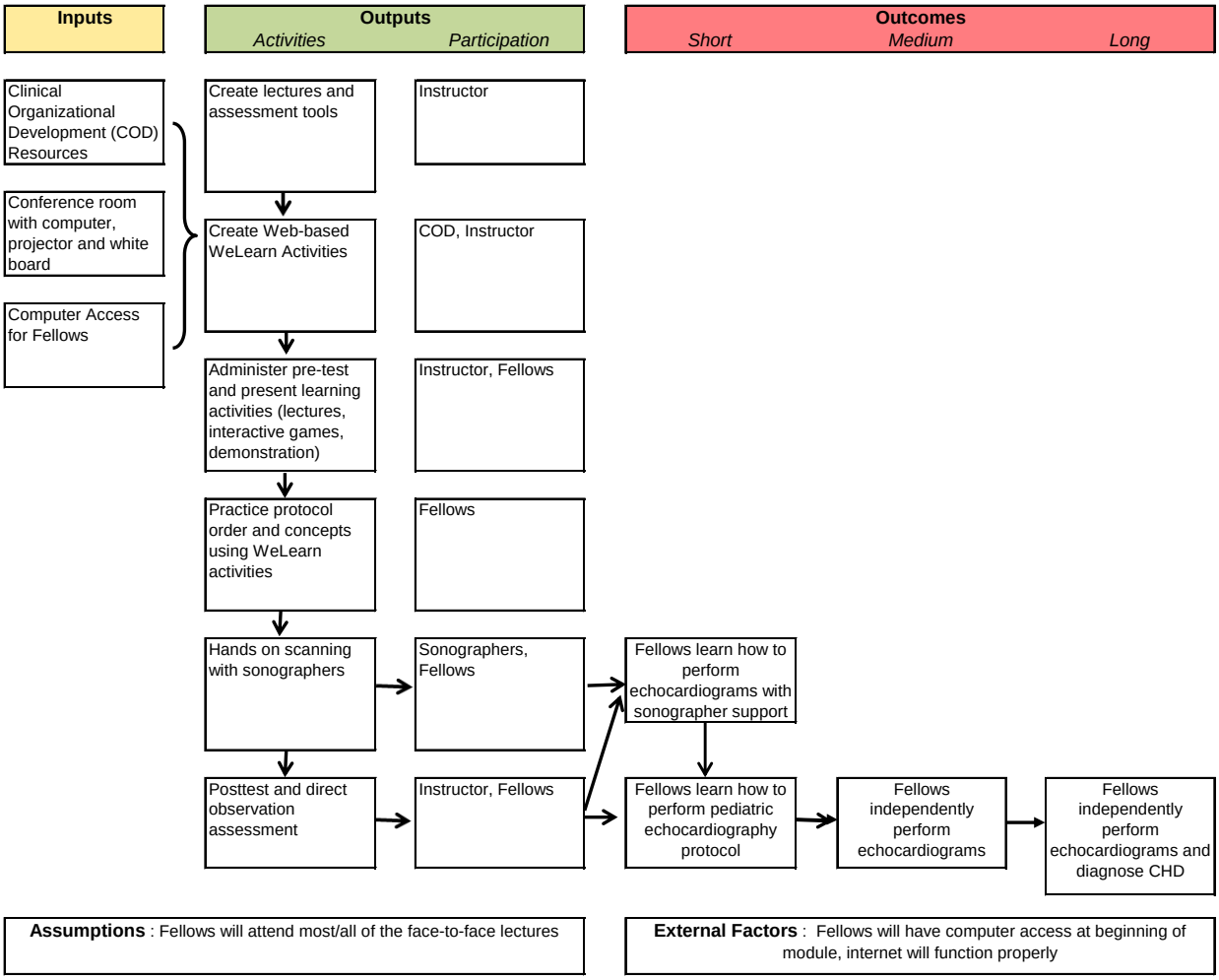
questions, or wish to offer input to someone who is not directly involved with this study, you may contact John Doe, by phone: (123)456-7890 or e-mail: jdoe@midwesternhospital.org.

This study has been reviewed and approved by the Midwestern Hospital's Institutional Review Board (IRB); IRB #XXXX-XXXXX.

You indicate your voluntary agreement to take part in this research study by completing and returning the survey and participating in the interview.

Appendix B: Logic Model

Program: **Echocardiography Training Module Logic Model**
Lynne Brown



Assumptions : Fellows will attend most/all of the face-to-face lectures

External Factors : Fellows will have computer access at beginning of module, internet will function properly

EVALUATION QUESTIONS

How effective Is the pediatric echocardiography protocol learning module?	How efficient Is the pediatric echocardiography protocol learning module?	How appealing Is the pediatric echocardiography protocol learning module?

INDICATORS

% Scale on posttest and direct observation rubric	% Scale on observation rubric, Likert scale from survey information and themes from interviews	Likert scale from survey information and themes from interviews

Appendix C: Demonstration Simulation Observation Rubric

Completion of this assessment requires a simulated demonstration of the pediatric echocardiography protocol. The goal of this assessment is for the student to demonstrate mastery of the protocol and an in-depth understanding of the purpose for each image acquired. The student will demonstrate the complete pediatric echocardiography protocol in order while narrating the views and other descriptive elements as outlined below. A doll or model will be used in place of a patient.

120 points are possible. 96 points (80%) are required to pass the competency. This assessment will be evaluated by the instructor with the rubric found below.

Required views in the correct order:

- Subcostal (coronal, left anterior oblique, sagittal and right anterior oblique)
- Parasternal (long and short axis)
- Apical (Apical 4-ch, 3-ch, 2-ch)
- Suprasternal Notch (coronal, sagittal)
- High Left Parasternal (sagittal)
- High Right Parasternal (sagittal)

During the demonstration narrative, the following descriptive elements will be assessed. Examples of each are included (this is not a comprehensive list):

- View names – subcostal left anterior oblique
- Clips acquired – 2 beat, 6 second
- Marker placement – 4:30 or towards right hip

- Imaging planes – sagittal, coronal
- Orientation of ultrasound beam – sweeping inferior to superior, anterior
- Imaging modalities – 2D, color Doppler, PW Doppler, as well as location of sample gate
- Anatomic references – sweeping from the coronary sinus to the RVOT
- Patient positioning – left lateral decubitus, supine
- Measurements – EF, SF, DTI
- Probe placement on model – sub-xiphoid, left chest, suprasternal notch

Echocardiography Protocol Demonstration Simulation Observation Rubric

	Beginning 0-1	**Developing 2-3**	**Proficient 4-5**	**Accomplished 6-8**	**Score**
Views					
Complete Study	The student did not complete all of the views and they were not in the correct order	The student did not complete all of the views but they were in the correct order	The student completed all of the views but they were not in the correct order	The student completed all of the views and they were in the correct order	
Subcostal View	The student did not complete all of the views and they were not in the correct order	The student did not complete all of the views but they were in the correct order	The student completed all of the views but they were not in the correct order	The student completed all of the views and the majority or all were in the correct order	
Parasternal View	The student did not complete all of the views and they were not in the correct order	The student did not complete all of the views but they were in the correct order	The student completed all of the views but they were not in the correct order	The student completed all of the views and majority or all were in the correct order	
Apical View	The student did not complete all of the views and	The student did not complete all of the views but	The student completed all of the views but	The student completed all of the views and majority or all	

	they were not in the correct order	they were in the correct order	they were not in the correct order	were in the correct order	
Suprasternal Notch View (including ductal view and RPSB)	The student did not complete all of the views and they were not in the correct order	The student did not complete all of the views but they were in the correct order	The student completed all of the views but they were not in the correct order	The student completed all of the views and majority or all were in the correct order	
Total View Score (Max 40)					
	Beginning 0-1	**Developing 2-3**	**Proficient 4-5**	**Accomplished 6-8**	**Score**
Descriptive Elements					
View Names	The student did not use the correct view names	The student used some correct view names	The student used many of the correct view names	The student used most or all of the correct view names	
Clips Acquired	The student did not describe the correct clips to acquire	The student described some of the correct clips to acquire	The student described many of the correct clips to acquire	The student described most or all of the correct clips to acquire	
Marker Placement	The student did not describe and demonstrate the correct marker placements	The student described and demonstrated some of the correct marker placements	The student described and demonstrated many of the correct marker placements	The student described and demonstrated most or all of the correct marker placements	
Imaging Planes	The student did not describe and demonstrate the correct imaging planes	The student described and demonstrated some of the correct imaging planes	The student described and demonstrated many of the correct imaging planes	The student described and demonstrated most or all of the correct imaging planes	
Orientation of Ultrasound Beam	The student did not describe and demonstrate the correct direction of the ultrasound beam	The student described and demonstrated some of the correct directions of the ultrasound beam	The student described and demonstrated many of the correct directions of the ultrasound beam	The student described and demonstrated most or all of the correct directions of the ultrasound beam	
Imaging Modalities (2D, Color or Spectral Doppler)	The student did not describe and demonstrate the correct imaging modalities (2D,	The student described and demonstrated some of the correct imaging	The student described and demonstrated many of the correct imaging	The student described and demonstrated most or all of the correct imaging	

	Color or Spectral Doppler)	modalities (2D, Color or Spectral Doppler)	modalities (2D, Color or Spectral Doppler)	modalities (2D, Color or Spectral Doppler)	
Anatomic References	The student did not describe and demonstrate the correct anatomic references	The student described and demonstrated some of the correct anatomic references	The student described and demonstrated many of the correct anatomic references	The student described and demonstrated most or all of the correct anatomic references	
Patient Positioning	The student did not describe and demonstrate the correct patient position	The student described and demonstrated some of the correct patient positions	The student described and demonstrated many of the correct patient positions	The student described and demonstrated most or all of the correct patient positions	
Measurements	The student did not describe the correct measurements	The student described some of the correct measurements	The student described many of the correct measurements	The student described most or all of the correct measurements	
Probe Placement on Model	The student did not describe and demonstrate the correct probe placement on the model	The student described and demonstrated some of the correct probe placements on the model	The student described and demonstrated many of the correct probe placements on the model	The student described and demonstrated most or all of the correct probe placements on the model	
Total Descriptive Elements Score Max (80 points)					
Total Score Max (120 points) **Pass 80% (96 points)**					

Appendix D: Echocardiography Protocol Learning Module Survey

The purpose of this investigation is to study the effectiveness, efficiency, and appeal of the instructional aids within the echocardiography learning module. Data will be grouped and your comments will not be individually identifiable. Filling out this survey indicates that you are at least 18 years old and are giving your informed consent to be a participant in this study.

The following questions concern the use of the web-based WeLearn activities as a learning tool.

Effectiveness of the web-based WeLearn activities

	Strongly Agree (1)	Agree (2)	Neither Agree nor Disagree (3)	Disagree (4)	Strongly Disagree (5)
The web-based WeLearn activities helped me when practicing the protocol. (1)	❍	❍	❍	❍	❍
The web-based We Learn activities helped me to better understand the protocol. (2)	❍	❍	❍	❍	❍
The web-based WeLearn activities put meaning into the written material (content) for this module. (3)	❍	❍	❍	❍	❍
The web-based learning helped me to better understand the reading materials. (4)	❍	❍	❍	❍	❍

Appeal of the web-based WeLearn activities

	Strongly Agree (1)	Agree (2)	Neither Agree nor Disagree (3)	Disagree (4)	Strongly Disagree (5)
The web-based WeLearn activities were organized by view so that it was easy to search and practice. (5)	❍	❍	❍	❍	❍
The web-based WeLearn activities offered feedback so I knew if my responses were correct or incorrect and if I needed to continue to review. (6)	❍	❍	❍	❍	❍
I was satisfied with the design of the web-based WeLearn activities. (7)	❍	❍	❍	❍	❍

I was satisfied with the look of the web-based WeLearn activities (visual clarity). (8)	❍	❍	❍	❍	❍

Efficiency of the web-based WeLearn activities

Q9 Approximately how many hours did you spend using the web-based WeLearn activities?

Q10 Select the purpose for using the web-based WeLearn activities (select all that apply).
- ❑ Reinforce (1)
- ❑ Clarification (2)
- ❑ Practice (3)
- ❑ Review (4)
- ❑ Retention (5)

Q11 Did you experience technical difficulty when using the web-based WeLearn activities
- ❍ Yes (1)
- ❍ No (2)

Q12 If yes, describe what technical problems you encountered.

General Satisfaction With the Web-based WeLearn Activities

	Strongly Agree (1)	Agree (2)	Neither Agree nor Disagree (3)	Disagree (4)	Strongly Disagree (5)
I liked using the web-based WeLearn activities. (13)	❍	❍	❍	❍	❍
Overall I was satisfied with the web-based WeLearn activities. (14)	❍	❍	❍	❍	❍
Overall I feel I was able to learn the information from the web-based WeLearn activities as well as I would have in a face-to-face class presentation. (15)	❍	❍	❍	❍	❍

The following questions concern the use of interactive games as a learning tool.

Effectiveness of interactive games

	Strongly Agree (1)	Agree (2)	Neither Agree nor Disagree (3)	Disagree (4)	Strongly Disagree (5)
The interactive games helped me when practicing the protocol. (16)	❍	❍	❍	❍	❍
The interactive games helped me to better understand the protocol. (17)	❍	❍	❍	❍	❍
The interactive games put meaning into the written material (content) for this module. (18)	❍	❍	❍	❍	❍
The interactive games helped me to better understand the reading materials. (19)	❍	❍	❍	❍	❍

Appeal of interactive games

	Strongly Agree (1)	Agree (2)	Neither Agree nor Disagree (3)	Disagree (4)	Strongly Disagree (5)
The interactive games were easy to play. (20)	❍	❍	❍	❍	❍
The interactive games included feedback so I knew if my responses were correct or incorrect. (21)	❍	❍	❍	❍	❍
I was satisfied with the design of the interactive games. (22)	❍	❍	❍	❍	❍
The competitive component of the interactive games enhanced learning. (23)	❍	❍	❍	❍	❍

Efficiency of interactive games

Q29 How did the interactive games assist your learning? (select all that apply)
- ❑ Reinforce (1)
- ❑ Clarification (2)
- ❑ Practice (3)
- ❑ Review (4)
- ❑ Retention (5)
- ❑ The interactive games did not assist my learning. (6)

Q30 Do you believe your learning was accelerated through the use of interactive games?
- ❍ Yes (1)
- ❍ No (2)

Q31 Please explain how interactive games did (or did not) accelerate your learning.

General Satisfaction With Interactive Games

	Strongly Agree (1)	Agree (2)	Neither Agree nor Disagree (3)	Disagree (4)	Strongly Disagree (5)
I liked playing the interactive games. (1)	❍	❍	❍	❍	❍
Overall I was satisfied with the interactive games. (2)	❍	❍	❍	❍	❍
Overall I feel I was able to learn the information from the interactive games as well as I would have in a face-to-face class presentation. (3)	❍	❍	❍	❍	❍

The following questions concern the use of face-to-face lectures.

Effectiveness of face-to-face lectures

	Strongly Agree (1)	Agree (2)	Neither Agree nor Disagree (3)	Disagree (4)	Strongly Disagree (5)
The face-to-face lectures helped me learn the protocol. (1)	❍	❍	❍	❍	❍
The face-to-face lectures helped me to better understand the protocol. (2)	❍	❍	❍	❍	❍
The face-to-face lectures put meaning into the written material (content) for this module. (3)	❍	❍	❍	❍	❍
The face-to-face lectures helped me to better understand the reading materials. (4)	❍	❍	❍	❍	❍

Appeal of face-to-face lectures

	Strongly Agree (1)	Agree (2)	Neither Agree nor Disagree (3)	Disagree (4)	Strongly Disagree (5)
The face-to-face lectures were organized so that it was easy to understand the content. (1)	❍	❍	❍	❍	❍
The face-to-face lectures included opportunities for discussion to clarify my understanding. (2)	❍	❍	❍	❍	❍
I was satisfied with the content presented during face-to-face lectures. (3)	❍	❍	❍	❍	❍
I was satisfied with how the content was presented during the face-to-face lectures (4)	❍	❍	❍	❍	❍

Efficiency of face-to-face lectures

Q38 How did the face-to-face lectures assist your learning? (select all that apply)
- ❑ Reinforce (1)
- ❑ Clarification (2)
- ❑ Practice (3)
- ❑ Review (4)
- ❑ Retention (5)
- ❑ The face-to-face lectures did not assist my learning. (6)

Q39 Do you believe your learning was accelerated through the use of face-to-face lectures?
- ❍ Yes (1)
- ❍ No (2)

Q40 Please explain how the face-to-face lectures did (or did not) accelerate your learning.

General Satisfaction With Face-to-Face Lectures

	Strongly Agree (1)	Agree (2)	Neither Agree nor Disagree (3)	Disagree (4)	Strongly Disagree (5)
I liked the face-to-face lectures. (1)	❍	❍	❍	❍	❍
Overall I was satisfied with the face-to-face lectures. (2)	❍	❍	❍	❍	❍
Overall I feel the face-to-face lectures contributed to learning the protocol. (3)	❍	❍	❍	❍	❍

General Satisfaction With Learning Module

	Strongly Agree (1)	Agree (2)	Neither Agree nor Disagree (3)	Disagree (4)	Strongly Disagree (5)
Overall I was satisfied with the learning module as a whole. (1)	❍	❍	❍	❍	❍
Overall I feel the learning module contributed to learning the protocol. (2)	❍	❍	❍	❍	❍

Appendix E: Interview Protocol

Project: Cardiology Fellow Echocardiography Protocol Learning Module

Time of Interview:
Date:
Place:
Interviewer:
Interviewee:

"The purpose of this study is to collect information from cardiology fellows who have completed the pediatric echocardiography protocol learning module at Midwestern Hospital. The data from this interview will be collected, transcribed, and stored electronically on a password protected computer. The original interview forms and audio recordings will be stored in a locked cabinet in the interviewer's office and destroyed after data collection and analysis are completed. To increase confidentiality, you have been assigned a code name for this interview. This interview will take approximately 45 minutes to complete. Do you have any additional questions regarding the interview?"

Questions in the first section are related to the effectiveness of the protocol learning module.

1. Explain how the face-to-face lectures contributed to your learning.

2. Explain how the interactive games contributed to your learning.

3. Explain how the online *WeLearn* activities contributed to your learning.

4. Please explain how combining multiple activities in the learning module helped you to learn the protocol.

5. Which of the learning activities were most useful to you when learning the protocol? (*WeLearn*, lectures, and games)

6. Which of the learning activities were the least useful to you when learning the protocol? (*WeLearn*, lectures, and games)

7. Do you think you would have been as successful learning the protocol without the learning module? Why?

8. Please describe your performance during the demonstration simulation? Did you learn the pediatric echocardiography protocol?

Questions in the second section are related to the efficiency of the protocol learning module.

9. Please explain how the use of multiple learning aids (*WeLearn*, lectures, and games) contributed to the efficiency of the learning module. (How they reduced the time needed to learn.)

10. Which of the learning aids (*WeLearn*, lectures, games) was the most efficient way for you to learn the protocol? Why?

11. How does this align with your VARK® analysis results?

12. Please describe the point at which the protocol started to make sense. Was it early or late in the process?

13. Did you require more time to learn the protocol? Why?

Questions in the third section relate to the appeal of the protocol learning module.

14. Did you like participating in the protocol learning module?

15. What were your favorite learning activities (*WeLearn*, lectures, games)? Please be specific.

16. Which activities were not appealing? Why?

17. How does this align with your VARK® analysis results?

Questions in the fourth section relate to the protocol learning module activities in general.

18. How would you improve the *WeLearn* activities? Interactive games? Face-to-face lectures?

19. Do you have any additional thoughts regarding the learning module that you would like to share?

Appendix F: VARK® Questionnaire Sample

The VARK Questionnaire (Version 7.8)

How Do I Learn Best?

Choose the answer which best explains your preference and circle the letter(s) next to it. **Please circle more than one** if a single answer does not match your perception.
Leave blank any question that does not apply.

1. You are helping someone who wants to go to your airport, the center of town or railway station. You would:
   V. draw, or show her a map, or give her a map.
   A. tell her the directions.
   R. write down the directions.
   K. go with her.

2. A website has a video showing how to make a special graph. There is a person speaking, some lists and words describing what to do and some diagrams. You would learn most from:
   V. seeing the diagrams.
   A. listening.
   R. reading the words.
   K. watching the actions.

3. You are planning a vacation or long holiday for others. You want some feedback from them about the plan. You would:
   V. use a map to show them the places.
   A. phone, text or email them.
   R. give them a copy of the printed itinerary.
   K. describe some of the highlights they will experience.

4. You are going to cook something as a special treat. You would:
   V. look on the Internet or in some cookbooks for ideas from the pictures.
   A. ask friends for suggestions.
   R. use a recipe.
   K. cook something you know without the need for instructions.

5. Some visitors want to learn about historical sites in your area. You would:
   V. show them maps and internet pictures.
   A. talk about, or arrange a talk for them about historical sites.
   R. give them a book or pamphlets about historical sites.
   K take them to an historical site and walk with them.

6. You are about to buy a mobile phone. Other than price, what would most influence your decision?
   V. It is a modern design and looks good.
   A. The salesperson telling me about its features.
   R. Reading the details or about its features.
   K. Trying or testing it.

7. Remember a time when you learned how to do something new. Avoid choosing a physical skill, e.g. riding a bicycle. You learned best by:
   V. diagrams, maps, and charts - visual clues.
   A. listening to somebody explaining it and asking questions.
   R. written instructions – e.g. a manual or book.
   K. watching a demonstration or an example.

8. You have a problem with your heart. You would prefer that the doctor:
   V. showed you a diagram of what was wrong.
   A. described what was wrong.
   R. gave you a something to read to explain what was wrong.
   K. used a plastic model to show what was wrong.