Obstetric and Gynecologic Ultrasound Training at the Uganda Nursing School Bwindi: Initial Experiences and Challenges

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***Abstract* — For many years, clinical ultrasound has dramatically improved patient care in industrialized countries. However, millions of people in low-resource geographies remain today without access to this life-saving diagnostic and treatment tool.**

Over the last five years, Imaging the World (ITW) has successfully incorporated obstetric ultrasound examination into routine antenatal care at lower level health clinics in rural Uganda by training health workers to perform high-quality, point-of-care ultrasound. The result: high-risk pregnancies are detected early and patients are directed for appropriate referral and treatment, thus improving outcomes for women, their babies and their families.

To build on ITW's success and quickly and efficiently increase the number of trained ultrasonographers, ITW has introduced an obstetric and gynecologic ultrasound training curriculum into the three-year nursing program at the Uganda Nursing School Bwindi (UNSB) in rural Uganda. This innovative addition to nursing education includes hands-on and online components that will enable graduate UNSB nursing students to perform obstetric and gynecological ultrasound examinations.

In this paper, ITW describes the design and implementation of the inaugural curriculum, including challenges encountered and solutions found. ITW also provides data concerning student participation, knowledge acquisition, and curriculum assessment. ITW believes its innovative ultrasound training curriculum, offered in association with a regional nursing school, provides a replicable model for enhancing health worker skills and improving patient outcomes in underserved communities around the world.

Keywords—ultrasound training, medical imaging, nursing education, obstetrics, gynecology

I. INTRODUCTION

The lack of medical imaging due to the shortage of specialized health care workers in resource-limited areas remains a significant barrier to improving public health. Uganda is one country deeply affected by the lack of accessible, high-quality health care. The rate of maternal mortality-related to childbirth is 438 deaths per 100,000 births [1]. Maternal death rates are highest in rural Uganda, where the shortage of health care workers is most significant. Sadly, many of the conditions women die of during pregnancy and childbirth could be ameliorated if women had better access to health care – especially if ultrasound were readily available.

ITW's mission is to integrate technology, training, and community outreach to bring medical expertise and high quality health care to remote and underserved areas worldwide. Due to the lack of available, advanced imaging technology, rural populations suffer needlessly. Without early diagnosis, many treatable diseases, especially maternal conditions, can quickly become critical, resulting in death or injury. ITW seeks to reduce maternal mortality by introducing ultrasound into the practices of Ugandan nurses [2]. These ITW-trained workers use ultrasound to identify high-risk pregnancies and refer them for management, treatment, and attended births with skilled practitioners [3]. An added benefit is that, in clinics where ultrasound has been introduced, antenatal visits have increased by 70 percent. This has resulted in the identification and treatment of comorbidities such as malaria, HIV, parasites, tetanus, and anemia [4].

To build on ITW's past successes, a partnership with Bwindi Community Hospital (BCH) and UNSB was developed in 2011. This collaboration will allow a greater number of nurses to be trained in obstetric and gynecologic ultrasound and is unique in the duration of training provided [5-7]. Furthermore, graduates of UNSB sign an agreement to practice in rural Uganda for three years, ensuring the ultrasound skills taught will be used in the areas of highest need. The nursing school program is of three years duration and results in a Registered Nurse (RN) equivalent degree. The training allows the nurses to serve on the frontline in the rural health facilities initiating care and treatment including the care of women during pregnancy and childbirth.

II. Materials and Methods

A. Selecting a training partner

UNSB and BCH aim to be "outstanding institutions in health care training to solve health challenges in the community". Their goals are closely aligned with ITW's mission of "integrating technology, training, and community to bring medical expertise and high-quality health care to remote and under-served areas". It was a logical choice to partner with BCH and UNSB.

BCH serves 100,000 people in the Kanungu District, delivering over 120 babies each month [5]. The Uganda Protestant Medical Bureau has recognized BCH as the best performing hospital in Uganda for the past five years [6]. In 2011, the hospital won the prestigious Health Impact Award for the Africa and Middle East region from the STARS Foundation (UK) [7].

UNSB was created through the collaborative efforts of a U.S./Ugandan team consisting of major donors James D. Jameson and Stephen M. Wolf, Dr. Scott Kellermann, the UNSB/BCH management team, the Kellermann Foundation, and Rotary International. Nurses trained at UNSB will be able to work independently throughout this remote region, greatly improving health care to a large, desperately underserved population in one of the poorest corners of Africa. UNSB is the only RN-level nursing school for a population of nearly one million people. UNSB graduates are crucial to changing health care in this isolated region.

The ultrasound program complements the existing curriculum at UNSB. Permissions were received from all the stakeholders prior to initiating the ultrasound program. The program was also approved by the Uganda National Council for Higher Education and by the Board of Governors at BCH/UNSB. ITW serves as an implementing partner.

B. Deciding on a curriculum.

Both written knowledge and hands-on knowledge is needed to perform and interpret ultrasound. The planned curriculum mirrors that of diagnostic radiology residency training in ultrasound in the U.S. ITW decided to use the wealth of learning resources currently online for the written knowledge component. This removed the need for local expertise to teach the material and proctor examinations, which could take months if not years to establish. ITW collaborated with the chief nursing officer and registrar of BCH. Both individuals played a critical role in preparation of the online course by providing a framework for implementation as well as logistic guidance. Ultimately, ITW's goal is to move course directorship fulltime to Bwindi once the program becomes well-established..

Through private funding, UNSB provides the students with Internet access, tablet computers, and a library with desktop computers. To allow for a central repository for course materials and a tool for administering and recording exams, ITW chose an online course platform. ITW members met with individuals affiliated with higher education in the United States who had expertise in online course platforms and also individuals in the University of Vermont information technology (IT) department. With permission, ITW ultimately chose to use the university's online course platform in order to minimize start-up costs, ensure online safety, protect material on the website, and have 24/7 IT support. ITW received permission to use video lectures already available online from the group that produced them.

ITW planned the implementation of the ultrasound course to coincide with a scheduled trip to Bwindi. Four radiology experts from the USA, as well as one instructor, an ITW administrator and an IT specialist from Uganda traveled to Bwindi. The instructors met the students, introduced the syllabus, and held a session to teach students how to access the course website, log in, and locate the required learning materials. Students took a mock test to ensure they understood how to open an online test, answer questions, and submit a completed exam. In addition, ITW delivered lectures and provided an introduction to hands-on scanning with an ultrasound device.

Since the students were more familiar with personal email services, ITW chose not to use the online course message platform. Students were instructed to communicate via email given time differences and student scheduling issues. If they wished to talk using FaceTime or Skype with an instructor an appointment could be scheduled.

ITW posted a 10-15 minute video and a quiz each week on the course website. Videos for the first semester addressed the fundamentals of ultrasound, including physics. Students could watch the videos unlimited times. Each quiz included 5 to 10 multiple-choice or true/false questions. All material from previous weeks could be tested on subsequent exams. Using the honor code, ITW asked students not to use assistive materials and established a 60-minute, one-session time limit (unless technology issues arose).

Four times during the first semester, a Ugandan sonographer was on-site to demonstrate applied practical aspects of ultrasound physics by scanning volunteer patients. Students were able to practice "knobology" techniques, the use of manually changing parameters to optimize image quality, while doing ultrasound scanning themselves. Subject content addressed in the online component of the course was reinforced during the sonography labs.

ITW administered a final examination online that covered all online material as well as the ultrasound lab component. Students had three days to complete the exam. The final exam included 30 multiple-choice and true/false questions chosen by instructors and the Ugandan sonographer.

ITW administered two end-of-semester surveys. One focused on the sonographer and the sonography labs and the other on the online component. ITW followed previously published examples of student surveys using a Likert Scale, but made changes to better reflect the unique aspects of the ultrasound curriculum. In addition, the online component survey included a section for students to comment on their greatest challenges.

III. RESULTS

A. First week and site visit

During the two-day curriculum initiation, ITW engaged with the students and USNB administrators. For the inaugural class, 22 students were enrolled (6 female, 16 male). The students were 18 to 26 years old, many traveling hundreds of kilometers to attend school. This was their first experience with any online education.

For the initial sign-on session, immediate support was available from ITW's IT staff. The team was able to troubleshoot Internet issues. Most students had not password-protected their tablets and were unfamiliar with logging onto a secure site. The team spent the first morning assisting students with usernames and passwords. Two students were unable to login that day, but were able to reset their passwords overnight.

Once students were able to log on, ITW created a test environment to assure they could access quizzes. Initially, only two students could view and complete the quiz. Others could view quizzes but could not select answer choices. After consulting with IT support, it was determined that the online course tool did not interface well with the tablets; students with newer software versions had difficulty with access and this could not be corrected by the IT support team. As a result, the students were instructed to take quizzes on the library desktop computers. This solution also provided a hard-wired Internet connection that was more stable.

The school's assigned classroom had interactive whiteboard technology, although the room arrangement was challenging due to cord and plug placement. During the initial site visit, the team delivered lectures on "Professional Ethics," "Basic Physics of Ultrasound," and "Introduction to Anatomic Radiology Positions and Clinical Terms." It was evident by their cogent questions and articulate discussion that students had reviewed the information provided prior to the start of the semester.

On day two, additional classroom time was spent answering questions about the online component. Students were also introduced to the hands-on lab. Several consenting, volunteer pregnant patients were scanned to build on the information learned in the classroom. Students reported they were favorably impressed with the technology and were eager to begin training.

At the end of the on-site initiation, each student was able to access the online course and take quizzes and exams on USNB's library desktops.

B. Challenges and Solutions During the Semester

ITW originally planned to allow students to independently view videos and then complete quizzes; however, delays in completion of assigned tasks quickly occurred as a result of frequent Internet outages that reported to be related to the rainy season. Consequently, some students could not complete assigned tasks, leading to a dichotomy within the class: those who were lucky to complete assignments and those unlucky due to weather issues. ITW sought the advice of the UNSB registrar, who suggested having the class view the videos together at an assigned time when the network was available. A weekly group video screening on Thursday nights was started. This allowed students to complete their assignment at the same time and decreased delays in progressing through the curriculum. Although occasional brief delays continued, the problem was essentially ameliorated.

During the semester ITW received 28 student emails – all concerning the online component. Nine emails related to power issues during test taking. Six requested that quizzes be reset due to issues other than power failures, namely students accidently selecting save final instead of just save. There were two emails asking for instructions on how to reset a password and two requesting additional material be provided to supplement the videos. Only one email asked for clarification on a specific topic (the Doppler effect). The remaining emails included one student indicating he was now able to take a quiz, one student appreciating our efforts, and one expressing problems viewing videos due to power issues. Duplicate emails accounted for the other five emails received.

Three of the students requested a FaceTime appointment with a U.S. instructor, but only one answered the FaceTime initiation request at the scheduled time. That student requested help with the online platform, but electrical power was out at the call time. A follow-up call was scheduled but the student did not answer the request.

During the first semester, ITW administered six quizzes. All students achieved a passing cumulative grade (>80 percent). Only one student failed to complete a weekly quiz by the due date. The school registrar confirmed with the student that their password was forgotten leading to a failure to complete the quiz. With instructions on how to reset the password, the student completed the remainder of the semester successfully without further issues. A summary of our first semester accomplishments is included in table 1.

Table 1: Semester One Accomplishments

Three-day on-site visit (hands-on assistance for initial online course login, four lectures, one sonography lab)
Four on-site days of sonography labs providing by ITW Ugandan sonographer
Six online videos
Six online quizzes
Final exam

Table 2: Sonographer Survey Results

All Strongly Agreed or Agreed
The sonographer clearly answers my questions.
Overall, the sonography labs are an effective learning tool.
The sonography labs address important topics.
13 of 14 Strongly Agreed or Agreed
The sonographer demonstrates adequate knowledge on the topic.
The sonographer is enthusiastic about the topic and the students.
The sonographer creates a learning environment that is open to questions by the students.
Overall, the sonography labs enhance my knowledge.
The sonographer treats each student with respect.

C. Final exam

ITW received no emails during the first two days the final exam was posted. On the final day, 10 emails were received. Two students reported they had pressed "save" and filed their incomplete exam accidently (one sent four emails stating the same problem), one student was concerned answers were not saved, three said they could view only some or none of the questions, and one student had problems locating the exam on the website. All emails sent on the last day of scheduled exam were answered within five hours (average reply time of 85 minutes) of being sent, allowing all students to complete the final exam on time.

All students achieved a passing grade on the final exam (>80 percent) and all final semester grades were above passing (>80 percent). There was no difference in the percent of questions answered correctly when comparing questions submitted by the ITW sonographer to those submitted by U.S. online course instructors.

Table 3: Online Component Survey Results

All Strongly Agreed or Agreed
It has been easy to take the course online.
Quiz and exam instructions are easy to read and follow.
My learning has been enhanced by an online course.
The online course is well organized and it is easy to find the topic/assignment I am looking for.
The amount of time provided to take the quizzes is adequate.
The number of questions on each exam is adequate to demonstrate my level of knowledge
It is easy to communicate with the course instructors.
Emails sent to the course account are answered in a timely manner.
Questions, whether via email or in person, are answered fully and appropriately
At least 12 of 14 Strongly Agreed or Agreed
Overall, the quizzes are an effective learning tool.
The questions on the quizzes reflect the material from the videos.
The course syllabus reflects the material in the videos.
Overall, the online course is an effective learning tool.
10 or 11 of 14 Strongly Agreed or Agreed
I prefer an online course for lectures and tests compared to textbooks and written exams.
< 10 of 14 Stronly Agreed or Agreed
The online course is easy to log in and access.
The weekly video sound quality is clear and understandable.
The information presented in the videos is important to the understanding and practice of ultrasound.
The videos are an effective learning material.
The questions on the quizzes are of appropriate difficulty.

D. Surveys

Fourteen students responded to the survey about the sonography lab (Table 2). Overall, the results were positive, with the exception of the time allotment for the on-site training, which only 9 of 14 students felt was adequate. Comments elicited from the sonography lab survey discussed the need for more hands-on training and formal lectures with the sonographer. 11 students provided written; seven referred to the online component; two requested more time with the sonographer; and two thanked the team.

Fourteen students completed the survey about the online course (Table 3).

Students indicated that the most challenging aspects of the online course were Internet availability, making unintended errors on exams, and watching the videos. Difficulty watching the videos due to the speed of the speaker was the most commonly cited challenge. Students provided comments on the online component, most addressing the videos (Table 4).

Table 4: End-of-semester Survey Comments

Accents on videos are difficult to understand.
Course accessibility is limited given requirement for internet access.
Pass mark is set too high.
The online videos should be supplemented with written material and/or transcript of the video.
More in person time with the course instructors is desirable.
Online course can be difficult to use. It is too easy to make a wrong selection given the webpage format.

IV. Discussion

ITW completed the design and implementation of the first semester of our integrated training program in obstetrical and gynecologic ultrasound at UNSB. Our experience and feedback will act as a guide for continued improvement of the course (Table 5).

A. Technology related improvements

The most significant issue ITW encountered during the first semester related to use of the Internet and the online component. In the future, much of the need for consistent electrical power and Internet access will be mitigated by delivering learning materials in formats that can be downloaded onto tablets when power is available and then accessed at another time. In addition, compatibility issues represent other technologic challenges we will face as our program continues. We are currently looking into other online course platforms which might be more compatible with the students` current tablets versus whether a different type of tablet would allow us more flexibility in the type of course content we provide.

B. User-related improvements

Students were least satisfied with the stock online videos, citing difficulties with the fast pace, unfamiliar accents and new vocabulaity terms. To address this, ITW is developing our own instructional videos and other online learning tools. When possible, Ugandan sonographers will record the videos. A script of each video will be accessible for students. Additional, supplemental reading to aid video comprehension will be provided. Some dissatisfaction with the videos may be related to the inability to ask for clarification in real time. When questions arose, the students preferred to ask our Ugandan sonographer for concept

clarification. We hope that students will begin emailing concept questions, but we understand the limitations of written correspondance compared to a face to face interaction.

When a student contacted ITW with a question or problem and they were offered a choice of FaceTime or Skype appointment times with a U.S. instructor, only once was a student available at the agreed time. An effort will be made to sensitize students to the idea of making and keeping appointments with instructors. Additional instruction in the use of FaceTime and Skype will also be given during the second semester. Additional Ugandan sonographers participating in subsequent training should allow for more effective communications and learning.

Our experience during the first semester highlighted the need to provide more training to students on how to access online courses, use passwords, and develop other skills needed to navigate online materials. We plan to dedicate more time early on helping students develop the tools needed for logistical participation in an online course.

C. Curriculum-related improvements

Students' experiences with the sonographer and sonography labs were very positive; students felt that more hands-on sessions would greatly improve their education. For the second semester, we have scheduled on site labs every other week. There will also be hands-on ultrasound outreach experiences whereby students will accompany sonographers to rural clinics in the catchment area.

One of our greatest challenges will be transitioning knowledge obtained from the online course into clinical skills. We are in the process of developing clinical vigenttes to teach algorithms of care. These vignettes will create situations that students may encouter, for example, a patient with first trimester bleeding. Instructors for the vignettes will walk the student through the next steps in care of the phantom patient. To assess development of these skills, Observed Structed Clinical Examinations (OSCEs) will be adminsistered to students.

Despite the challenges, all of the students were able to successfully learn the online material as evidenced by their examination scores and on-site assessments. ITW believes this innovative ultrasound-training curriculum, offered in association with a regional nursing school, provides a replicable model for enhancing health worker skills. Certainly, ITW must learn from this early experience, make changes, and incorporate best practices in order to create a sustainable program - one that might be disseminated to other rural nursing schools to expand service and improve patient outcomes in underserved communities.

V. Acknowledgments

Imaging the World Africa, UNSB students and Mereth Murezi, Registrar UNSB

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	Table 5: Action Plan for Continued Improvement			
	Challenge	***Solution***	***Action Plan***	***Assessment***
Technology -related	Internet accessibility	Less reliance on a functioning network	Increase course content that can be downloaded onto tablets	Continue student surveys as changes are made
	Tablet compatibility with online course	Find more compatible online course platform	Consider changing tablets or assess which online platform is most compatible with current tablets	Continue student surveys as changes are made
User-related	Accents on videos	Increase student ability to understand videos	Provide transcripts of videos Create videos with native speaker and/or slower speech	Continue student surveys and analysis of test score changes
	Password use	Teach students about passwords and basic computer/ Internet literacy	Develop introductory lectures that address password use, resetting passwords, and security	Query number of emails for password changes/issues received per semester
	Problems using online platform	Teach students how to use online program	Conduct new hands-on labs to help students navigate online course	Monitor user issue correspondence with incident "tickets"
	Communi-cating with course instructors abroad	Build personal relationships; education	Emphasize course instructors' availability via email, phone or Skpye/FaceTime	Monitor email correspondence, student participation in Skype/FaceTime
Curriculum - related	Limited sonography lab time	Increase accessibility to ultrasound hands-on teaching	Increase number of sonographers and number of visits to UNSB. Require students to rotate at local health care facilities with ITW-trained sonographers	Measure sonography lab time per semester Require students to log performed exams
	Translation of classroom knowledge to practice performance	Develop learning tools and testing which models "real life" ultrasound scenarios	Design interactive sessions which teach students patient assessment, appropriate use of ultrasound and clinical decision-making	Assess student abilities through OSCEs