Cardiac Sonography:

Basics of Imaging

[redacted]

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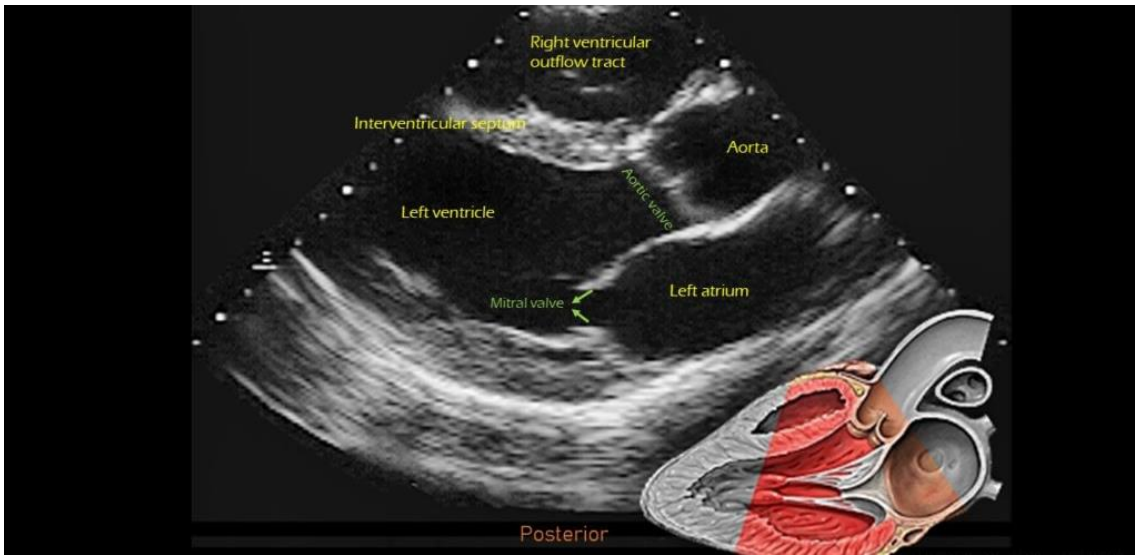
Zach Larson

Acknowledgments

Thanks to my wife Sara for her unwavering support and encouragement.

Also, thanks to my first co-worker and friend, Barry Ptak. I would not be half the sonographer I am without your training and expertise.



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1. GOAL STATEMENT

The goal of this learning module is to increase the scanning proficiency of third year (junior) cardiac sonography students. As third year students begin their clinical rotations, they must perform exams to the standard guidelines to meet the recommendations of The American Society of Echocardiography to create continuity among serial exams, distinguish normal cardiac structures, and identify pathology. When starting clinical rotations, students may be subject to non-standardized practices from their preceptors. With the assistance of instructional lecture and gamified content, students will be able to identify correct scanning windows and optimize images to the highest quality. In doing so, students will significantly improve their outlook on their future cardiac sonography career.

2. NEEDS ANALYSIS

Subject and Concept Area:

Subject: Cardiac sonography

Concept: Scanning proficiency

Gap, Problem, or Learning Need

Current Practice	Desired Result: Ideal Practice	Performance Gap/Educational Need	This is a Gap in:	Learning Objective	Designed to Change
The inability to capably image in the correct scanning window for the parasternal and apical view.	Better alignment of parasternal windows so the heart is not viewed from windows that are too posterior or anterior. Better alignment of apical windows so the heart is not foreshortened or viewed too medially or laterally.	Awareness that scanning in the wrong window can over or underestimate measurements and may not visualize critical findings. Scanning in the correct window creates continuity among serial echocardiograms and allows consistent interpretation of findings.	✓ Knowledge ✓ Competence ✓ Performance	Recognize correct scanning windows so measurements are accurate, common structures are identified, and findings are not missed.	✓ Competence ✓ Performance ✓ Patient Outcomes
The inability to adequately manipulate ultrasound machine settings to optimize images to their highest quality.	Increased use of machine settings such as depth, sector width, zoom, and more to maximize frame rate for image quality.	Awareness that assessing cardiac structure and hemodynamics in a suboptimal frame rate setting will lead to visual distortion and aliasing causing a misinterpretation of findings.	✓ Knowledge ✓ Competence ✓ Performance	Utilize multiple machine settings to optimize frame rate and image quality.	✓ Competence ✓ Performance ✓ Patient Outcomes
The inability to acceptably manipulate the ultrasound transducer to visualize cardiac structures on	Distinguishing cardiac anatomy on the correct axis by rotating, swinging, sliding, and pulling the transducer in	Understanding directional movement of the transducer, transducer head, and transducer tail to appropriately image cardiac	✓ Knowledge ✓ Competence ✓ Performance	Recognize how manipulating movements of the transducer affect the correctness of the scanning window.	✓ Competence ✓ Performance ✓ Patient Outcomes

the correct axis.	the correct position.	structures on-axis.			

Resources:

1. **Professional or specialty society guidelines (Competence and Performance)**
   a. *Guidelines for Performing a Comprehensive Transthoracic ...*, www.asecho.org/wp-ontent/uploads/2018/10/Guidelines-for-Performing-a-Comprehensive-Transthoracic-Echocardiographic-Examination-in-Adults.pdf.
      i. The American Society of Echocardiography recommendations for performing a comprehensive transthoracic echocardiogram.
2. **Quality improvement/risk management /audit data (Competence and Performance)**
   a. "How to Obtain High-Quality Echocardiographic Images." *Executive Electrocardiogram Education*, 21 June 2023, www.ecgedu.com/high-quality-echocardiographic-images/.
      i. Techniques for improving the quality of echocardiography images.

Proposed Solution

The goal of this module will be to instill a high level and quality of scanning proficiency in students early in their sonography education. In doing so, students will gain concrete scanning skills including correct window recognition, image optimization, ultrasound machine competency, transducer dexterity, and critical thinking.

Delivery Format

Blended – More complicated content such as explaining ultrasound machine functions will need to be performed in-person. Formative assessments and recorded lectures can be accessed online in the student portal.

Enrollments and Users

Enrollment size of cardiac ultrasound students at the University of Iowa ranges from 8-10 students per class.

Module Length

During week 1 of a 15-week semester. Every fall for incoming junior sonography students.

Degree of Distribution

Local – Within the Radiation Sciences program at the University of Iowa.

Module Design Timeframe

The timeframe of module design should be relatively quick. Design will take place over the summer leading up to fall semester for incoming junior students. Having a high level of familiarity with the Microsoft suite, PACS systems, and Gimkit, the development should not take no longer than two weeks. The remainder of the summer will be used to have the design approved by the Radiation Sciences Director and to have the module tested.

Level of Human Resources

Having 14 years of sonography experience, I will be the subject-matter expert and will develop the content by myself. Described previously, I have a high level of familiarity with the tools to develop the content.

Instructional Delivery Resources

Licensing for Microsoft Suite, a PACS system, and Gimkit will be required to deliver the content. Students will need access to a computer and internet connection to access the content delivered online.

Budget

Budget cost will be minimal for personal wages, considering the time to create module content by myself should take roughly three to four hours total. The university and university hospital should already have licenses through Microsoft and a PACS system to build lecture material. The largest cost would be purchasing a departmental license through Gimkit to build gamified learning assessments ($650).

Usability Testing

Usability should be medium to high after first implementation. The content is designed to be easy to use and straightforward. The ‘Think Aloud Protocol’ will be used to test the lecture content while the ‘Hallway Testing’ will be used to test the gamified content.

Nature of Content (Subject Matter)

Stable. There will be minimal need to change the model as learning how to operate ultrasound equipment is standardized.

3. LEARNER SITUATIONS AND CHARACTERISTICS

Education Level and Target Population

The learner population is undergraduate students at the University of Iowa in the Diagnostic Medical Sonography program through the Radiation Sciences Program. Specifically, these will be third-year incoming junior echocardiography students. There are no anticipated changes to educational level in the future as sonography degrees are not presented as Graduate or Doctoral degrees.

Gender Distribution

Sonography students at the University of Iowa are predominantly women. No anticipated changes to gender distribution as the sonography field has been historically female dominant and will likely continue this trend in the future.

Experience

Students are third-year incoming junior echocardiography students at the University of Iowa. Students have gained healthcare experience or exposure in the form of internships or job shadowing prior to enrollment. Once enrolled, students have completed one year of prerequisites and one year of introductory sonography classes but have not begun clinical scanning.

Attitudes & Motivation toward Content

When applying to the Diagnostic Medical Sonography program, students must choose a concentration in general sonography or cardiac sonography. This content is designed for students who are designated towards the cardiac sonography program. Students will have a high level of motivation towards the content, as scanning proficiency is a primary skill necessary for this degree field. No anticipated changes as this content is tailored to cardiac students only.

Preferred Delivery System, Instructional Settings & Strategies

Learners primarily learn face-to-face in a classroom setting. Students also train hands-on in a lab to practice scanning. The design of this content should be synchronous whether it is face-to-face or online to promote collaborative learning as content is a higher degree of difficulty. Content could be moved online only, as other sonography programs are designed that way. However, from anecdotal experience, students perform higher in a face-to-face setting.

4. TEACHING AND LEARNING (TL) ACTIVITY - I

Activity Name

Sonography Case Study: How Did We Get Here?

List and Summary of Principles & Tips for the activity

- Signaling Principle: Will use graphics and cues to point out important elements of the case study such as the direction of the apex to bring students' attention to cardiac structure when in the act of scanning.
- Pretraining Principles: Students will have a complex understanding of cardiac structures as a prerequisite for this course so they will easily recognize cardiac anatomy.
- Modality Principle: The module will have audio narration with images as opposed to on-screen text.
- Personalization Principle: Narration will use a conversational and friendly voice style.
- Explicitly prepare learners to transfer knowledge to new settings: Teaching students how to critically think and apply complex schemas learned in the activity and transfer this knowledge to the clinical setting.
- Promote the development of expertise: There are multiple scanning windows the heart can be scanned through. However, there are explicit guidelines to be followed to create continuity and allow for more precise measurements of cardiac structures. This demonstration will help students avoid the "easy and lower" scanning windows and provide instructions on how to scan in the correct windows.

Planned Length of Activity

The activity will take one hour to complete. Half of the activity will focus on correcting scanning mistakes in the parasternal window and the other half will focus on the apical window.

Activity Goal

The goal will be to help students correct common scanning mistakes by identifying proper scanning windows and correcting transducer positions.

Teaching and Learning Objectives

After completing this unit, students will be able to;

- Distinguish on-axis cardiac images from off-axis cardiac images with 100% accuracy.
- Manipulate the transducer to properly re-create cardiac structures in two separate scanning windows.

Activity Specifics

This activity will be presented as a synchronous online lecture. A PowerPoint presentation will be used to showcase images from cardiac sonography scans. A cardiac structure will be shown in an incorrect scanning window, and I will narrate and explain why this image is deemed to be incorrect. I will use graphics and markers on the images to help draw importance to the areas that help us conclude that this scanning window is incorrect. In the next slide I will show the same cardiac structure but in the correct scanning window. I will again narrate and explain how to manipulate the transducer to find this window and use graphics and markers on the image to prove to students that this is the standardized window to view the heart in. This pattern will continue for multiple views that

are used in parasternal and apical imaging. In the synchronous format will allow students to ask questions and receive immediate feedback. Students will also benefit from collaborative learning with their peers. The lecture will be recorded and posted online so the students can use this module to review.

Activity Assessment Summary

Formative assessment – Multiple examples of the same scanning mistake will be presented throughout the lecture to identify student understanding.

Roles and Key Responsibilities

I will be responsible for creating the content through Microsoft PowerPoint. I will also be responsible for finding and acquiring the ultrasound images for the case study from the hospital picture archiving and communications systems (PACS). Images used from actual patients with have name and other patient identifiers removed per HIPPA policies. Images may also include sonographic pictures of my heart to further demonstrate incorrect scanning techniques if examples from patients cannot be found.

Publishing Plans

A narrated video of the case study will be published to the university's student portal so it can be accessed outside of class.

Time Constraints

Content will take time to build through PowerPoint, finding and importing ultrasound images, including graphics and cues to highlight points of interest, and taking ultrasound images of my own heart if necessary. For viewing outside of class, the case study will be roughly one hour long for students to review.

Technology Constraints

Minimal technology constraints with the use of PowerPoint and digital PACS systems.

Budget

Costs for my time building the case study, Microsoft license, and license for PACS system.

Usability Testing

Use the "Think Out Loud" protocol to determine usability. Looking for feedback to help determine if users understand the purpose and value of the module.

Works cited or References

Clark, R. C., & Mayer, R. E. (2023). E-Learning and the science of instruction: Proven Guidelines for Consumers and Designers of Multimedia Learning. John Wiley & Sons.

Gooding, H. C., Mann, K., & Armstrong, E. (2016). Twelve tips for applying the science of learning to health professions education. Medical Teacher, 39(1), 26–31. https://doi.org/10.1080/0142159X.2016.1231913

5. ASSESSMENT FOR TEACHING AND LEARNING ACTIVITY - I

Name of Assessment

Self-Explanation of Case Study: How Did We Get Here?

Type of Assessment

Formative assessment of scanning knowledge gained from Case Study: How Did We Get Here?

Question Summary

10 questions, short answer self-explanation of how to correct the ultrasound image shown.

Timing & Location

Assessment will be distributed as a separate activity. Students will be able to take the assessment online 24 hours after the lecture.

Purpose

The formative feedback will determine if the students are learning and gaining a better understanding of the concept that is being taught. If there are discrepancies, I can adjust the module and continue to use it in the future to help concrete these scanning principles.

Format

Low stakes quiz.

Congruency

The assessment will be aligned with the lecture case study activity, How Did We Get Here? The assessment is designed to test student's basic scanning proficiencies before they begin scanning patients in a clinical setting.

Scoring

Each question will be worth 0.5 points for a total of 5 points. The goal is to keep this assessment low stakes to determine if adjustments need to be made to the content before final summative assessments.

Feedback

Feedback will be given within 24-48 hours after the quiz is completed due to the nature of the short answer format.

Rubric

A tabular rubric will be used to provide structure to help assess student responses. There will be three levels of criterion; Exemplary, Good, and Needs Improvement. This will give students clear expectations of the quiz, and the depth of knowledge will be assessed in the student.

Directions

The quiz will instruct students to answer questions with a short answer response by expressing in writing the best way to correct the incorrect ultrasound image shown to them. Directions will state to answer 10 questions, with each question being worth 0.5 points.

Design & Appeal considerations

Questions will be text-based with 18-point Serif font accompanied by a picture of an ultrasound image. A text box will be present for students to type a short-answered response.

Tracking & Storage of data

Assessment will be stored to determine if the teaching activity is sufficient in helping students how to identify and correct wrong scanning windows.

Development & Peer review

The quiz will be developed in the student portal for access. The content will be developed by me; however, I will need assistance from IT to build the quiz in the portal. Questions will be reviewed by the Radiation Sciences Director for verification.

6. STORYBOARD FOR TEACHING AND LEARNING ACTIVITY - I

Activity Name

Sonography Case Study: How Did We Get Here?

Amount of Storyboard

Selected storyboard portions include T&L activity and Assessment snippets.

Use of Design Principles and Tips – Description

The signaling principle will be used for visual cues when describing how to correct an ultrasound image. The modality principle will be used to narrate words as opposed to on-screen text.

Media Logistics:

Vocabulary, tone, and language elements- Description

Tone will be in a conversational style with a polite and friendly voice.

Typography – Description

Typography will use a serif font that is traditional and formal

Media and materials – Description

Images will be used from cardiac ultrasound pictures acquired from a PACS system.

Transcripts and Accessibility Considerations – Description

Captions and a media transcript of the case study will be available.

Logical Progression and Navigation – Description

“Next” and “Previous” button navigation

Interactivity/Interactive elements functionality - Description

Interactive limited to navigation buttons due to nature of lecture activity and short answer quiz assessment.

7. TEACHING AND LEARNING ACTIVITY -2

Activity Name

What Does This Do? - Optimizing the Cardiac Ultrasound Machine

List and Summary of Principles & Tips for the activity

- Multimedia Principle: Combining images and animations with the game mechanics to enhance learning.
- Redundancy Principle: Excess information such as text and narration is avoided to emphasize the delivery the information through animation and visuals.
- Create Learning Spaces that are Psychologically Safe: Achieving greater learning in a safe and relaxing environment. Negative-emotion states can impede problem-solving, whereas a game environment that is fun and stress-free can promote an emphasis on learning.
- Create Opportunities for Retrieval Practice Appropriate for the Content to be Learned: A game can be replayed over a span of a semester. New information can be added to the game as the lessons advance. Replaying the game is an opportunity for students to retrieve previously learned information in the course and will help enhance learning.

Planned Length of Activity

The activity will be planned in two segments. The first segment will be a lab demonstration of the ultrasound machine mechanics of improving image quality. This demonstration will take one hour. The second segment will be a gamified formative assessment of the lab demonstration. This assessment will take 30 minutes.

Activity Goal

The goal will be to help students identify ways to manipulate the ultrasound machine settings to create images of the highest quality.

Teaching and Learning Objectives

After completing this unit, students will be able to;

- Modify at least three different machine settings to optimize images.
- Produce high quality images with a frame rate over 60 Hz with 2D images and over 20 Hz with color images by adjusting machine settings.

Activity Specifics

Segment One

A lab demonstration will be performed in-person with students to demonstrate the mechanics of operating an ultrasound machine. A volunteer will be brought in and scanned while I show images of the volunteer's heart and explain machine settings. Primary functions of the machine such as depth, sector width, color sector width, color scale, Doppler scale, zoom, frequency, and frame rate will be explained to provide basic knowledge of machine settings. This demonstration will take one hour.

Segment Two

A gamified formative assessment will be assigned to students the following day. Students will play the game, Fishtopia, to assess their knowledge gained from the lab demonstration presented the prior day. Students will have to correctly answer multiple choice and true/false questions to make progress in the game. Students will try to collect the most in-game cash to top the leaderboard. The game can

be replayed throughout the semester and new questions will be added periodically to test students' knowledge of new material while retrieving previously gained knowledge. The student that is atop the leaderboard after the activity will receive an online badge that states “Best Angler of the Week”, to help avoid an overemphasis on the reward of the activity (Administrator, 2024).

The core dynamic of this game is an easy and relaxing fishing game. The purpose of this dynamic is to create a psychologically safe learning space to help promote greater learning transfer in an environment that is relaxing, low stakes, and fun. The game mechanics include students receiving two pieces of bait after correctly answering a question. This bait will be used to catch fish throughout different areas of the gaming map. The fish collected will be turned in for in-game cash, which is the metric used to determine which player has the highest score. Game elements include leaderboards and many additional in-game purchase options to modify gameplay, including; fishing rods to collect rarer fish, larger backpacks to store more fish, upgrades to move your character around faster, upgrades to catch fish quicker, upgrades to earn more cash per fish, and boat tickets to explore new maps to fish at.

Activity Assessment Summary

Formative assessment – Students will answer questions during the game session about ultrasound machine settings. When the 30 minutes have expired, I will receive a summary of each student's performance during the game round, including the number of questions answered and the percentage of correct answers.

Roles and Key Responsibilities

I will be responsible for creating and inputting the 30 questions to Gimkit.

Publishing Plans

A link to the game will be provided to students so they can play and practice on their own anytime.

Time Constraints

Questions to build for the bank should take roughly one to two hours to complete. Learners will be able to access this activity immediately through a provided link. The activity will take learners 30 minutes to complete.

Technology Constraints

Students must have access to a computer and internet to access this activity.

Budget

Cost for my time building the bank of questions in Gimkit. There is a free version of Gimkit, but it’s use would be extremely limited and not applicable to a classroom larger than five students. Licensing options begin at a departmental level for $650 a year with unlimited access for up to 20 teachers. For $1,000 a year, unlimited access would be granted to every teacher in the school. Considering that Radiation Sciences at the University of Iowa is a smaller department, the department level at a cost of $650 a year would be sufficient.

Usability Testing

“Hallway testing” will be used to test the Fishtopia game with five to six participants chosen at random. The original content is specifically intended for sonography students. The questions in the game will be changed to general knowledge questions so that users can test all the functions of the game.

Works cited or References.

Administrator. (2024, December 10). 10 Effective examples of gamification in the classroom. University of San Diego - Professional & Continuing Education. https://pce.sandiego.edu/gamification-in-education/

Clark, R. C., & Mayer, R. E. (2023). E-Learning and the science of instruction: Proven Guidelines for Consumers and Designers of Multimedia Learning. John Wiley & Sons.

Gooding, H. C., Mann, K., & Armstrong, E. (2016). Twelve tips for applying the science of learning to health professions education. Medical Teacher, 39(1), 26–31. https://doi.org/10.1080/0142159X.2016.1231913

8. ASSESSMENT FOR TEACHING AND LEARNING ACTIVITY - 2

Name of Assessment

Fishtopia – Ultrasound Machine Settings

Type of Assessment

Gamified formative assessment of machine setting knowledge gained from the in-lab demonstration of ultrasound equipment.

Question Summary

30 questions, a variety of multiple choice and true/false questions related to improving ultrasound image quality by adjusting machine settings.

Timing & Location

Assessment will be a separate activity the next day after segment one of the Teaching and Learning Activity. Students will play the Fishtopia game for 30 minutes synchronously online.

Purpose

The formative feedback will determine if students are understanding how the ultrasound machine functions and how to optimize the equipment for the highest possible quality image.

Format

Fishing game quiz through Gimkit.

Congruency

The assessment will be aligned with segment one of the second learning activity. The assessment will evaluate student's understanding and operability of the ultrasound machine.

Scoring

When a student answers a question correctly, they are rewarded with two pieces of bait to fish with. The student will use the bait to catch fish in various locations in the game. With their caught fish, students can head to the 'Sell Station' and sell their fish for cash. A leaderboard will track students to determine who has the most cash at the end of the 30 minutes.

Feedback

Feedback will be given immediately after a question is answered. If the question is answered correctly, the student will receive two pieces of bait. If the question is answered incorrectly, they will receive an 'incorrect' prompt and will have to wait three seconds before they can answer another question.

Rubric

There will be no rubric since scores are based on correct and incorrect answers. Once the activity has been completed, I will receive a Question Breakdown, Student Overview, and Quick Stats showing the percentage of each question answered correctly, how each student performed individually, and the total number of correct and incorrect answers.

Directions

Students will use their character to go to the ‘Question Answering Station’ to receive one of the 30 questions in the activity randomly. When a question is answered correctly, the student will receive two pieces of bait for fishing. The bait will be used to catch fish in various locations in the game. Fish caught in the game can be redeemed for in-game cash. The goal of the game is to accrue the most amount of in-game cash before the 30 minutes is up.

Design & Appeal considerations

The Fishtopia game is designed within Gimkit. The nature and design of the game is intended to be simplistic, with students controlling their character with the arrow keys and interacting with elements using the enter button.

Tracking & Storage of data

Tracking will involve the scores in the leaderboard stored on the Gimkit website.

Development & Peer review

The questions will be developed by me. The Fishtopia game is a pre-existing game already developed within Gimkit. Questions and game validity will be reviewed by the Radiation Sciences Director.

9. STORYBOARD FOR TEACHING AND LEARNING ACTIVITY - 2

Activity Name

Fishtopia – Ultrasound Machine Settings

Amount of Storyboard

Selected storyboard portions include snippets from Fishtopia assessment.

Use of Design Principles and Tips – Description

The multimedia principle will be used combining images and animations to enhance student learning. The nature of the game is relaxing and laid back to help foster a psychologically safe learning space.

Media Logistics:

Vocabulary, tone, and language elements- Description

The game does not have verbal audio. However, the tone of the game is designed to be cheerful and calm.

Typography – Description

Sans serif font used in game to provide simple and easy to read instructions.

Media and materials – Description

Media and materials provided by Gimkit.

Transcripts and Accessibility Considerations – Description

Verbal audio is not used in the assessment, therefore there will be no transcripts or captions for this activity.

Logical Progression and Navigation – Description

Students will use arrow keys to navigate their character. Students will use in-game cash to make progress in the game such as unlocking new maps, better equipment, and upgrades.

Interactivity/Interactive elements functionality – Description

Students will use the enter button to interact with elements throughout the game.

10. PEER REVIEW SUMMARY AND SELF-REFLECTION

Peer Review Summary

In summary, this module was felt to be a necessary part of early sonography education. In most educational content, the student is shown the bare minimum basics of finding cardiac windows. Unfortunately, when you start scanning clinical patients, this black and white approach usually leads to frustration and failure for students. Having a more practical and in-depth approach could lead to more success early in students' clinical rotations and promoting their scanning independence faster.

Ultrasound is a very hands-on approach. A suggestion for adding dimension to the lecture is pairing it with a video demonstration of the instructor making the movements and showing how it improves the image on the ultrasound machine. Showing still pictures with verbal instructions may still leave students in question if they cannot see the actual skill being performed.

Self-reflection Statement

I’m really proud of my work on my IDP since I do not have any formal classroom teaching experience. Many concepts that applied to this project including the teaching activity, assessment activity, and the storyboard activity were new to me. I would like to revisit this project once I have some classroom teaching experience and make enhancements based on working experience. From the direction of my peer feedback, I believe I would incorporate more videos of scanning techniques as opposed to a lectured PowerPoint presentation. I believe seeing the context being applied live would be much more beneficial to my learners as opposed to them trying to visualize technique with still images on a screen.

11. MEDIA LIST

IDP: zLarson_IDProjectWorking

Storyboard for activity 1: zlarson_IDPStoryboard1

Storyboard for activity 2: zlarson_IDPStoryboard2