Master in Health Professions Education 2019 – 2021

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Unit 8 - Assignment 1

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Introduction

Point-of-care musculoskeletal ultrasound (MSKUS) has improved diagnostic and procedural care in rheumatology (Epis et al., 2014). However, only half of Canadian rheumatologists use MSKUS (Larché et al., 2011). The main obstacle is lack of adequate training, as MSKUS is a complex skill that relies on a combination of technical and cognitive competencies (Burnley & Kumar, 2019).

In this paper, I discuss the current MSKUS curriculum for rheumatology trainees at University of Toronto (UofT), the issues with it, and propose a re-design.

Context

Rheumatology residents complete two years of subspecialty training after their internal medicine residency. UofT has a total of six residents per year. MSKUS teaching is embedded within their weekly academic-half day curriculum. The current MSKUS curriculum consists of four consecutive weekly sessions, each 4 hours long (Figure 1). After these sessions, there is no formal training until the next academic year. Some residents take extra private courses. There are only 5 faculty members trained in MSKUS. Residents come in with varied ultrasound experiences based on previous exposure.

Expert faculty provide lectures and demonstrate technique. Residents practice in groups of 2-3 individuals. Faculty provide immediate feedback during practice. After these sessions, trainees can practice on their own time, but there is no official curricular structure and no faculty to guide them. Assessment is a short pre-and-post written test covering ultrasound physics, optimizing images, anatomy, and recognizing MSKUS images. There is no practical assessment. This curriculum is very introductory and only provides basic concepts to trainees, without building expertise.

	Session 1	**Session 2**	**Session 3**	**Session 4**
8am-10am	Anatomy lab – review anatomy on cadavers and link to ultrasound images	Anatomy lab from 8-9am. 9-10am: Lecture on images of upper extremity	8-9am: Lecture on images of lower extremity 9-10am: Practice obtaining images of lower extremity	All 4 hours to practice and work on areas of weakness with faculty supervision.
10am-12pm	Lecture on introductory concepts (knobology, holding probe, generating image)	Practice obtaining images upper extremity	Practice obtaining images of lower extremity	

Figure 1: UofT MSKUS curriculum.

Problems with current curriculum

Since there are no clear objectives, learners and instructors do not know what drives instruction and assessment (Barrow, McKimm, & Samarasekera, 2010). There is a lack of explicitly stated foundational skills, which are needed to achieve objectives, since trainees have different experiences entering residency.

Tasks are taught in a compartmentalized and fragmented manner (i.e. anatomy first, then knobology, etc.) rather than in a holistic whole-task manner, where all components are taught together. Furthermore, there is high cognitive load in learning a complex skill within such limited time (Merrienboer & Kirschner, 2018). Therefore, learners will have difficulty creating cognitive schemas and progressing to mastery at their own pace. There are no resources, supportive information, or 'how-to' instruction on how to approach such a complex skill. Lastly, the written quiz does not assess whole-task performance. Hence, residents struggle to develop any competency in MSKUS.

Goals of redesign

The goal is to create a learning environment using instructional design (ID) principles for complex learning of whole-tasks, using theoretical principles to underpin my decisions. The focus of the redesign will be on task-centered teaching, activation of prior knowledge, providing scaffolding of support, and resources for learners to apply new knowledge and skills, feedback to promote improvement, and effective assessment that drives learning.

Summary of literature search

The literature search is summarized in Appendix 1. I am familiar with the Four-Component Instructional Design (4C/ID) model as my thesis project utilizes this model.

There wasn't much literature specifically around ID for ultrasound. However, insights from learning and teaching other complex procedural skills, right from simple focused procedures like paracentesis up to full surgeries, can be applied to MSKUS curricula.

Much of the procedural literature focused on constructivist theories of learning, suggesting that learners construct new knowledge and skills based on pre-existing experiences and frameworks (Sadideen, Plonczak, Saadeddin, & Kneebone, 2018). Vygotsky's zone of proximal development (ZPD) underpins constructivist theory, and explains how learners may explore personal development while still in their comfort zone (i.e. ZPD), before progressing to the next stage.

The Fitts and Posner three-stage model of motor skill acquisition was repeatedly mentioned for psychomotor skill development in procedural training (Fitts & Posner, 1967). Learners move from the *cognitive stage* (understands the task, but performs erratically), to the *associative stage* (knowledge translated to motor behaviour, but still interrupted), and lastly to the *autonomous stage* (perform task automatically with minimal mental effort). Recent literature highlights how ID strategies such as procedural guides, direct observation, immediate feedback, repetitive practice, and formative assessments can assist in motor skill acquisition at various stages as per Fitts and Posner's model (Rajaratnam, Rahman, & Dong, 2021; Sadideen et al., 2018).

Ericsson's deliberate practice model also helps with acquisition and retention of motor skills. Deliberate practice is defined as repeated practice with a highly structured set of activities, with the explicit goal of improving performance, while receiving regular reinforcement and feedback (Ericsson, 1996; Nestel, Dalrymple, Paige, & Aggarwal, 2019). Studies have shown deliberate practice and scaffolding provide a more efficient and effective way of teaching psychomotor and cognitive skills together in cardiac ultrasound and various surgeries (McConnaughey, Freeman, Kim, & Sheehan, 2018; Wulf, Shea, & Lewthwaite, 2010).

Simulation training has proven to be an excellent tool through which ID principles can be applied to procedural training. They provide a safe and learner-centered environment for repeated practice, an opportunity to repeat whole-tasks or individual components, and the training trajectory can be determined by learner needs (Sidhu, Olubaniyi, Bhatnagar, Shuen, & Dubbins, 2012). Simulation training has been shown to have face, content, and construct validity, suggesting simulators "look like" the real world, provides a teaching tool to cover critical steps, and improves performance in a particular task (Samia, Khan, Lawrence, & Delaney, 2013). There is ample literature that simulation can assist with learning in surgical specialties (Samia et al., 2013). In contrast, a systematic review revealed that studies fail to demonstrate compelling evidence to support transfer of skills and improvement of ultrasound skills "in-vivo" (i.e. in real life) (Sidhu et al., 2012). Although this was mostly attributed to poor study design, compared to other procedures, ultrasound-based simulation does not demonstrate the same evolution towards a well-defined evidence base over time. However, if validated, they have the potential to objectively improve the psychomotor, cognitive, and problem-solving skills in ultrasound (Sultan, Shorten, & Iohom, 2013). Overall, simulation benefits can only be realized if integrated well into a curriculum utilizing other ID principles.

Learning procedural skills includes cognitive and psychomotor complexity that must be managed simultaneously. Cognitive load theory (CLT) postulates that the working memory can only manage a few informational elements at any given time, and if overloaded, learning and performance suffer (Sewell, Boscardin, Young, Ten Cate, & O'Sullivan, 2017). Intrinsic load (IL) is greater when learners are less experienced, or the task is more complex. Providing graded simple-to-complex tasks, worked examples, tapering feedback, and part-task approaches can mitigate IL (Sewell et al., 2017). Sewell et al. (2017) also found that extraneous load (EL) factors such as procedure order and supervisor engagement played a role in procedural training. Supervisors can reduce EL by engaging learners and helping them use techniques to manage IL, including schema formation, information chunking, and task automation (Sewell et al., 2017).

Literature for curricular design in ultrasound training shows wide variability in the content and techniques used (Sena, Alerhand, & Lamba, 2021; Tarique, Tang, Singh, Kulasegaram, & Ailon, 2018). A few specialties use competency-based education principles (i.e. emergency medicine), but most do not, despite the rest of medical education moving in that direction. Specific to MSKUS in rheumatology, isolated attempts at developing competency based outcomes have not been adopted by training programs widely (Brown et al., 2006). Less than half of American program utilized a formal curriculum. The most commonly used strategy was 'hand-on teaching during clinic' followed by didactic lectures and isolated workshops (Torralba et al., 2017). Supportive information and materials were only provided by 30% of programs. Overall, there is no good evidence of ID principles being used to teach MSKUS.

<u>Instructional design model and literature used in re-design</u>

The 4C/ID model and the ten steps to complex learning was used to redesign the MSKUS curriculum (Frerejean et al., 2019; Merrienboer & Kirschner, 2018). A task description and three different task classes for MSKUS (Appendix 2, 3) was designed using the literature (Brown et al., 2007; Smith & Finnoff, 2009) and in discussions with other experts.

Step 1 starts with designing learning tasks based on whole task problems. Task classes ensure learners perform all relevant constituent skills during all aspects of the task (i.e. during video analysis, simulation, or practice on patients). Guidance by faculty decreases as the learner masters the task class. Task variability within each class is provided by the different videos or patients they perform the scan on.

Step 2 is designing performance assessments. In order to assess the bottom levels of Miller's pyramid ("knows" and "knows how"), such as anatomy, there will knowledge based assessments (i.e. MCQ, labelling images) (Miller, 1990). The higher levels on Miller's pyramid ("shows" and "does") will be assessed using global rating scales (GRS) for the whole learning tasks, which are more dependable than checklists in other similar procedures (Lord, Zuege, Mackay, des Ordons, & Lockyer, 2019). These assessments are low stakes, with lots of feedback provided, and will be included in the overall assessment portfolio which is used to monitor progress over time.

Learning tasks are organized from simple to complex, as recommended in Step 3 (Appendix 3). Tasks classes include complexity levels for both cognitive and motor skills. Closely related to this is *Step 4 which is the design of supportive information* describing cognitive information and mental models. These include online introductory manuals, instructional videos, image banks, lectures, and modeling by experts.

The next step is *analysis of cognitive strategies (Step 5)* which guide experts' task performance or problem-solving behaviour. This is used for designing the supportive information in Step 4 and for providing feedback during learning activities. Some of this information is available in the literature (Smith & Finnoff, 2009). However, cognitive task analysis by asking experts to "think aloud" while doing ultrasound scans, will help develop systemic approaches to problem-solving (SAPs). Therefore, a few rheumatology sonographers may be asked to scan joints and think aloud to generate SAPs and provide analysis of cognitive strategies.

Analysis of mental models (Step 6) is not required in this re-design as the information is already available through the literature and from private MSKUS courses.

Step 7 is the design of procedural information. This involves "just-in-time (JIT) information" by faculty ALOYS (Assistant Looking Over Your Shoulder), which is immediate, corrective feedback about what is wrong, why it is wrong, and corrective hints about recurrent psychomotor aspects of the task. Complete information is provided at first and then fades as the learner gains experience within the task class.

Analysis of cognitive rules (Step 8) has already been identified in the literature and for private MSKUS courses. These cognitive rules are well known to the faculty and can be translated to the procedural information provided to learners or in verbal JIT feedback.

The penultimate step is *analysis of pre-requisite knowledge (Step 9)* and has already been identified in the literature (Brown et al., 2007; Smith & Finnoff, 2009). Learners should have the basic cognitive and procedural rules from Internal Medicine training, and supportive information in task class 1 will also provide this.

Step 10 is the design of part-task practice. The main skill that needs high level of automaticity is recognition of anatomy, normal and pathological images. This needs to be automated for accuracy, speed, and to maximize performance of the whole task and minimize cognitive load. This is achieved by providing the learners with a large image bank which they can repeatedly go through to automate recognition.

Innovative re-design will support learning

Whole-task ID approaches for ultrasound curricula have not been described in the literature. This innovative curriculum is whole-task centered, with increasing levels of difficulty (task classes), with supportive and procedural information, and part-task practice, utilizing 4C/ID principles.

The curriculum will change from 4 academic half-days to a longitudinal curriculum throughout the year, with regular exposure to MSKUS and time to progress through the task classes. Each trainee will get 4 hours every 2 weeks to participate in the longitudinal re-designed MSKUS curriculum. Faculty at each site will also be available during those hours.

The new curriculum has utilized evidence from the literature search. The learners' prior knowledge is activated through the supportive information provided prior to learning tasks. Learners construct new knowledge and skills based on pre-existing frameworks (Sadideen et al., 2018), and this is improved with facilitator feedback, online websites, deconstructing videos, and lectures in the curriculum. As the learner goes through each task class, we see principles from Fitts and Posner's three-stage model of motor skill acquisition. Modelling and deconstructing videos allow the learner to intellectualize the task through content analysis in the cognitive stage. Direct observation, repetitive practice, and immediate feedback by ALOYS reinforces the associative stage. As the learner becomes more skillful, feedback reduces and the focus of teaching moves to other aspects of the task (Sadideen et al., 2018). Deliberate practice through highly structured activities (i.e. task classes), has been shown to improve psychomotor performance (Rajaratnam et al., 2021). Although simulation does not have compelling evidence in ultrasound specifically, it does in procedural training, and hence we have chosen to integrate it into our curriculum. Simulation allows learners to make mistakes, gain feedback, improve, and continue with deliberate practice in a safe and high-fidelity environment before moving on to real patients. Simple-to-complex task classes, and even tasks within each class, allows us to reduce intrinsic load of the learners (Sewell et al., 2017). Faculty ALOYS will provide immediate feedback to reduce extrinsic load and help learners use cognitive techniques to manage IL (Sewell et al., 2017).

Reflection

The 4C/ID model was chosen due to its evidence-based principles that support effective learning of complex tasks. It is practical, prescriptive, and readily applicable to MSKUS, which requires the coordination of different cognitive and psychomotor skills and part-tasks (Frerejean et al., 2019). The *Ten Steps* are based on educational science and theories such as CLT, self-regulated learning, and Miller's pyramid for assessment (Merrienboer & Kirschner, 2018).

When compared to other whole-task ID models, such as Merrill's First Principles of Instruction or Gagne's Nine Step model, the 4C/ID model incorporates similar key principles, but builds on with more systematic and practical approaches. Similar concepts include activating pre-existing knowledge, deliberate practice of whole tasks, guidance, and feedback with reflection. However, the 4C/ID model builds on this by explicitly describing sequencing of tasks and scaffolding with diminishing support within each task class. The 4C/ID model also provides the designer with guidance on supportive and procedural information and part-task practice. This detailed guidance was not available in the other models.

Strengths

The 4C/ID model prevents compartmentalization and fragmentation increasing the chances that transfer of learning occurs (Merrienboer & Kirschner, 2018). It is a holistic model that promotes declarative, procedural and affective learning, facilitating an integrated knowledge base rather than focusing on one particular domain. The 4C/ID model focuses on developing an integrated set of objectives, and importantly, the coordinated attainment of those objectives.

There is clear direction on assessment by suggesting alignment with learning activities (Frerejean et al., 2019; Merrienboer & Kirschner, 2018). It shows us a link between the four blueprint components with Miller's Pyramid levels. There is guidance on testing all levels of Miller's pyramid, using formative and summative assessments, creating a complete program of assessment and aligning with approaches such as programmatic assessment within the larger curriculum (Merrienboer & Kirschner, 2018; van der Vleuten et al., 2012).

Weaknesses

The 4C/ID model has many parts and is complex to understand initially. I had a better understanding since my thesis is based on 4C/ID, but the first time it required several re-reads and explanations by my supervisor. The practical examples help. However, this model is more difficult to implement for novice designers without support.

Secondly, it is relatively resource intensive, especially if implementing all ten steps for a completely new curriculum. The designer would need significant time, money, and human resources. In this case, many steps did not have to be repeated as resources were available, making it easier to re-design.

Another gap is that evaluation is not explicitly addressed. Instructional designers should be aware of evaluation methods (i.e. ADDIE). The 4C/ID model covers the “ADD” (analysis, design, development), but does not necessarily expand on “IE” (implementation and evaluation). Therefore, designers must be aware of the processes of implementation and evaluation to be successful in curriculum design.

Lastly, the 4C/ID method relies on methods that may be challenging in very large sized groups of learners. The *Ten Steps* briefly addresses this by suggesting mass customization, automation, and big data as solutions (Merrienboer & Kirschner, 2018). However, more research is needed on this.

Appendix 1

Table 1. Literature Search Summary

<table>
<tr><td>Research Questions</td><td colspan="4">What instructional design principles or frameworks have been used in designing training blueprints for:
1. Musculoskeletal ultrasound (MSKUS)
2. Point of care ultrasound (POCUS)
3. Medical procedures in general</td></tr>
<tr><th>List of sources or databases searched</th><th>Keywords/Search terms (include search equations)</th><th>Search strategy used, inclusion and exclusion criteria/limits (eg. language, date ranges of publication, types of publication)</th><th>Total number of results found</th><th>Comments (include strategy used to finalize results)</th></tr>
<tr><td>PubMed</td><td>(instructional design) AND (ultrasound)</td><td>none</td><td>3516</td><td rowspan="4">Staged search from broad search terms to more specific and limits.

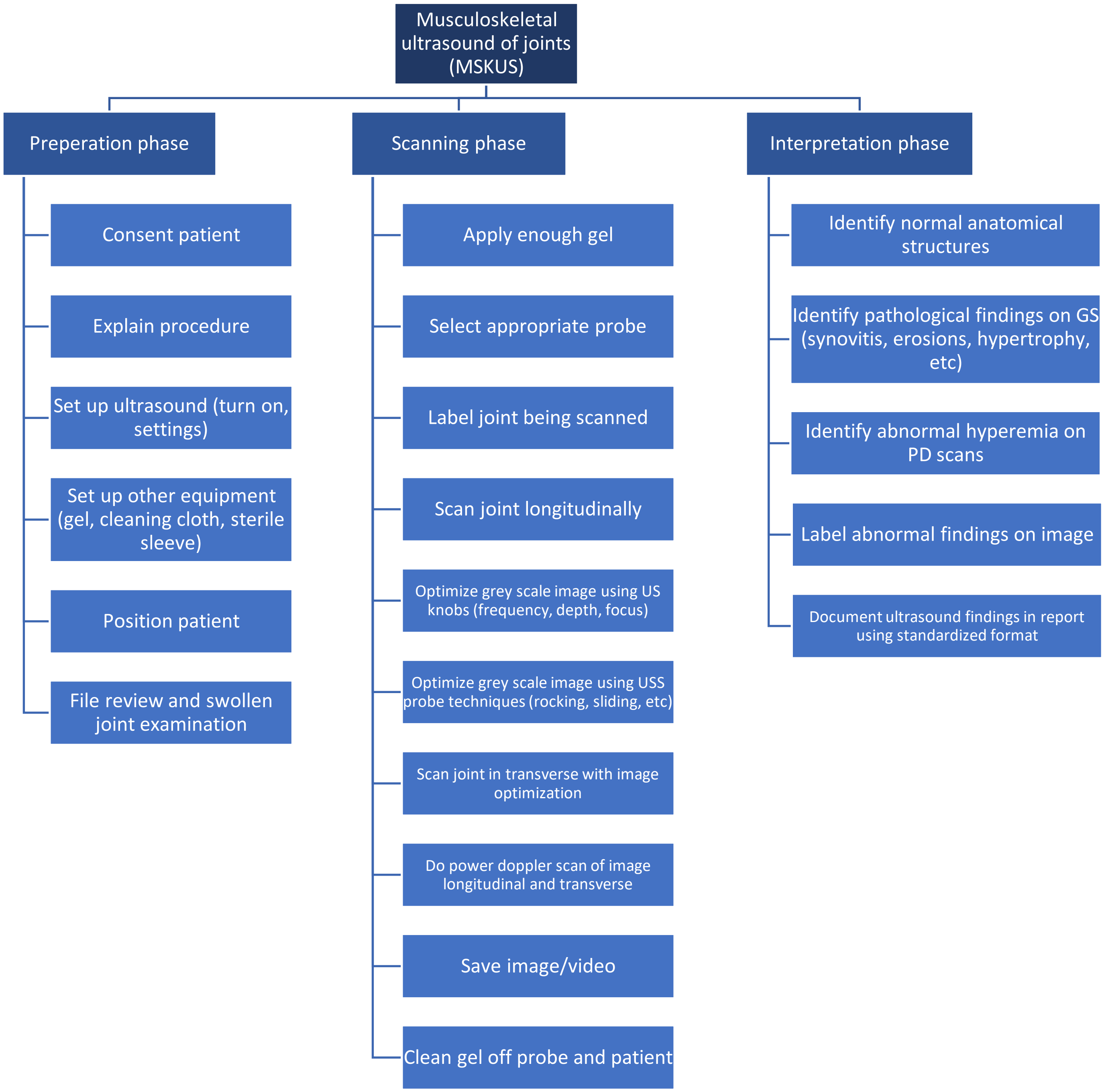
Looked at title, abstract, then review of article if relevant.

Few articles identified around POCUS, but more generally around procedures, and included in literature summary in text.</td></tr>
<tr><td>PubMed</td><td>(instructional design) AND (ultrasound)</td><td>Limit by ‘clinical trial’ or ‘randomized controlled trial’ or ‘review’ or ‘systematic review</td><td>652</td></tr>
<tr><td>PubMed</td><td>(instructional design) AND (point of care ultrasound)</td><td>none</td><td>125</td></tr>
<tr><td>PubMed</td><td>(instructional design) AND ((musculoskeletal ultrasound) OR (point of care musculoskeletal ultrasound))</td><td>none</td><td>86</td></tr>
<tr><td>PubMed</td><td>(instructional design) AND (medical procedures)</td><td>Limit by ‘books and documents’ or ‘review’ or ‘systematic review’</td><td>1532</td><td>Had to go broader as not many articles around ID and POCUS or MSKUS specifically</td></tr>
<tr><td>PubMed</td><td>(instructional design [title/abstract]) AND (procedures)</td><td></td><td>495</td><td rowspan="2">Limiting to instructional design in title or abstract due to large numbers and non-relevant articles above.
Useful articles highlighted in literature summary in text</td></tr>
<tr><td>PubMed</td><td>(instructional design [ti/ab]) AND (procedures)</td><td>Limit by ‘books and documents’ or ‘review’ or ‘systematic review’</td><td>90</td></tr>
</table>

ERIC (EBSCO host)	(instructional design) AND (medical procedure)	none	8	None relevant
ERIC (EBSCO host)	(instructional design) AND (procedure) AND (medicine or medical or health)	none	50	Broadened previous search as only 8 hits None relevant
ERIC (EBSCO host)	(instructional design) AND (point of care ultrasound)	None	0	
ERIC (EBSCO host)	(instructional design) AND (ultrasound or sonography or ultrasonography)	None	2	Both were already identified in PubMed
MEDLINE (OVID)	(instructional design) AND (point of care ultrasound)	None	2	Both were already identified in PubMed
MEDLINE	(instructional design) AND (ultrasound)	None	6	Done as too narrow above – found a few articles of relevance (McConnaghay – scaffolding in FOCUS)
MEDLINE	(instructional design) AND (procedure)	None	18	One other identified Sadideen
Maastricht LibSearch (includes multiple relevant databases)	(instructional design [ti/ab]) AND (point of care ultrasound [kw])	none	62	Nothing new
Maastricht LibSearch (includes multiple relevant databases)	(instructional design [ti/ab]) AND (medical procedure [kw])	'Articles' 'From 2011-2021'	583	Limited due to POCUS being new/advanced in last 10 years Several repeated articles and several new articles focused on ID in procedures in general but none that were new to POCUS

Appendix 2

Figure 2: Task description of point-of-care MSK Ultrasound (MSKUS)



Appendix 3 – Training blueprints for MSK ultrasound of hand joints

Task class 1: Low difficulty (normal patient, no inflamed joints, normal anatomy)

<table>
<tr><td colspan="3">Task class description:
- Healthy patient with no underlying rheumatic or joint issues
- Normal anatomy with no deformities or swollen joints
- Normal weight and BMI
- No issues with patient positioning and able to follow all instructions and sit still
- No time urgency
- Machine pre-set to optimal settings (learner does not need to adjust ultrasound settings)</td></tr>
<tr><td colspan="3">Supportive information: Online resources
- Introductory manual on MSK US principles, machine ‘knobology’, image acquisition
- Online website to review hand/wrist anatomy images, as well as relevant anatomical images on ultrasound
- Introductory video deconstructing the task of image acquisition/optimization into key steps and common novice problems related to this.</td></tr>
<tr><td colspan="3">Supportive information: Presentation of mental models and cognitive strategies
- Lecture on ultrasound concepts, performing MSKUS, and obtaining and optimizing images</td></tr>
<tr><td colspan="3">Supportive information: Modeling
- Learners watch an expert obtain images of hand joints, while expert explains their actions while doing so.</td></tr>
<tr><td>Learning task 1.1
Watch video demonstrations of MSKUS and resultant images. Learners have to identify steps that were correctly and incorrectly done and ways to correct steps.</td><td>Procedural information:
Corrective feedback</td><td rowspan="3">Part task practice:
Image bank of ultrasound images and anatomy where student can go through in different modes (learning, testing, timed, etc.) to have repetitive practice to recognize normal and abnormal anatomical and ultrasound images</td></tr>
<tr><td>Learning task 1.2
Simulation on hand mannequin using mastery-based approach</td><td>Procedural information:
Procedure checklist
Image optimization guide (directing to knobs to use on machine and how to optimize image)
Corrective feedback by ALOYS (faculty) during performance until they achieve all performance standards without interruption.</td></tr>
<tr><td>Learning task 1.3
Practice on another student</td><td>Procedural information:
Procedure checklist
Image optimization guide
Corrective feedback by ALOYS (faculty) during performance
GRS scale used for assessment</td></tr>
</table>

Task class 2: Moderate difficulty (normal anatomy, swollen and inflamed joints)

<table>
<tr><td colspan="3">Task class description:
- Patient with non-deforming rheumatoid arthritis
- Normal anatomy with no deformities but with swollen joints
- Normal weight and BMI
- No issues with patient positioning and able to follow all instructions and sit still
- No time urgency
- Machine pre-set to optimal settings (learner does not need to adjust ultrasound settings)</td></tr>
<tr><td colspan="3">Supportive information: Online resources
- Online website to review hand ultrasound images showing swollen joints and pathology.
- Video deconstructing the task of image acquisition/optimization of pathologic and swollen joints into key steps and common novice problems related to this.</td></tr>
<tr><td colspan="3">Supportive information: Case studies
- 4 videos on scanning pathologic and swollen joints with resultant ultrasound images. These examples will have 2 good and 2 bad demonstrations. Learners identify what was done well and what could be improved.</td></tr>
<tr><td colspan="3">Supportive information: Modeling
- Learners watch an expert obtain images of swollen hand joints, while expert explains their actions while doing so.</td></tr>
<tr><td>Learning task 2.1
Reverse task:
Shown videos demonstrating incorrect MSKUS technique and resultant images. Learners identify what went wrong and what could be improved.</td><td>Procedural information:
Reminder of steps in ideal image acquisition by faculty
Procedure checklist available
Image optimization guide available</td><td rowspan="4">Part task practice:
Image bank of ultrasound images and anatomy where student can go through in different modes (learning, testing, timed, etc.) to have repetitive practice to recognize normal and abnormal anatomical and ultrasound images</td></tr>
<tr><td>Learning task 2.2
Simulation on hand mannequin using mastery-based approach</td><td>Procedural information:
Procedure checklist
Image optimization guide
Corrective feedback by ALOYS (faculty) during performance.</td></tr>
<tr><td>Learning task 2.3
Practice on patients with rheumatoid arthritis and swollen joints</td><td>Procedural information:
Procedure checklist
Image optimization guide
Corrective feedback by ALOYS (faculty) during performance
GRS scale used for assessment</td></tr>
<tr><td>Learning task 2.4
Interpret and document images obtained from patient with rheumatoid arthritis and swollen joints</td><td>Procedural information:
Image bank of normal and pathological joints in greyscale and power doppler (to act as reference for learners to compare their images to)
Corrective feedback by ALOYS (faculty) during performance</td></tr>
</table>

Task class 3: High difficulty (rheumatoid hand deformities and swollen joints)

<table>
<tr><td colspan="3">Task class description:
- Patient with deforming rheumatoid arthritis and hand swollen joints
- Normal weight and BMI
- Patient has minimal difficulty positioning hand due to deformities/pain.
- No time urgency
- Learner has to modify certain ultrasound settings to optimize image.</td></tr>
<tr><td colspan="3">Supportive information: Online resources
- Online website to review hand ultrasound images showing deformities, swollen joints and pathology.
- Video deconstructing the task of image acquisition/optimization of pathologic and swollen joints into key steps and common novice problems related to this.</td></tr>
<tr><td colspan="3">Supportive information: Case studies
- 4 videos on scanning pathologic and swollen joints with resultant ultrasound images. These examples will have 2 good and 2 bad demonstrations. Learners identify what was done well and what could be improved.</td></tr>
<tr><td colspan="3">Supportive information: Modeling
- Learners watch an expert obtain images of swollen hand joints, while expert explains their actions while doing so.</td></tr>
<tr><td>Learning task 3.1
Reverse task:
Shown videos demonstrating non-optimal ultrasound images due to incorrect settings. Learners have to identify ways to optimize image using ultrasound settings (frequency, focus, depth, etc.)</td><td>Procedural information:
Image optimization guide available</td><td rowspan="4">Part task practice:
Image bank of ultrasound images and anatomy where student can go through in different modes (learning, testing, timed, etc.) to have repetitive practice to recognize normal and abnormal anatomical and ultrasound images</td></tr>
<tr><td>Learning task 3.2
Simulation on hand mannequin using mastery-based approach</td><td>Procedural information:
Procedure checklist
Image optimization guide
Corrective feedback by ALOYS (faculty) during performance.</td></tr>
<tr><td>Learning task 3.3
Practice on patients with rheumatoid arthritis deformities and swollen joints</td><td>Procedural information:
Procedure checklist
Image optimization guide
Corrective feedback by ALOYS (faculty) during performance
GRS scale used for assessment</td></tr>
<tr><td>Learning task 3.4
Interpret and document images obtained from patient with rheumatoid arthritis and swollen joints</td><td>Procedural information:
Image bank of normal and pathological joints in greyscale and power doppler (to act as reference for learners to compare their images to)
Corrective feedback by ALOYS (faculty) during performance</td></tr>
</table>

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