Qualitative Evaluation of Incorporating Ultrasound Education Into an Undergraduate Medical Education Clinical Human Anatomy Course

Jared R. Muench, MD; Michael A. Schellpfeffer, MD, MS

ABSTRACT

Introduction: Ultrasound use as a procedural guide and diagnostic tool has led many to herald it as the "new stethoscope." Thus, medical schools are seeking to integrate ultrasound training into their longitudinal curricula. While various methods have been trialed, incorporating ultrasound into basic science courses as a supplementary learning tool often offers students their first exposure. This study seeks to identify factors that affected student excitement and perceived value of ultrasound training as part of an anatomy course.

Materials and Methods: A brief survey was distributed to first-year medical students after completing ultrasound education in a clinical human anatomy course. This survey gauged student excitement and perceived value of the ultrasound sessions. Through free-response, students expounded on factors that affected their ratings. Qualitative student feedback was organized, coded, and associated with student excitement and perceived value ratings using thematic analysis.

Results: Responses were returned from 26.2% of the surveyed group. Ten and 6 themes were identified in response to students' excitement and perceived value ratings of the sessions, respectively. Clinical relevance/utility was identified consistently as the most influential factor affecting student engagement. In addition, students' personal motivation and incentive, as well as the structure and learning environment of the sessions, were found to impact student engagement.

Conclusions: We identified multiple factors that may impact student engagement with ultrasound sessions that are included as part of an anatomy course. Medical schools seeking to incorporate ultrasound sessions in a similar fashion could consider these factors when designing their own curricula.

INTRODUCTION

Ultrasound's proven use as a procedural guide and powerful diagnostic tool has led to its utilization across nearly all medical specialties. Incorporating point-of-care ultrasound (POCUS) into practice has been shown to improve diagnosis,[1] efficiency,[2,3] patient satisfaction,[2,3] and procedural success rates[3,4] as well as to decrease procedural complication rates,[4,5] hospital length of stay,[5,6] and hospitalization costs.[5] When performed with a targeted question, bedside ultrasound enhances and augments the physical exam to improve diagnostic accuracy and expediency.[7,8] The age of POCUS has been heralded as the "new stethoscope" or the "5th pillar of physical diagnosis," where all clinicians will be required to have a strong foundation in ultrasound use and image interpretation.[9-11] Indeed, current hospitalists and advanced practice providers desire this training.[12]

Given ultrasound's emerging clinical utility, many medical schools are seeking to integrate hands-on ultrasound training into their curricula in an effort to improve the readiness of future physicians. Based on a 2012 self-report survey of 134 US medical institutions, 62.2% reported ultrasound education was incorporated into their undergraduate medical education (UME) curriculum.[13] In just under 10 years, this percentage increased to 72.6% among a similar survey of 200 institutions,[14] reflecting the urgency with which medical institutions are pursuing ultrasound education in UME. However, multiple methods have been employed, including vary ing tim-

• • •

Author Affiliations: Aurora St. Luke's Medical Center, Milwaukee, Wisconsin (Muench); Department of Cell Biology, Neurobiology, and Anatomy, Medical College of Wisconsin, Milwaukee, Wisconsin (Schellpfeffer).

Corresponding Author: Michael Schellpfeffer, MD, MS, Department of Cell Biology, Neurobiology, and Anatomy, Medical College of Wisconsin, 8701 Watertown Plank Rd, Milwaukee, WI 53226; phone 262.914.0708; email mschellpfeff@mcw.edu; ORCID ID 0000-0002-3508-5564

ing of implementation, course length, number of sessions offered, and staffing.[15] Because ultrasound training has been integrated to varying degrees and through a wide variety of curriculum innovations, educators are often left wondering the best approach for their program.

Despite myriad curriculum changes being trialed,[15,16] medical school anatomy courses consistently have provided the opportunity for the incorporation of ultrasound into UME. Ultrasound provides the ability to combine surface anatomy with cross-sectional anatomy to better supplement students' learning. Furthermore, the dynamic, real-time aspect of ultrasound imaging offers additional learning opportunities in anatomy that conventional diagnostic imaging, anatomy atlases, and cadaver dissections cannot. Nicholas et al found that nearly 75% of those medical schools with integrated ultrasound curricula used basic science courses to introduce ultrasound.[14] Using ultrasound as an innovative learning modality in anatomy courses has been well-received by students who perceive ultrasound training as valuable to their understanding of human anatomy and other basic science topics.[16,17]

The aim of this study was to gauge first-year medical students' overall engagement with ultrasound sessions as part of a clinical human anatomy course. While previous studies have demonstrated overall success in integrating ultrasound into medical school curricula, this study specifically used thematic analysis to further identify factors that contributed to students' excitement and perceived value of the sessions. It is unlikely that any single ultrasound curriculum will be effective for every UME program. Instead, with a thorough understanding of the various factors influencing students' level of engagement, educators can employ strategies that will allow for more effective ultrasound initiatives and curricular efforts at the UME level.

MATERIALS AND METHODS

This study was performed at the Medical College of Wisconsin during the first-year medical student Clinical Human Anatomy (CHA) course of the 2019-2020 academic year. This course taught students the structural aspects of the human body and clinical correlations to regional anatomy using both didactic lectures and cadaveric dissections. During cadaver dissection lab, all students were invited to participate in a scanning session in groups of 5 or 6, with 1 or 2 being asked to serve as a "peer model" for the group. If consent was given, a faculty facilitator used ultrasound to identify anatomical structures relevant to the current anatomy unit (ie, Back and Upper Limb, Thorax and Abdomen, Pelvis and Lower Limb, Head and Neck) and highlighted clinical implications of these structures. After an initial demonstration activity by the facilitator, each student was given the opportunity for hands-on scanning. Each session was 30 minutes long, and 4 sessions were offered throughout the course. In addition, 3 informational 30-minute webcasts were created by a course instructor with extensive clinical ultrasound use and also offered online for students' optional viewing. These webcasts covered basic ultrasound physics (eg, acoustic waves, frequency), instrumentation and "knobology" (eg, freezing the frame, measuring tools), modalities and techniques (eg, B-mode, M-mode, Doppler), and ultrasound applications in specific specialties, such as obstetrics, cardiology, and anesthesiology.

Ultrasound sessions were developed strictly as a value-added component of the course, rather than a mandatory component of the curriculum on which students were assessed. While participation was entirely voluntary and did not affect students' grades in the course, nearly all – if not all – students chose to participate. Facilitators included radiologists, physiatrists, obstetricians and gynecologists, anesthesiologists, emergency medicine physicians, and cardiologists. In addition to allowing for built-in hands-on ultrasound probe time for the students, facilitators were instructed on specific images to capture during the session related to the current anatomy unit (eg, Thorax: 4-chamber view of the heart, great vessels; Abdomen: liver, gallbladder, kidneys; Head and Neck: thyroid, neck vessels). Throughout the sessions, facilitators also highlighted the utility of various probes (eg, linear, curvilinear, phased array) and explained different ultrasound modalities (eg, B-mode, Doppler, M-mode).

A brief Qualtrics survey (Provo, Utah) was created and distributed in coordination with the first-year CHA course. This survey was constructed by a single study investigator as a novel means to evaluate the ultrasound education sessions, prior to being reviewed by the remainder of the study team. The survey was released on May 13, 2020, with the end-of-course evaluation to 206 first-year medical students, all of whom had been invited (but not required) to participate in the ultrasound sessions. Anonymous responses were collected for 1 week until May 20, 2020. Participants were first asked to rate on a numerical scale of 1 to 10 their answers to the following questions: "How excited were you to participate in the ultrasound education sessions when they were available in lab?" and "How valuable was the information covered during ultrasound educations sessions toward your clinical training as a physician?" A rating of 1 equated to "not excited" or "not valuable," and a rating of 10 equated to "extremely excited" or "extremely valuable." Participants were then asked to expound on factors that affected their ratings through the following open-ended prompts: "Please explain what would have made you more excited to participate in these sessions," and "Please explain why you did or did not find this information valuable." Excitement and perceived value ratings were chosen as intermediaries for assessing students' level of engagement with the sessions.

Data collected from the student survey included numerical ratings for students' excitement and perceived value of the ultrasound sessions, as well as qualitative feedback on factors that affected these ratings. When analyzing qualitative feedback, thematic analysis was performed. Thematic analysis has been shown

to be a powerful research method used for analyzing qualitative data when the relationships and patterns within a data set are instrumental to answering the research question.[18] Using Kiger and Varpio[19] as a guide to thematic analysis, free-response answers were organized, coded, and separated into distinct themes to reflect on students' experiences, as described below. Coding was performed initially by a single investigator before subsequent validation by a doctorate-level statistician, neither of whom held a teaching role within the anatomy course. The statistician had prior experience in thematic analysis and debriefed the study team on the iterative process using prior studies and referencing Kiger and Varpio.[19]

After becoming familiar with the entire data set of student responses, "codes" were generated within each individual's free-response answer. Each code contained a basic, unique element that influenced the participant's experience during the ultrasound sessions and affected their rating. As a result, each individual's response could have multiple codes.[19] After all students' free-response extracts were coded, patterns and connections between codes were identified to help develop "themes" of broader significance. Each theme was independently meaningful and added perspective to the overall question. An inductive approach was used when developing all codes and themes, meaning that determination of codes and themes was data-driven as there were no set preexisting codes or themes prior to reviewing the free responses.[20] The entire thematic analysis was an iterative process to discern appropriate fit of codes into refined themes. When there was disagreement among the team in the significance of a theme or in the distinction between themes, the reviewers discussed whether the codes within a theme formed a coherent pattern, whether the themes were valid in relation to the entire data set of codes, and, when reviewed together, whether the themes were an accurate representation of the data set as a whole. This resulted in some candidate themes being collapsed to form a single theme, while other themes were too diverse and were separated into multiple themes.

Finally, students' numerical ratings for excitement and perceived value were grouped by theme in order to determine which themes were associated with higher or lower ratings. For example, if any of an individual student's codes fit in the "Aided Learning of Anatomy/Structures" theme, the student's numerical rating was grouped with other students' ratings who also made related statements. Descriptive statistics of ratings were then calculated by theme to assess which factors had the greatest impact on students' excitement and perceived value of the sessions.

RESULTS

Sixty-three surveys were returned from the 206 individuals included in the survey group. However, while all 63 participants provided a numerical rating for both excitement and perceived value, only 54 of these responses included answers to 1 or both of the free-response prompts. Because free-response answers were needed in order to be incorporated into the study's thematic analysis, in accordance with the consensus statement of the American Association of Public Opinion Research,[21] the adjusted response rate was 26.2%." Of the 54 returned surveys that included free-response answers, there were 40 fully completed responses, including ratings for both questions as well as free-response answers to both prompts.

Table 1. Themes Identified for Student Excitement and Perceived Value

	No. of Codes (%)
Feedback Theme: Excitement (n = 65)	
Poor timing of sessions/not scheduled	17 (26.2)
Applicable to clinical setting	9 (13.8)
Desired more time/opportunities	8 (12.3)
Active clinical demonstrations (positive)	7 (10.8)
Lacked understanding of ultrasound basics	7 (10.8)
No incentive to learn/not tested	5 (7.7)
Environment not conducive to learning	4 (6.1)
Instructors (positive)	3 (4.6)
Instructors (negative)	3 (4.6)
Student unprepared for session	2 (3.1)
Feedback Theme: Perceived Value (n = 66)	
Clinical utility (positive)	27 (40.9)
Aided learning of anatomy/structures	12 (18.2)
Provided basic ultrasound appreciation	12 (18.2)
No incentive to learn/not tested	10 (15.2)
Lack of session structure/adequate time	3 (4.5)
Clinical utility (negative)	2 (3.0)

Ten themes were identified for Student Excitement, with the number of codes per theme ranging from 2 to 17. Six themes were identified for Student Perceived Value, with the number of codes per theme ranging from 2 to 27.

Sixty-five unique codes were generated from 45 students' responses regarding factors influencing their excitement. After reviewing the codes, 10 themes were established, with the number of individual codes in each theme ranging from 2 to 17 (see Table 1). Themes relating to the overall organization of ultrasound sessions (eg, session structure, scheduling/frequency, scanning volume) were among the themes that contained the most feedback data. In addition to session organization, several students reported that session content influenced their excitement – particularly the clinically focused demonstrations and clinical applications. Students also reflected on how both the instructors and learning format affected their engagement level. Finally, students stated the lack of incentive to engage in or prepare for the sessions affected their enthusiasm, as these sessions were optional. Taken together, themes reflected several factors influencing students' excitement or lack of excitement for the sessions, including both the organization and content of the sessions, the environment in which students learned, and students' personal motivation toward the sessions. Representative extracts from each theme can be seen in Table 2, and the overall

Table 2. Student Excitement for Ultrasound Sessions

Theme	Representative Excerpts
Poor timing of sessions/not scheduled	"I loved the sessions but always felt like when I was at them, I was getting behind on lab but maybe if they were explicitly on the schedule, it would feel less like that" … "It's hard to switch from elbows deep in the dissection to going to the radiology room" … "I think having a more set schedule for when we were going to be having our ultrasound lesson would help, as I often felt like we were pulled away in the middle of a specific lab task"
Applicable to clinical setting	"I enjoyed seeing structures from a point of view that we will be using as clinicians" … "ultrasound was something I knew we as medical students would have to understand for the future and so something that seemed like it would be useful for clinic sounded awesome"
Desired more time/opportunities	"I wish there were more sessions!" … "allocating more time to each session would be helpful as I felt rushed at times"
Active clinical demonstrations	"Demonstrations where the 'patient' would do something (eg, flex a muscle to see the tendon slide) were very intuitive to me and aided my understanding" … "I liked that we got to practice on each other and be able to handle the machine ourselves"
Lacked understanding of ultrasound basics	"I believe most people were excited or at least somewhat interested to learn about ultrasound but had no knowledge whatsoever about the field or its fundamentals, which made it confusing"
No incentive to learn/ not tested	"The sessions were very helpful and informative, but not on the test and thus took lower priority" … "while I was very interested in ultrasound, it didn't feel necessary for me to master the course" … "maybe having ultrasound images on the exam would make me more interested"
Environment not conducive to learning	"I think sometimes the overzealousness of other classmates hindered my learning, and I didn't want to take too long learning if I was orienting the probe wrong because my classmates still needed to learn, too" … "what would have made me more excited to participate would have been less cadaver smell and less dirty scrubs"
Instructors (positive)	"I had a great time interacting with the radiology team and anesthesiologists"
Instructors (negative)	"The instructors would sometimes go on tangents rather than helping us find structures" … "if the faculty were more enthusiastic about ultrasound, I would be more interested"
Student unprepared for session	"Sometimes it was hard to follow along when the topic covered in the ultrasound lab was what we had just talked about in lecture—in those cases, I hadn't yet studied that specific material and wasn't very comfortable with it yet"

Table 3. Student Perceived Value of Ultrasound Sessions

Theme	Representative Excerpts
Clinical utility (positive)	"Any exposure we have to clinical tools is extremely beneficial" … "even if we may not be directly involved in conducting ultrasounds ourselves in the future, we may find ourselves in situations where we need to interpret findings from ultrasounds" … "ultrasound is increasingly used in majority of medical specialties today" … "the radiologist had a clinical story for each part, which really made me appreciate the skills we were learning" … "I was able to better understand what my preceptor was showing me in clinic on the ultrasound"
Aided learning of anatomy/structures	"Sessions provided another dimension to learning and remembering anatomy" … "ultrasound helped me to build a better mental map of the human body"
Provided basic ultrasound appreciation	"Having no prior experience with ultrasound, I think it was important to learn at least a basic understanding of ultrasound, how it works, and how to use it effectively" … "I think it was helpful for learning the very basics of how to use an ultrasound" … "while I definitely do not feel like I have a solid understanding of ultrasound yet, having these lab sessions gave me an important first look, appreciation, and more knowledge than I had prior to lab"
No incentive to learn/ not tested	"Most likely because we weren't being tested on ultrasound in any form, I noticed that several of my group members didn't go to the sessions" … "it was such a limited scope of practice that I feel I've already forgotten most of what I learned about ultrasound and will need to relearn it to make it valuable as a clinician"
Lack of session structure/adequate time	"This part of lab needs to be more structured and have more defined goals" … "I wish we had access to this outside of lab hours, because I sometimes felt like my group was in a hurry to get back to our dissection because we still had a lot to finish"
Clinical utility (negative)	"Sessions seemed to be very isolated cases of trying to identify structures and there weren't many explicit applications to understanding how physicians actually use this in clinic"

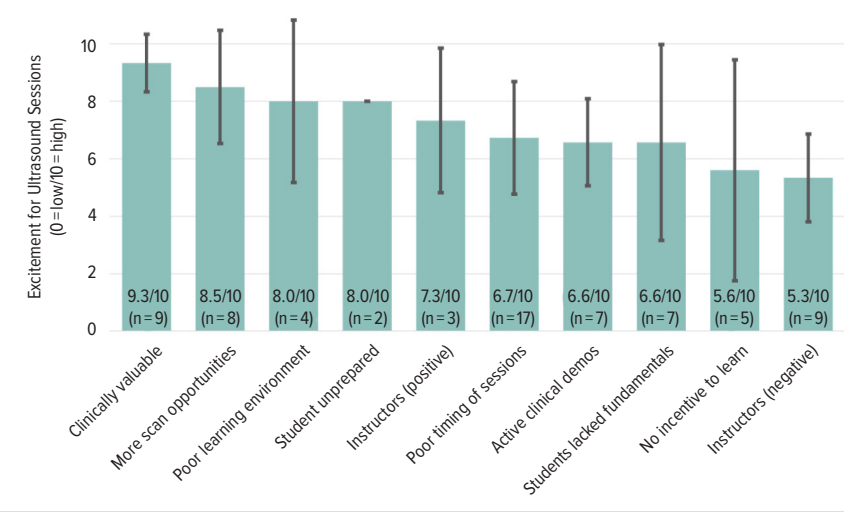
interpretation for each theme can be seen in Appendix A.

Sixty-six unique codes were generated from 46 students' responses regarding factors influencing their perceived value of the sessions. After reviewing the codes, 6 themes were established, with the number of individual codes in each theme ranging from 2 to 27 (see Table 1). Students again specifically addressed the role of session content in their perceived value and its effects on learning – for the clinical setting, for the anatomy course directly, and in their understanding of ultrasound. Feedback data also acknowledged that the voluntary nature of the sessions, as well as how the sessions were structured, affected how students viewed the sessions. Broadly, these themes again reflected the impact of session content and organization—as well as personal motivation – on the value that students derived from the sessions. Representative extracts from each theme can be seen in Table 3, and the overall interpretation for each theme can be seen in Appendix B.

Students' numerical ratings for excitement and perceived value

of the sessions were then plotted by theme. (See Figures 3 and 4.) Ratings varied by theme; however, clinical relevance/utility consistently was identified as the most important factor in generating student engagement. Students who found the sessions clinically valuable reported the highest excitement rating among all themes (9.33/10). Similar results were reflected in perceived value ratings, as students who identified the ultrasound sessions as clinically relevant and essential to their future in medicine found the sessions to be the most valuable (8.22/10), while students who stated the sessions were not clinically relevant reported the lowest perceived value rating (3.50/10). In fact, students who found the sessions valuable because of their clinical utility reported higher perceived value ratings than students who identified the sessions as helping them learn anatomy course content (8.22/10 vs 7.00/10, respectively).

Figure 1. Student Excitement Rating by Theme

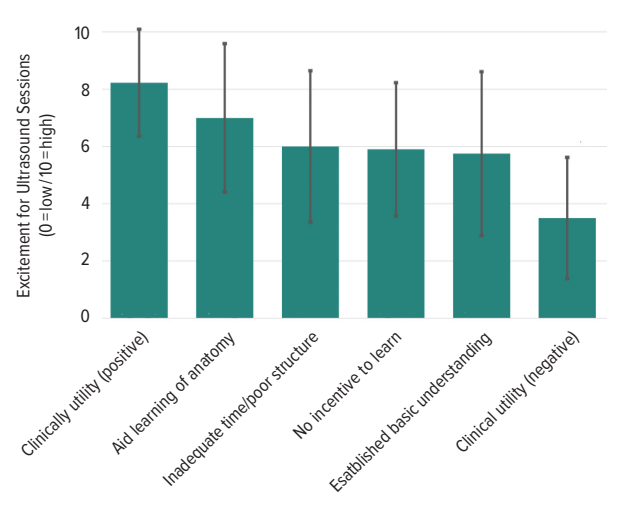


Themes in student excitement arranged by descending average excitement rating. Group size indicates the number of codes that fit within the theme.

As expected, ratings from students who cited no motivation or incentive to engage as an impacting factor were among the lowest excitement (5.60/10, second-lowest excitement rating) and lowest perceived value (5.90/10, third-lowest value rating) ratings. However, there were some themes that generated higher ratings than expected. Students who desired more opportunities and time for scanning reported the second-highest excitement rating among all themes (8.50/10), and students who commented that the environment was not conducive to learning reported the third-highest excitement rating (8.00/10).

Mixed results were seen from themes relating to instructors. Students who made negative remarks regarding instructors had the lowest excitement scores among all themes (5.33/10), while students who made positive remarks regarding instructors rated their excitement 2 points higher (7.33/10). However, this theme was still ranked as only the fifth-highest student excitement rating.

Figure 2. Student Preceived Value Rating by Theme



Themes in student perceived value arranged by descending average value ratings. Group size indicates the number of codes that fit within the theme.

DISCUSSION

Using thematic analysis, this study identified several factors affecting medical students' engagement with ultrasound education in a human anatomy course. Clearly, the content of ultrasound sessions is critically important for engaging learners, both in preparing them for clinical responsibilities and for learning anatomy. However, there must first be either personal motivation or incentive to engage on the student's behalf if sessions are scheduled during competing academic activities or course components. In addition, it is important to consider the overall learning environment, structure, and timing of sessions as having an impact on students' excitement and perceived value. Educators may improve student engagement and ultimately better prepare student-doctors in their ultrasound education efforts and across UME more broadly by addressing these factors.

Clinical relevance/utility was identified consistently as the single most important factor influencing students' excitement and perceived value. Students' examples of clinical benefits gained during the sessions included understanding when ultrasound could be used to determine a medical diagnosis, supplementing their physical exam skills, early exploration of medical specialties that utilize ultrasound, and becoming familiar with terminology and images that are seen in students' clinical learning environments (eg, student-run clinic, early-exposure preceptorships, etc). Moving

forward, these ultrasound sessions could be approached from a more clinical perspective by including mock patient cases where students must brainstorm appropriate uses of ultrasound imaging to determine a diagnosis instead of seeking only to capture specific views of relevant organs during the sessions. While incorporating ultrasound into anatomy courses certainly aids students' learning of anatomy, it undoubtedly has further-reaching, secondary outcomes of enhancing students' career exploration and clinical skillset as well.

One factor that played a greater role than expected in affecting engagement in this cohort of students was the fact that sessions were not mandatory, and thus, students were not tested on ultrasound material. The reason these sessions were not mandatory was to avoid review by the medical school's curriculum and evaluation committee, which would result in more standardized objectives and testing requirements. These sessions were strictly meant to be a value-added component of the curriculum. However, because students were not tested on the material, their engagement suffered as a result. In addition, while this ultrasound program was used as a supplementary resource to the anatomy course alone, the ideal ultrasound curriculum may be one in which ultrasound training in anatomy courses provides just the initial component of a more robust, longitudinally integrated ultrasound program. Findings from this study suggest that ultrasound also could be incorporated into courses such as physical exam courses or clinical clerkships, as students were most engaged when material was presented from a clinical perspective. While opportunities for increased scanning time may be limited in the medical school curriculum itself, hosting voluntary "office hours" apart from dissection lab or establishing an Ultrasound Interest Group may be feasible extracurricular methods to further promote ultrasound education among medical students.[22]

The primary strength of this study was in its use of thematic analysis. By translating students' free-response prompts into overall themes, this method captured data that would not be available through numerical ratings alone. Furthermore, this method identified important factors to consider when targeting improved student engagement that are appropriate not only for the intended CHA course, but also among other basic science courses and in medical education more broadly.

Although the results of the study were informative regarding medical student engagement, the current study had the following limitations. The survey could have benefited from a pilot distribution to a subset of students. This would have allowed for changes to be made prior to the larger distribution in order to better justify the survey as a valid assessment tool. Additionally, just over 25% of those surveyed returned responses that were usable for this study's analysis, which resulted in some themes having low code volumes. Receiving limited responses to the survey may introduce bias into the analysis and limit its generalizability, as it is commonly individuals with the strongest opinions – both positive and negative – who respond, while the more moderate voices may be underrepresented. Despite this, with greater than 50 respondents, numerous codes were identified that still generated several strong themes. One additional limitation included the fact that this was a purely observational, subjective study, as responses reflected students' own assessment of their excitement and perceived value.

CONLCUSIONS

This study used thematic analysis to evaluate qualitative feedback from medical students regarding their level of engagement in ultrasound education sessions in an UME anatomy course. Multiple factors were identified that may impact their excitement and perceived value of the sessions, including clinically relevant content, personal motivation, learning environment, and session organization.

Moving forward, next steps will include putting interventions into place in ultrasound sessions to explore how direct, student-driven improvements may translate into greater student engagement. Additionally, evaluating objective measures for students' interest, information retention, and subsequent use of ultrasound in clinical settings would offer enhanced insight into the role of ultrasound education on higher-level outcomes.

Financial Disclosures: None declared.

Funding/Support: None declared.

Acknowledgements: The authors would like to thank Tavinder Ark, PhD, for her insight and assistance with the thematic analysis.

Appendices: Available at www.wmjonline.org

REFERENCES

1. van Alfen N, Gijsbertse K, de Korte CL. How useful is muscle ultrasound in the diagnostic workup of neuromuscular diseases? *Curr Opin Neurol.* 2018;31(5):568-574. doi:10.1097/WCO.0000000000000589

2. Costantino TG, Parikh AK, Satz WA, Fojtik JP. Ultrasonography-guided peripheral intravenous access versus traditional approaches in patients with difficult intravenous access. *Ann Emerg Med.* 2005;46(5):456-461. doi:10.1016/j.annemergmed.2004.12.026

3. Li Y, Carandang RA, Ade S, Flahive J, Daniello K. Ultrasound-guided lumbar puncture improves success rate and efficiency in overweight patients. *Neurol Clin Pract.* 2020;10(4):307-313. doi:10.1212/CPJ.0000000000000725

4. Leung J, Duffy M, Finckh A. Real-time ultrasonographically-guided internal jugular vein catheterization in the emergency department increases success rates and reduces complications: a randomized, prospective study. *Ann Emerg Med.* 2006;48(5):540-547. doi:10.1016/j.annemergmed.2006.01.011

5. Mercaldi CJ, Lanes SF. Ultrasound guidance decreases complications and improves the cost of care among patients undergoing thoracentesis and paracentesis. *Chest*. 2013;143(2):532-538. doi:10.1378/chest.12-0447

6. Beals T, Naraghi L, Grossestreuer A, Schafer J, Balk D, Hoffmann B. Point of care ultrasound is associated with decreased ED length of stay for symptomatic early pregnancy. *Am J Emerg Med.* 2019;37(6):1165-1168. doi:10.1016/j.ajem.2019.03.025

7. Kimura BJ. Point-of-care cardiac ultrasound techniques in the physical examination: better at the bedside. *Heart*. 2017;103(13):987-994. doi:10.1136/heartjnl-2016-309915

8. Kobal SL, Trento L, Baharami S, et al. Comparison of effectiveness of hand-

carried ultrasound to bedside cardiovascular physical examination. *Am J Cardiol.* 2005;96(7):1002-1006. doi:10.1016/j.amjcard.2005.05.060

9. Benninger B. Google Glass, ultrasound and palpation: the anatomy teacher of the future? *Clin Anat.* 2015;28(2):152-155. doi:10.1002/ca.22480

10. Sekiguchi H. Tools of the trade: point-of-care ultrasonography as a stethoscope. *Semin Respir Crit Care Med.* 2016;37(1):68-87. doi:10.1055/s-0035-1570353

11. Bledsoe A, Zimmerman J. Ultrasound: the new stethoscope (point-of-care ultrasound). *Anesthesiol Clin*. 2021;39(3):537-553. doi:10.1016/j.anclin.2021.03.011

12. Taylor A, Koratala A, Jha P. Do internal medicine hospitalists and advanced practice providers desire training in diagnostic point-of-care ultrasound? A cross sectional survey. *WMJ*. 2023;122(1):3.

13. Bahner DP, Goldman E, Way D, Royall NA, Liu YT. The state of ultrasound education in U.S. medical schools: results of a national survey. *Acad Med.* 2014;89(12):1681-1686. doi:10.1097/ACM.0000000000000414

14. Nicholas E, Ly AA, Prince AM, Klawitter PF, Gaskin K, Prince LA. The current status of ultrasound education in United States medical schools. *J Ultrasound Med.* 2021;40(11):2459-2465. doi:10.1002/jum.15633

15. Patel SG, Benninger B, Mirjalili SA. Integrating ultrasound into modern medical curricula. *Clin Anat.* 2017;30(4):452-460. doi:10.1002/ca.22864

16. Davis JJ, Wessner CE, Potts J, Au AK, Pohl CA, Fields JM. Ultrasonography in undergraduate medical education: a systematic review. *J Ultrasound Med.* 2018;37(11):2667-2679. doi:10.1002/jum.14628

17. Rempell JS, Saldana F, DiSalvo D, et al. Pilot point-of-care ultrasound curriculum at Harvard Medical School: early experience. *West J Emerg Med*. 2016;17(6):734-740. doi:10.5811/westjem.2016.8.31387

18. Braun V, Clarke V. Thematic analysis. In: *APA Handbook of Research Methods in Psychology, Vol 2: Research Designs: Quantitative, Qualitative, Neuropsychological, and Biological.* American Psychological Association; 2012:57-71. doi:10.1037/13620-004

19. Kiger ME, Varpio L. Thematic analysis of qualitative data: AMEE Guide No. 131. *Med Teach*. 2020;42(8):846-854. doi:10.1080/0142159X.2020.1755030

20. Braun V, Clarke V. Using thematic analysis in psychology. *Qual Res Psychol.* 2006;3(2):77-101. doi:10.1191/1478088706qp063oa

21. American Association of Public Opinion Research. Standard Definitions: Final disposition of case codes and outcome rates for surveys. Revised 2016. Accessed June 30, 2016. https://aapor.org/wp-content/uploads/2022/11/Standard-Definitions20169theditionfinal.pdf

22. Dubosh NM, Kman N, Bahner D. Ultrasound interest group: A novel method of expanding ultrasound education in medical school. *Crit Ultrasound J.* 2011;3(3):131-134. doi:10.1007/s13089-011-0088-x

advancing the art & science of medicine in the midwest

WMJ

WMJ (ISSN 1098-1861) is published through a collaboration between The Medical College of Wisconsin and The University of Wisconsin School of Medicine and Public Health. The mission of *WMJ* is to provide an opportunity to publish original research, case reports, review articles, and essays about current medical and public health issues.

Visit www.wmjonline.org to learn more.