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Two-week intensive medical student point-of-care ultrasound training impact on long term utilization

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Abstract

Background There is little to no data evaluating long term usage of point of care ultrasound (POCUS) after a training intervention for medical students. The purpose of this study was to examine the impact of an intensive POCUS training program on medical student's usage at 9-months post-program.

Methods This was a prospective cross-sectional study of rising second year medical students who participated in a 2-week summer POCUS training program. Instruction consisted of 8 h of asynchronous online didactic material, 2–4 h of daily hands-on instructor-led and independent scanning, and instruction on how to teach POCUS. Students were assessed pre- and post-program, and again at 9 months post-program to evaluate POCUS usage.

Results A total of 56 students participated in the program over 2 summers; 52 (92.9%) responded to the 9-month post-program survey. At 9 months, 49 (94.2%) of students taught POCUS after the program to peers or faculty. Students reported serving as a POCUS instructor in 283 subsequent teaching sessions accounting for 849 h of POCUS instruction time. Six (11.5%) students were involved in the creation of a POCUS interest group on their regional campus, 7 (13%) created a POCUS curriculum for their student interest group, and 4 (7.7%) created an opt-in co-curricular POCUS program for students at their regional campus. Three (5.8%) students did not serve as educators after the program and only one student reported not using POCUS again after the program.

Conclusion After a 2-week intensive POCUS training program for medical students, the majority of students demonstrated continued involvement in POCUS learning and education at 9-month follow-up including serving as peer instructors and assisting with limitations in financial resources and trained faculty.

Keywords Point-of care ultrasound, POCUS, POCUS education, Medical education, Peer instruction, Student-led instruction

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Background

Point-of-care ultrasound (POCUS) is a non-invasive diagnostic imaging technique that has become increasingly recognized as an important tool for physicians in most specialties. Generally, education and training of POCUS was reserved for residency programs. In recent years, however, medical student training has expanded with most medical schools now including some ultrasound training in the curriculum [1–3]. These curricula serve to train students in the use of POCUS and serve as a scaffolding to reinforce the medical school curriculum [1–5] by strengthening physical exam training and furthering the understanding of anatomical structures and relationships [6–8].

Traditionally, POCUS training has been provided by experienced physicians or diagnostic sonographers. However, POCUS training is labor-intensive, time-consuming, and expensive. Additionally, a lack of trained faculty is often cited as a barrier to implementation of POCUS into undergraduate medical education curricula [1]. In recent years, there has been a growing interest in using medical students to train other students in POCUS [9, 10]. Peer-teaching, simulation-based education, and gamification-driven educational programs have all been described [11–15]. Peer teaching, particularly, has been shown to be an effective way for students to retain knowledge even after short courses and decrease resources needed to implement POCUS into undergraduate medical education [16–18].

In this study we examined the effect of creating and implementing a two-week intensive summer POCUS training program for incoming second-year medical students that included didactic lectures and hands-on training. Specifically, we evaluated the efficacy of this curriculum based on Kirkpatrick levels 2 (learning and attitudes) and 3 (behavioral changes after learning) [19]. The study's main aim was to evaluate the 2-week POCUS summer curriculum's impact on medical student behavior by determining how often students continued ultrasound engagement in the 9-months following course completion. Our secondary goal was to determine student changes in knowledge, psychomotor skill, and attitude towards POCUS before and immediately after course completion.

Methods

This was a prospective cross-sectional study of a summer training program for second year medical students. This study was approved by the local institutional review board.

Students were recruited from a multi-site allopathic medical school that has an integrated, longitudinal POCUS curriculum to participate in a two-week summer training program. Students completed a pre-survey that included demographic elements and baseline POCUS skills and experience. Students were questioned about their confidence level in several areas including: performing POCUS, differentiating between normal and abnormal exam images, and their ability to teach POCUS to other learners. The same survey was re-administered at the conclusion of the summer program (see Supplementary Material Table 1).

Students were taught POCUS using both asynchronous materials delivered online and dedicated hands-on training sessions. Instructors were POCUS trained emergency medicine faculty and ultrasound imaging technology students who received directed POCUS education on modalities taught during the course.

Before hands-on training sessions, students had to complete asynchronous learning material delivered via an online learning management system (LMS) (Canvas by Instructure, Salt Lake City, Utah) for each modality. Students reviewed lectures created by POCUS trained emergency medicine faculty that required approximately 8 h to complete. Students completed a quiz prior to viewing the asynchronous material and participating in hands-on training and then repeated a post-quiz for each training session to assess their knowledge acquisition.

After completion of asynchronous material, students participated in hands-on ultrasound skill labs where they scanned human models. The students used either a Philips Lumify or Butterfly IQ handheld ultrasound probe. Hands-on skill labs amounted to 20 h of instruction time during the 2-week course.

Psychomotor skills were assessed at the end of the 2-week program by one of three POCUS trained faculty members or by a sonography student who had completed their first year of sonography training. During the assessment, students were asked to perform various views of different POCUS exams on a standardized patient (see Supplementary Material Table 2). Students were evaluated on their ability to obtain images and recognize key anatomic structures in each view. Nine months post-course, students completed a third survey evaluating their post-course POCUS usage (see Supplementary Material Table 3). Study data were collected and managed using REDCap electronic data capture tools hosted at Indiana University [20, 21].

Statistical analysis

Hands-on POCUS evaluations were administered as part of the program. Each year included a pre and a post evaluation. The exact binomial test was used for binary data, and the sign test was used for scale data to measure significant improvement/worsening from pre to post. The type of ultrasound machine used (Butterfly IQ or Philips Lumify) was recorded and compared with the exact binomial test to see if either time-period was significantly associated with either type of ultrasound machine.

The same POCUS surveys were given to students in both 2021 and 2022. Each year included a pre, post, and Spring follow-up survey. Comparisons were made between the pre and post surveys and the post and Spring follow-up periods using the sign test.

Results

Fifty-six second year medical students completed the curriculum; 28 students in both years and 50% were female. The majority of students planned to go into internal medicine, surgery, or emergency medicine as future specialties, see Table 1 for student demographics.

Table 1 Student demographics and pre-curricular ultrasound experience, n (%)

	2021	2022
Gender	***n* = 28**	***n* = 28**
Male	12 (42.9%)	16 (57.1%)
Female	16 (57.1%)	12 (42.9%)
Age		
Mean (SD), range	23.68 (1.56), 22–29	24.11 (2.28), 21–32
Future Intended Specialty		
Internal Medicine	7 (25%)	6 (21.4%)
Surgery	3 (10.7%)	7 (25%)
Emergency Medicine	5 (17.9%)	5 (17.9%)
Radiology	4 (14.3%)	5 (17.9%)
Anesthesia	4 (14.3%)	4 (14.3%)
Other	5 (17.9%)	1 (3.6%)
Prior ultrasound experience		
Little to none	15 (53.6%)	20 (71.4%)
I had an US exam performed on me as a patient	8 (28.6%)	5 (17.9%)
I had an US exam performed on me as a training model	4 (14.3%)	0 (0%)
I had another experience	8 (28.6%)	5 (17.9%)
Reviewed POCUS modules within the last year		
Introduction	28 (100%)	27 (96.4%)
Physics	21 (75%)	21 (75%)
Head and neck	8 (28.6%)	9 (32.1%)
Lower Extremity Veins	10 (35.7%)	25 (89.3%)
Aorta	25 (89.3%)	24 (85.7%)
Pelvis	5 (17.9%)	12 (42.9%)
Ocular	1 (3.6%)	11 (39.3%)
Liver, Spleen, and Bowel	25 (89.3%)	27 (96.4%)
Cardiac and Thoracic	22 (78.6%)	27 (96.4%)
Renal	6 (21.4%)	15 (53.6%)
Attended a hands-on POCUS scanning session within the last year		
Anatomy lab	25 (89.3%)	22 (78.6%)
Physical examination class	3 (10.7%)	9 (32.1%)
POCUS Interest Group	1 (3.6%)	9 (32.1%)
Other	2 (7.1%)	4 (14.3%)

Thirty-five (62.5%) students had little to no prior POCUS experience before the curriculum; 15 in 2021 and 2022. All students had previously reviewed at least one POCUS module during their first year of medical school and most students completed the introductory, aorta, abdomen, cardiac and thoracic modules. Most students completed at least one hands-on POCUS training session during their first-year anatomy course prior to starting the program (See Table 1 for student demographics and pre-curricular experience assessment).

Psychomotor skill

Comparing student's ability to acquire ultrasound images and identify anatomy from pre- to post-curriculum we found a significant improvement in their ability to acquire images and identify pertinent anatomy (see Table 2). Quality of images acquired as assessed on a 5-point scale also significantly improved ($p < 0.001$). We found no significant association between the type of handheld ultrasound device used ($p = 0.687$).

Confidence

When evaluating confidence from pre- to post-curriculum, in both cohorts, we found students felt significantly more confident with operating the machine ($p < 0.001$), obtaining images of anatomic structures like the liver, aorta, and kidney ($p < 0.001$), recognizing anatomic structures on the ultrasound screen ($p < 0.001$), ability to differentiate normal from abnormal anatomy ($p < 0.001$), and teaching other medical students in POCUS ($p < 0.001$).

At 9-months post-program, all students felt significantly more confident with operating the machine, obtaining images, recognizing anatomic structures, and teaching other medical students POCUS from baseline (pre-curriculum), $p < 0.001$. However, when comparing post-curriculum to 9-months post-curriculum in the initial student cohort we found student's confidence in their ability to perform pregnancy, soft tissue, aorta and ocular POCUS decreased significantly, while their confidence remained high in cardiac, lung, FAST and DVT. In the second cohort of students, confidence remained high for all modalities except pregnancy and soft tissue.

Long term impact

Long term impact of the program was assessed 9 months after conclusion of the program. Fifty-two students completed the 9-month post-program survey; 25 in 2021, 27 in 2022. We found that 49 of 52 (94%) students taught POCUS to peers and faculty after completing the 2-week program (see Fig. 1). In total, students instructed at 283 sessions, covering about 849 h of POCUS instructor time (see Fig. 2). In addition to assisting with peer teaching within the faculty developed school of medicine curriculum, six (11.5%) students were involved in

Table 2 Pre and post skills assessment

2021				**2022**				**Total**			
n	**Before**	**After**	**p-value**	**n**	**Before**	**After**	**p-value**	**n**	**Before**	**After**	**p-value**
Able to acquire an image of the hepatorenal recess (Morison's Pouch)?											
28	14 (50%)	28 (100%)	0.0001	28	20 (71.4%)	28 (100%)	< 0.0001	56	34 (60.7%)	56 (100%)	< 0.0001
Identifies Liver/Kidney and Morison's Pouch											
28	6 (21.4%)	28 (100%)	< 0.0001	27	19 (70.4%)	27 (100%)	< 0.0001	55	25 (45.5%)	55 (100%)	< 0.0001
Identifies where free fluid collects											
28	6 (21.4%)	28 (100%)	< 0.0001	28	15 (53.5%)	27 (96.4%)	0.0018	56	21 (37.5%)	55 (98.2%)	< 0.0001
Able to acquire and image of the left kidney in long access?											
28	4 (14.3%)	27 (96.4%)	< 0.0001	28	20 (71.4%)	27 (96.4%)	0.0390	56	24 (42.8%)	54 (96.4%)	< 0.0001
Identifies the renal sinus from the renal parenchyma											
28	3 (10.7%)	25 (89.3%)	< 0.0001	28	13 (46.4%)	28 (100%)	< 0.0001	56	16 (28.6%)	53 (94.6%)	< 0.0001
Able to acquire an image of the proximal aorta in short axis?											
28	15 (53.6%)	28 (100%)	0.0002	28	13 (46.4%)	26 (92.8%)	0.0002	56	28 (50%)	54 (96.4%)	< 0.0001
Identifies the vertebral body, abdominal aorta, and SMA											
27	1 (3.7%)	21 (77.8%)	< 0.0001	27	4 (14.3%)	14 (50%)	0.0212	54	5 (9.2%)	35 (64.8%)	< 0.0001
Describes where the calipers are placed to measure the abdominal aorta											
28	1 (3.6%)	25 (89.3%)	< 0.0001	28	6 (21.4%)	28 (100.00%)	< 0.0001	56	7 (12.50%)	53 (94.64%)	< 0.0001
Able to acquire a parasternal long axis view of the heart?											
28	9 (32.1%)	28 (100%)	< 0.0001	28	12 (42.86%)	28 (100.00%)	< 0.0001	56	21 (37.50%)	56 (100.00%)	< 0.0001
Identifies the LV, RV, MV, LA, Proximal Aorta											
28	1 (3.6%)	24 (85.71%)	< 0.0001	28	0 (0%)	27 (96.43%)	< 0.0001	56	1 (1.79%)	51 (91.07%)	< 0.0001
Able to acquire a subxiphoid view of the heart?											
28	11 (39.3%)	28 (100%)	< 0.0001	28	17 (60.7%)	28 (100.00%)	0.0009	56	28 (50.00%)	56 (100.00%)	< 0.0001
Identifies LV, RV, RA											
28	1 (3.6%)	22 (78.6%)	< 0.0001	**28**	**6 (21.4%)**	24 (85.71%)	< 0.0001	56	7 (12.50%)	46 (82.14%)	< 0.0001
Able to identify the RV in subxiphoid view?											
28	1 (3.6%)	22 (78.5%)	< 0.0001	28	7 (25%)	24 (85.71%)	< 0.0001	56	8 (14.29%)	46 (82.14%)	< 0.0001
Able to acquire an image of the gallbladder in long axis?											
28	9 (32.1%)	25 (89.3%)	0.00014	28	11 (39.3%)	28 (100.00%)	< 0.0001	56	20 (35.71%)	53 (94.64%)	< 0.0001
Identifies the gallbladder and the liver											
28	7 (25%)	26 (92.8%)	< 0.0001	28	13 (46.4%)	28 (100.00%)	< 0.0001	56	20 (35.71%)	54 (96.43%)	< 0.0001
Able to acquire a transverse view of the bladder?											
28	4 (14.3%)	27 (96.4%)	< 0.0001	28	12 (42.9%)	26 (92.9%)	0.0005	56	16 (28.57%)	53 (94.64%)	< 0.0001
If a male model, identifies the prostate											
28	2 (7.1%)	24 (85.7%)	< 0.0001	14	1 (7.14%)	8 (57.14%)	0.01563	42	3 (7.14%)	32 (76.19%)	< 0.0001
If a female model, identifies the vagina and uterus (if present)											
28	1 (3.57%)	23 (82.1%)	< 0.0001	15	0 (0.00%)	11 (73.33%)	0.00098	43	1 (2.33%)	34 (79.07%)	< 0.0001
Identifies where free fluid accumulates in the pelvis											
26	0 (0%)	21 (80.7%)	< 0.0001	28	12 (42.86%)	23 (82.14%)	0.01273	54	12 (22.22%)	44 (81.48%)	< 0.0001
Able to acquire an image of the pleural line?											
28	1 (3.6%)	28 (100%)	< 0.0001	27	2 (7.41%)	27 (100.00%)	< 0.0001	55	3 (5.45%)	55 (100.00%)	< 0.0001
Identifies a rib, intercostal space, intercostal muscle											
28	0 (0%)	24 (85.7%)	< 0.0001	28	1 (3.57%)	22 (78.57%)	< 0.0001	56	1 (1.79%)	46 (82.14%)	< 0.0001
Describes how a PTX would be differentiated from normal lung sliding											
28	0 (0%)	25 (89.3%)	< 0.0001	28	2 (7.14%)	28 (100%)	< 0.0001	56	2 (3.57%)	53 (94.64%)	< 0.0001

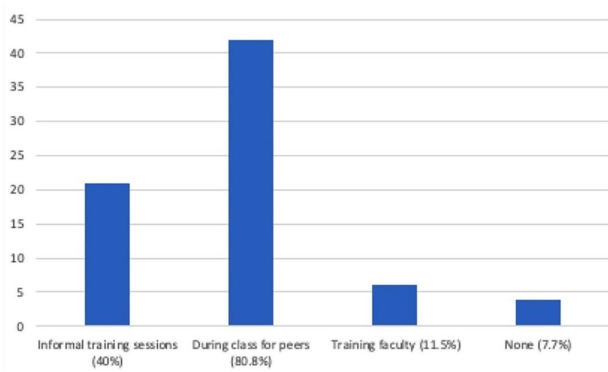

Fig. 1 Percent participation in post-program POCUS instruction per training type

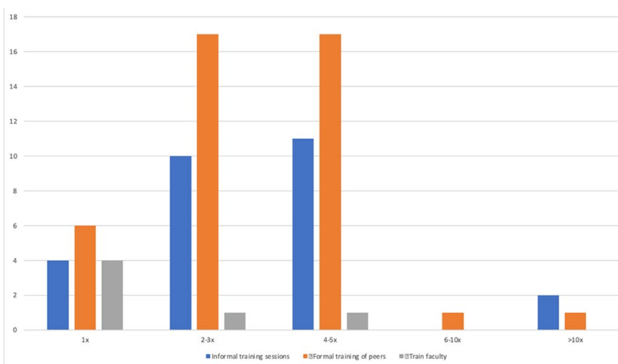

Fig. 2 Frequency of POCUS instruction post-summer intensive per training type

the creation of a POCUS interest group on their regional campus, 7 (13%) created a POCUS curriculum for their student interest group, and 4 (7.7%) created an opt-in co-curricular POCUS program for their regional campus. All students reported using ultrasound after the summer program. Three students did not serve as educators after the program but did complete required POCUS labs integrated into the 2nd year curriculum. Forty-nine (94%) students felt that their POCUS skills continued to improve after the summer program.

Discussion

Very little is known about long-term POCUS usage by medical students after initial training, with most studies focusing on knowledge, attitudes, and hands-on skill [22, 23]. The aim of our study was to assess long term POCUS usage by medical students after an intensive training program. We found all students continued using POCUS at 9 months post-intervention. Additionally, at this multi-campus institution, students on regional campuses were shown to augment or create additional POCUS learning opportunities in the form of formal, extra-curricular, and student interest led sessions. Most remarkably, 94% of students reported serving as educators for peers and faculty since the conclusion of the training, resulting in almost 850 h of POCUS instruction time.

While prior POCUS studies have evaluated medium and long-term skill and knowledge retention [24–27], to our knowledge no prior studies have evaluated long term usage. Jujo et al. and Steinmetz et al. evaluated medium-term and long-term skill retention in medical students respectively and they found demonstration of retention at 8 weeks and 8 months, respectively [24, 25]. Additionally, Menegozzo et al. demonstrated that medical students' retained knowledge with how to perform and interpret an extended-FAST exam 3 months after a trauma symposium [26]. Contrary to the findings in these studies, Rappaport et al. demonstrated a cognitive decline in pleural ultrasound and motor skills decline in cardiac ultrasound at four weeks [27].

Our study also found that students had significantly improved confidence in using POCUS, ability to perform POCUS and identify pertinent anatomy from pre- to post-curriculum. This is unsurprising and consistent with prior literature showing similar results [28–30]. Our study differs from these prior studies in that we also found confidence remained high long term for all POCUS modalities, except early pregnancy and soft tissue for both cohorts of students, with aorta and ocular decreasing for the first cohort only. The findings of long-term high confidence with most POCUS modalities are likely a reflection of the high amount of peer teaching hours reported after the completion of the initial training. Soft tissue and pregnancy likely have a reported lower confidence because of decreased exposure during their medical school training. Additionally, a study completed by Russell et al. found soft tissue POCUS was more challenging for students to learn compared to other modalities [31]. This may also contribute to the finding of decreased long-term confidence in our study.

Evidence shows that required POCUS curricula have expanded among allopathic medical schools across the country in recent years [1]. Despite increasing prevalence, many barriers have remained stable, including availability of trained faculty [1]. Previous studies suggest that the use of peer education methods for POCUS training are a viable and successful option [15–18]. Outcomes have shown to be comparable to education from trained faculty when evaluating knowledge, skills, and learner perception [32–36]. Some of these studies have even found that skill acquisition was improved on post-course assessment with the peer teaching model versus trained physicians or sonographers [33]. As peer and near peer training is supported by multiple studies, the implications of teaching hours led by the students in our study had a huge impact on our ability to teach the POCUS curriculum across 9 campuses. In addition, multiple POCUS interest groups were created along with extra-curricular educational opportunities that were developed to further increase the usage and awareness of POCUS across the medical school. Overall, this program demonstrated the utility of an intense summer training program to amplify the long-term reach of POCUS education opportunities, while decreasing resources needed, at a large multisite medical school. This evidence demonstrates that an intensive POCUS education program is a viable and sustainable option to expand resources for POCUS education. Future studies will aim to demonstrate the effect of an intensive POCUS program on continued use into residency and clinical practice and ultimately the effect on patient care and outcomes.

Limitations

Our study is limited for several reasons. Study participants self-enrolled in the course and were highly interested in POCUS. Students who enrolled in the summer program make up only a small percentage of the average class size of 360 students. A larger deployment of such a course is unlikely to have the same effect for all students, who would likely have less interest than those included in our study. Our institution is also unique due to its size and multi-campus model. Each campus is varied and unique. As a result, many students had unique opportunities based on the unique needs of their individual campus which may have had less developed POCUS resources than other campuses. This unique situation severely limits our studies generalizability to different medical schools with only a single campus. While we initially set out to evaluate teaching quality of the student's we were unable to gather this data. Future studies evaluating peer teaching ability of students should address this limitation.

Conclusion

In this small study, we found a 2-week immersive summer program led to long-term POCUS usage and engagement for most medical students. Over a nine-month period post-curriculum, students taught peers and faculty, started POCUS interest groups, and developed POCUS curricula. This program demonstrates one possible avenue to address the barriers of financial resources and trained instructor availability required to implement or expand an undergraduate medical school POCUS curriculum.

Abbreviations

POCUS Point of care ultrasound

Supplementary Information

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Supplementary Material 1

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Author contributions

AH, FMR, RMF conceived the study. AH takes responsibility for the paper as a whole. AH, FMR, JD, JW, DP, JD, BZ, PMW helped with implementation, data collection, and drafting of the manuscript. MH performed data analysis. All authors contributed substantially to manuscript editing and revision.

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Data availability

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate

This study was reviewed by the Institutional Review Board of Indiana University and was determined to be exempt. Verbal informed consent was performed, and data collection was made on a voluntary basis by program participants.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

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