The Role of Mastery Learning in Basic Skills in Upper Abdominal Ultrasound: Insights from a Comprehensive Training Workshop for Internists

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ABSTRACT

Background: *Abdominal ultrasound is an essential competency for internists, although traditional workshop often lack structured learning strategies and measurable skill outcomes. To address this limitation, mastery learning offers deliberate practice, standardized assessment, and competency-based progression. However, the use of mastery learning in abdominal ultrasound training for internists remains limited. Therefore, this study aimed to evaluate the feasibility and effectiveness of applying mastery learning principles within a point-of-care basic upper abdominal ultrasound workshop designed for internists.*

Methods: *A prospective study was conducted during the JIMDACE 2025 upper abdominal ultrasound workshop. Participants were subjected to pre- and post-training assessments across six targeted skills using a standardized checklist based on the Expert Performance Method. Subsequently, real-time feedback was provided during hands-on sessions. The scores obtained were analyzed using the Wilcoxon signed-rank test, followed by the calculation of effect size.*

Results: *The results showed that the total scores of all 13 participants included in the final analysis improved from 1.750 (±1.571) at pre-test to 5 (range 0–6) at post-test. Furthermore, significant improvements were observed overall (p=0.001).*

Conclusion: *The mastery learning-based workshop significantly improved abdominal ultrasound competence among internists, showing feasibility and strong educational impact. This method showed potential as a foundation for future structured ultrasound training programs.*

Keywords: *Abdominal Ultrasound, Continuous Medical Education, Mastery Learning Point-of-Care Ultrasound, Ultrasound Education*

ABSTRAK

Latar Belakang: *USG abdomen merupakan kompetensi penting bagi seorang internis, namun pelatihan konvensional sering tidak memiliki struktur pembelajaran yang sistematis dan penilaian kompetensi yang terukur. Metode mastery learning memberikan latihan terarah, evaluasi terstandar, dan pendekatan berbasis kompetensi, namun penerapannya dalam pelatihan USG abdomen atas dasar bagi internis masih terbatas. Oleh karena itu, kami merancang studi ini untuk mengevaluasi kelayakan dan efektivitas penerapan mastery learning dalam workshop USG abdomen point-of-care bagi internis.*

Metode: *Studi prospektif dilakukan pada workshop USG abdomen atas JIMDACE 2025. Peserta menjalani penilaian pre-test dan post-test melalui enam keterampilan terstandar, berdasarkan Expert Performance Approach. Umpan balik diberikan secara langsung selama sesi praktik. Analisis statistik menggunakan Wilcoxon signed-rank test dengan perhitungan effect size.*

Hasil: *Tiga belas peserta memenuhi kriteria analisis. Skor total meningkat dari rerata 1,75 (±1.571) pada pre-test menjadi 5 (rentang 0–6) pada post-test. Perbaikan signifikan ditemukan (p=0,001).*

Kesimpulan: *Penerapan mastery learning terbukti meningkatkan kemampuan peserta dalam melakukan USG abdomen dan dinilai layak untuk dikembangkan sebagai model pelatihan terstandar di masa mendatang.*

Kata kunci: *Ultrasonografi Abdomen, Pendidikan Kedokteran Berkelanjutan, Pembelajaran Penguasaan Ultrasonografi di Tempat Perawatan, Pendidikan Ultrasonografi*

INTRODUCTION

The application of ultrasound (USG), particularly in abdominal settings, is significantly increasing for both diagnostic and therapeutic purposes. Ultrasound examinations are straightforward, non-invasive, relatively cost-effective, and widely accessible in approximately all healthcare facilities. Proficiency in basic abdominal ultrasound is a crucial competency for internal medicine practitioners (internists), playing an integral role in comprehensive diagnostics and patient management, specifically in assessing intra-abdominal organs, including the liver, biliary system, spleen, and kidneys.[1-3]

To ensure the effectiveness of these examinations, internists must gain extensive experience, which requires ongoing training and workshops to maintain and refresh their competencies. However, many existing workshops predominantly focus on skill demonstrations and practical sessions. These programs often lack structured frameworks, standardized protocols, and measurable outcomes regarding competency enhancement following completion, showing the need for effective strategies such as mastery learning.[1]

Previous studies have shown the efficacy of mastery learning method, obtaining significantly favorable outcomes in training for abdominal ultrasound for non-internists,[2,3] and gastrointestinal endoscopy.[4,5] Compared to conventional training methods, mastery learning principles emphasize deliberate practice, timely feedback, and the Expert Performance Approach (EPA). Despite the numerous advantages, the application of abdominal ultrasound remains limited. To address this knowledge gap, the Jakarta Internal Medicine in Daily Practice (JIMDACE) committee has adopted the concept for the abdominal ultrasound workshop at the JIMDACE 2025 event. This initiative signifies an essential advancement toward the incorporation of evidence-based training methodologies in abdominal ultrasound education.

Based on the description above, this study aims to examine the feasibility of embedding mastery learning fundamentals into the abdominal ultrasound workshop. The underlying hypothesis states that the implementation of mastery learning principles during the workshop will effectively equip participants with the essential knowledge and skills required to perform abdominal ultrasound examinations.

METHODS

This prospective pre-post interventional study included the collection of data from a basic upper abdominal ultrasound workshop (consisting of liver and biliary system, spleen, and kidney examinations) conducted on September 12, 2025, during the JIMDACE event held at the Shangri-La Hotel. The study protocol was approved by the Ethics Committee of the Fatmawati General Hospital (Approval Number: DP.04.03/DXXI.2/7818.2025, dated July 14, 2025). The subjects were recruited from workshop participants, and inclusion criteria were enrolled internists who provided written informed consent. However, exclusion criteria were participants who failed to complete the training, as showed by a missing post-test. A total sampling method was used, producing a final sample size of thirteen participants.

The workshop was designed to include two lectures, each lasting 30 minutes, followed by six hands-on practice sessions of the same duration. To facilitate practical learning, six ultrasound stations were established, each equipped with either a Philips or GE ultrasound machine, accommodating several participants, one healthy subject, and supervised by an expert faculty member. Furthermore, trainers provided real-time feedback during the hands-on sessions to enhance participant skill development. As preparation, a mini-workshop was previously conducted with a smaller sample, along with a training-of-trainers session to standardize the understanding of the module that would be used.

Using the EPA, this study broke down the procedural steps of abdominal ultrasound into a module with checklist and standardized six assessors to evaluate the acquisition of scanning skills for six specific methods both before and after the training. The six targeted skills were measurement of liver diameter (skill 1), gallbladder visualization (skill 2), determination of portal vein diameter (skill 3), measurement of spleen diameter (skill 4), measurement of right kidney diameter (skill 5), and measurement of left kidney diameter (skill 6). Participants received one point for each successful attempt within the allocated time frame of 30 seconds for each skill, while unsuccessful attempts were scored as zero. However, those who did not attend the pre-test assessment session received zero scores for all skills. Only participants with complete post-test examinations were included in the final analysis.

Data analysis was conducted using SPSS software version 26.0 (IBM Corp., Armonk, NY, USA). Continuous variables were first evaluated for normal distribution using the Shapiro-Wilk test. Normally distributed data were expressed as mean ± standard deviation (SD), while median with range showed non-normally distributed data. A paired sample t-test and Cohen's D effect size (with a large effect showed by values greater than 0,8) were used to analyse learning outcomes for normally distributed data. For unevenly distributed data, the Wilcoxon signed-rank test was used. There were no artificial intelligence (AI) tools were used during this study, apart from basic AI-assisted grammar and spelling corrections.

RESULTS

A total of 15 participants registered for the course, although two were excluded from the final analysis because of failure to attend the post-test examination, leading to the inclusion of 13 subjects. The descriptive statistics were presented in **Table 1.**

Table 1. Descriptive Statistics Analysis

	N	Mean	Std. Deviation	Median	Minimum	Maximum
Pre-Test 1	15	N/A	N/A	0	0	1
Pre-Test 2	15	N/A	N/A	0	0	1
Pre-Test 3	15	N/A	N/A	0	0	1
Pre-Test 4	15	N/A	N/A	0	0	1
Pre-Test 5	15	N/A	N/A	1	0	1
Pre-Test 6	15	N/A	N/A	0	0	1
Total Pre-Test	15	1.750	1.571	N/A	N/A	N/A
Post-Test 1	13	N/A	N/A	1	0	1
Post-Test 2	13	N/A	N/A	1	0	1
Post-Test 3	13	N/A	N/A	1	0	1
Post-Test 4	13	N/A	N/A	1	0	1
Post-Test 5	13	1.000	0.000	-	-	-
Post-Test 6	13	N/A	N/A	1	0	1
Total Post-Test	13	N/A	N/A	5	2	6

Normality test with Shapiro-Wilk analysis showed that most skills showed uneven data distribution, except for the total pre and post-test 5 scores. The median pre-test score for all skills was 0, with the exception of skill 5. In comparison, the median post-test score for all skills rose to 1. Additionally, the mean total pre-test score was 1.75, while the median post-test score increased to 5, as shown in **Figure 1.**

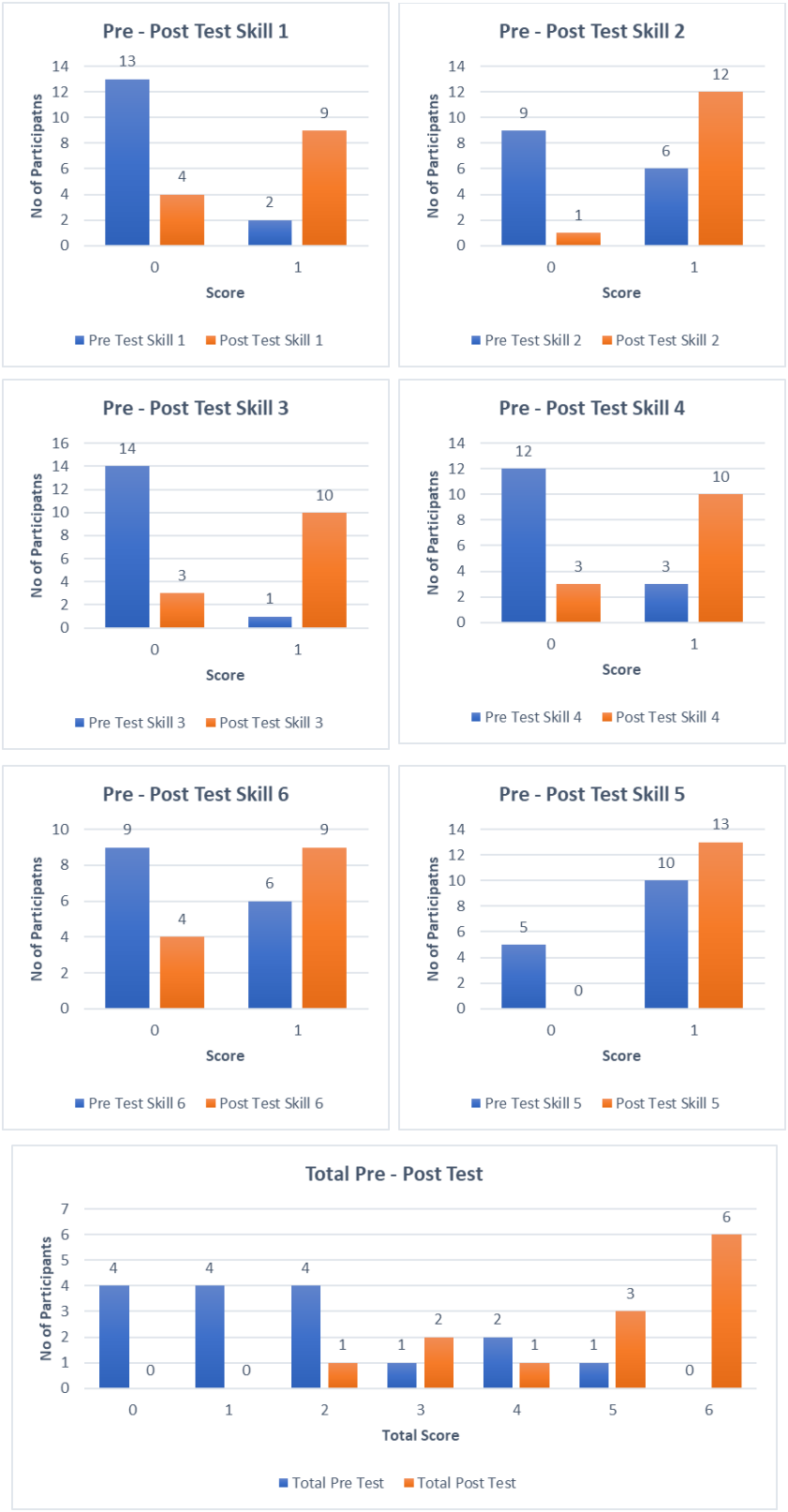

Figure 1. Result of Pre and Post-Test Skills (Skill 1 to 6 and Total Score)

Table 2. Rank Differences Analysis of Post and Pre-Test Skills

	Negative Ranks	Positive Ranks	Ties	Total	Wilcoxon Test (p-value)
Post-Test – Pre-Test 1	0	7	6	13	0.008
Post-Test – Pre-Test 2	0	8	5	13	0.005
Post-Test – Pre-Test 3	0	9	4	13	0.003
Post-Test – Pre-Test 4	0	8	5	13	0.005
Post-Test – Pre-Test 5	0	4	9	13	0.046
Post-Test – Pre-Test 6	1	5	7	13	0.102
Total-Post – Pre-Test	0	13	0	13	0.001

The analysis of rank differences for the pre- and post-tests showed a total of 13 cases. Each participant had a positive change in their total scores, showing that post-test scores exceeded pre-test in every case **(Table 2).** Among the analyzed differences, only one negative rank was observed in skill 6. As reported by the examiner, the placement of the ultrasound probe was accurate, although the participant was unable to achieve proper angulation to obtain optimal images within the specified time frame. Further statistical analysis with the Wilcoxon test in **Table 2** showed significant differences in total scores ($p = 0.001$) and in skills 1 to 5 ($p = 0.001$), while skill 6 had no substantial variation ($p = 0.102$).

DISCUSSION

The application of the mastery learning concept in current skill training appears to be a promising new trend that yields favorable results. Specifically, mastery learning is a structured pedagogical method that emphasizes the achievement of competence up to a level of proficiency by all trainees. The core principle of the model considers variation in learning pace, showing the need for differentiated supervision or guidance among trainees. Progression within the model is regulated through defined competency levels, with each level strictly requiring verification of mastery by the supervisor before advancement is permitted. This structured framework establishes clear learning outcomes and an explicit pathway for skill development. Furthermore, mastery learning incorporates continuous assessment to deliver immediate performance feedback, enabling trainees to promptly identify gaps and solidify their understanding.[6-8]

This study shows significant improvements in skills based on comparisons of test scores, showing that the method is adequate for refining participants' basic upper abdominal ultrasound capabilities. Although it has been integrated into the competency curriculum for internal medicine specialists, the abilities of each participant can vary significantly, as shown by the different pre-test scores. This variation may be influenced by exposure during educational training and the frequency of abdominal ultrasound application in their daily practice.

The presence of one negative rank difference requires particular attention. However, it can be understood in the context of the short post-test assessment time (only 30 seconds), which differs from actual examination scenarios requiring longer durations. Variations in the difficulty of the examination, depending on the patient, can also contribute to the negative rank. Assessment from the examiner was that the method and placement of the probe were already accurate, but the participant was unable to obtain optimal images within the specified time frame. Therefore, the outcome was more related to the time limitation problem compared to the competence problem.

Previous randomized controlled trials comprising radiology residents have shown superior outcomes compared to conventional training methods.[2] Other studies by Britz et al. reported the superiority of the mastery learning method compared to the traditional "see one, do one" in training related to focused assessment with sonography for trauma (FAST) among undergraduate medical students.[3] Another study from Moga et al. has shown that significant improvements in competency can still be observed regardless of the training methods used.[9] Post et al. reported the potential of combining the mastery learning concept with ultrasound training based on simulator/virtual reality, all accomplished within a median of three-hour timeframe.[10]

Comparative studies on abdominal ultrasound training comprising internists or internal medicine residents remain relatively limited. The training methods used vary across different studies. The majority focus on the implementation of specific curricula or training sessions for internal medicine residents aimed at developing point-of-care ultrasound (POCUS) skills, including in the abdominal region, with most studies showing successful competency improvements. Similar observations were reported

by Ferre et al., Eliott et al., Schnobrich et al., and Haghighat et al.[11-14] Another study conducted by Andrea et al. evaluated the enhancement of internal medicine residents' or gastroenterology trainees' ability to detect subclinical ascites using pocket bedside ultrasound during an eight-hour training session, yielding positive results across all subjects.[15]

Most studies included one to two-day workshops with four to eight hours of practice.[1] Previous reports of ultrasound training with mastery learning method have reported significantly shorter learning curves for complete novices, approximately between three to four hours for specific examination (gynecological- or FAST-only), or up to six hours for a complete abdominal scan in the study by Post et al.[10] Therefore, the one-day training conducted in this study was considered sufficient for the comprehension of the competences.

All studies used as reference combined theoretical and hands-on training with varying methods. Theoretical training ranged from 30 minutes to eight hours. Several analyses have also used an e-learning platform for the theoretical content, allowing flexible time for lectures. These results suggested that online learning could be considered to be an alternative, although the total time spent by participants was more difficult to track.[1]

The post-test evaluation methods varied between previous studies. Some reports focused on theoretical knowledge with written and/or multiple-choice questions, others included both objective assessments of theoretical knowledge and practical competencies, while the rest only evaluated practical competencies. Several studies used post-curriculum image interpretations as an assessment, where participants performed scans on patients, followed by review by an expert or a trainer.[1] Since this study focused on participants' achievement of the mastery level, the procedure adopted the last method for post-test evaluation.

Compared to other reports, the training in this study can be characterized as more complex and comprehensive, addressing abdominal ultrasound competencies in a holistic manner. However, no comparative analyses with a similar training design have been identified to date. The workshop used in this study was well-prepared, featuring a structured module and a training-of-trainers method to ensure consistent knowledge among instructors. The training was also designed to facilitate practice on six different standardized patients, allowing participants to engage in examination procedures across various patient scenarios.

Despite the significant contribution, this study has several limitations. In mastery learning setting, the final assessor should be different from the module developer due to concerns regarding potential bias or subjectivity in the scoring of both the pre and post-test. Furthermore, the smaller number of participants did present a unique advantage, as it enabled more practice time for each individual and allowed instructors to focus more on observation and feedback. The limited sample size also presented a clear weakness regarding the statistical analysis power of the results.

The JIMDACE workshop was conducted in a single-center setting, with a short duration of the study. Furthermore, the long-term retention of competencies gained from this workshop remains an unresolved issue, as previous studies have rarely evaluated continuous competency assessment after training completion. Future implementation of logbook documentation or periodic competency reassessment may be considered to monitor skill retention and ensure sustained proficiency. Therefore, this study serves as an important preliminary report that shows the need for future investigations, including larger cohorts, multicenter settings, and longer follow-up periods, to evaluate the effectiveness and consistency of the mastery learning method.

CONCLUSION

In conclusion, this study shows that the implementation of mastery learning effectively equips the majority of participants with the essential skills required for performing abdominal ultrasound. The method shows significant potential for enhancing the effectiveness of abdominal ultrasound training in the future.

CONFLICT OF INTEREST

All authors declare no conflicts of interest.

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AUTHOR CONTRIBUTIONS

All authors contributed equally to this work.

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DATA AVAILABILITY

The data supporting the findings of this study are available from the corresponding author upon reasonable request.

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