Comparison of Web-Versus Classroom-Based Basic Ultrasonographic and EFAST Training in 2 European Hospitals

Elke Platz, MD, RDMS, Katja Goldflam, MD, Maria Mennicke, MD, Emilio Parisini, PhD, Michael Christ, MD, PhD, Christian Hohenstein, MD

From the Department of Emergency Medicine, Brigham and Women's Hospital, Boston, MA (Platz, Goldflam, Mennicke); the Harvard School of Public Health, Boston, MA (Platz, Parisini); the Department of Emergency Medicine, Klinikum Nürnberg, Nürnberg, Germany (Christ); and the Department of Anesthesiology, Klinikum Kempten Oberallgäu, Kempten, Germany (Hohenstein).

Study objective: Training physicians in new skills through classroom-based teaching has inherent cost and time constraints. We seek to evaluate whether Web-based didactics result in similar knowledge improvement and retention of basic ultrasonographic principles and the Extended Focused Assessment with Sonography for Trauma (EFAST) compared with the traditional method.

Methods: Physicians from 2 German emergency departments were randomized into a classroom group with traditional lectures and a Web group who watched narrated lectures online. All participants completed a pre- and posttest and a second posttest 8 weeks later. Both groups underwent hands-on training after the first posttest. A control group completed the 2 initial tests without didactic intervention.

Results: Fifty-five subjects participated in the study. Both the classroom and Web group showed significant improvement in pre- and posttest 1 scores (75.9% versus 93.9% and 77.8% versus 92.5%; $P<.001$ for both), with similar knowledge retention after 8 weeks (88.6% and 88.9%; $P=.87$). No statistically significant difference in mean test scores could be found between the 2 groups at each point: –1.9% (95% confidence interval [CI] –5.2% to 1.4%) for the pretest, 1.4% (95% CI –0.6% to 3.4%) for posttest 1, and –0.3% (95% CI –3.9% to 3.3%) for posttest 2. The control group showed no learning effect without intervention (83.3% versus 82.8%, ; $P=.88$).

Conclusion: Web-based learning provides the potential to teach physicians with greater flexibility than classroom instruction. Our data suggest that Web-based ultrasonography and EFAST didactics are comparable to traditional classroom lectures and result in similar knowledge retention. [Ann Emerg Med. 2010;56:660-667.]

Please see page 661 for the Editor's Capsule Summary of this article.

Provide feedback on this article at the journal's Web site, www.annemergmed.com.

0196-0644/$-see front matter

doi:10.1016/j.annemergmed.2010.04.019

INTRODUCTION

Emergency medicine education in Europe has traditionally used a mixture of techniques, including locally based lecture participation and hands-on teaching. Given remarkable challenges to education of practitioners with limited emergency medicine experience in distant locations, distance education appears as an alternative to locally based lectures.[1] Several European countries, including Germany, are in the process of building interdisciplinary emergency departments (EDs) and efforts are under way to establish an independent specialty.[2-4] Traditionally, hospital-based emergency care in Germany has involved separately staffed EDs within each hospital for internal medicine, surgery, obstetrics and gynecology, and pediatrics. In the past decade, many hospitals have created one "centralized" ED (*Zentrale Notaufnahme*), typically staffed by internists, surgeons, anesthesiologists, and physicians in training. A major challenge faced by these EDs is the need to cross-train attending physicians from various specialties in new clinical areas and in skills. Furthermore, because emergency medicine does not yet exist in Germany as a separate specialty with structured residency training, resident physicians rotating through EDs are doing so as part of their training in internal medicine, surgery, or other specialties.[3] Consequently, there is a need for the development of effective and flexible methods to train both resident and attending physicians in emergency medicine–relevant areas. Several countries have approached this problem in different ways. In Italy, a sophisticated "train-the-trainers" program used US emergency physicians to train a group of Tuscan physicians from various specialties, who later trained their peers.[4] However, taking large

Editor's Capsule Summary

What is already known on this topic

Classroom education is labor intensive. Once made, web-based learning modules can be used repeatedly at no cost and offer the possibility of multimodal education.

What question this study addressed

The authors assigned 42 German residents and attending physicians to an electronically administered didactic program in trauma ultrasonography (Extended Focused Assessment with Sonography for Trauma), combined with a hands-on skill session, or to a conventional course and measured acquisition and retention of cognitive skills.

What this study adds to our knowledge

Cognitive skill acquisition and retention were similar when learners received the didactic portion of an ultrasonographic training program electronically.

How this is relevant to clinical practice

This study will not change clinical practice. However, it suggests that blended learning may constitute a cost-effective alternative to focused ultrasonographic training of emergency practitioners.

groups of trainees out of the clinical work schedule to participate in classes is a logistically challenging endeavor that can be difficult to implement on a national or regional level.[4]

Emergency bedside ultrasonography performed by clinicians is becoming an indispensable diagnostic tool in the assessment and management of critically ill and injured patients.[5,6] For example, the Extended Focused Assessment with Sonography for Trauma (EFAST) is a potentially lifesaving ultrasonographic application, and it has been argued that it should be considered an essential skill for emergency practice.[5-8] It has become a diagnostic standard in many trauma centers internationally and is part of the Advanced Trauma Life Support protocol.[9,10] However, bedside ultrasonography is uniformly a relatively new technology requiring skills that many practicing clinicians have not yet acquired. Traditionally, didactic training for emergency ultrasonography has occurred through classroom-based lectures, with subsequent hands-on workshops for the acquisition of practical skills. "Blended learning" is a new concept in both ultrasonography and general medical education and refers to a combination of e-learning and other learning modalities.[11] In the context of ultrasonographic education, blended learning can be used in combination with computer- or Web-based lectures, with practical instruction for skills acquisition.[12,13] Trainees can thereby study independently without being tied to a classroom, allowing physicians more flexibility in their own scheduling.[14] Blended learning may therefore present a lower-cost alternative to face-to-face instruction in both the financing of educators and work-hours lost by students (see Table E1, available online at http://www.annemergmed.com).[4] Although a few commercially available emergency ultrasonographic courses recently incorporated blended learning strategies, sufficient data comparing this teaching modality with traditional techniques for emergency ultrasonographic applications are lacking. We sought to evaluate whether Web-based didactic training results in similar knowledge improvement and retention of basic ultrasonographic principles and the EFAST in a group of German physicians compared with traditional classroom-based didactic education.

MATERIALS AND METHODS

Setting

Two German hospitals currently in the process of transitioning to interdisciplinary EDs participated in the study. They were chosen because of their need for training of practicing physicians in new skills, including emergency ultrasonography. In designing the study, we followed the recommendation of Ban et al,[4] based on their experience in Tuscany, which indicates that, in countries where emergency medicine is in the early stages of development, curricular and educational methods should initially be tested in small pilot studies.

Selection of Participants

Recruitment for study participation took place by e-mail and announcement on the 2 participating hospitals' bulletin boards. The announcements stated that previous ultrasonographic knowledge or skills were not required for participation. Resident and attending physicians were uniformly welcome. Enrollment was voluntary and occurred on a first-come, first-served basis. No incentives were offered to the subjects. We included physicians aged 18 years or older and currently practicing in a German ED, regardless of their specialty training. Learners unable to participate in all aspects of the study, eg, because of scheduling conflicts and, within the control group only, those not completing the pretest, were excluded.

The goal was to enroll 48 subjects (24 per study site) in the study groups. This number was chosen because only 2 instructors were available for the ultrasonographic workshops and it was considered that 6 subjects per instructor was the upper limit for optimal hands-on instruction.[7] We also sought to enroll an additional 24 subjects as a control group. The control subjects were physicians currently practicing in German EDs and were approached by an equivalent recruitment e-mail by the 2 study site coordinators. The sole purpose of the control group was to assess whether this group's average test score showed any significant improvement between the pretest and posttest 1 without being exposed to any training.

Study Design

After enrollment, study group participants at each site were allocated to a classroom (Class) and a Web group (Web) according to their last name in alphabetical sequence (A=Web, B=Class, C=Web, D=Class, etc). Allocation was performed for both study sites separately (to ensure similar group sizes at each site) by the principal investigator after receipt of the name lists. Control subjects were not included in the allocation process. Web-based, narrated lectures were developed in German by the principal investigator and two coinvestigators. Identical PowerPoint slides (Microsoft, Redmond, WA) were used for the classroom lectures. Two of the lectures were used for the didactic instruction of both the Web and the Class group. Lectures contained text in bullet points and pictorials, as well as ultrasonographic still images and video clips of both normal and pathologic findings. The first lecture was an introduction to ultrasonography and was composed of basic ultrasonographic physics and instrumentation, including an overview of common artifacts and probe orientation. The second lecture introduced the EFAST examination and taught sonographic evaluation of pneumothoraces, pleural effusions, pericardial effusion, and free intraperitoneal fluid.[6,8] Both lectures were presented to the classroom groups by the same instructors who wrote the script for the narrated Web lectures and recorded the narration. The Web-based lectures were hosted on a password-protected research Web page.

Prior to the didactic training, all subjects were asked to complete a Web-based multiple-choice pretest. The Web group was then granted access to the online lectures 2 weeks before the practical ultrasonographic workshop. After review of the online lectures, they were asked to complete the first Web-based posttest. Although our principal objective was to assess the feasibility of Web-based didactic instruction compared with classroom didactic instruction as a component of an EFAST course, we believe image acquisition and real-time interpretation to be an important part of ultrasonographic training for clinicians. For this reason, we opted to include practical instruction (because it would take place in an actual ultrasonographic course regardless of the venue of didactic instruction) between posttest 1 and posttest 2. Accordingly, the Web group then attended a half-day course that comprised practical EFAST training in a hands-on workshop (Table E1, available online at http://www.annemergmed.com). A brief (approximately 15 minute) question and answer session was held at the beginning of the workshop to provide subjects with the opportunity to ask questions.

The classroom group attended a 1-day course, during which they completed the online pretest, listened to traditional lectures, completed the first posttest (online), and underwent the same hands-on training. Both groups were contacted by e-mail 8 weeks after the ultrasonographic workshops and asked to complete the second Web-based posttest. Although subjects in the control group did not undergo didactic or hands-on training between the pretest and the first posttest, they were offered access to the Web-based lectures after completion of the first posttest. The control group was not asked to complete the second posttest, because their purpose was solely to control for "pretest/posttest" effect within our measurements.[15] This study was exempt from review by the institutional review board of all 3 institutions involved.

Methods of Measurement

The assessment tool consisted of a 29-item multiple-choice test with 4 answer options per question. The same test was used for the pretest and for both posttests. It evaluated factual knowledge, image recognition and interpretation, and the ability to incorporate ultrasonographic findings into patient management scenarios. The content of the 29 multiple-choice questions was designed according to the lecture content and covered the following topics: ultrasonographic physics and instrumentation, as well as probe orientation (7 questions); ultrasonographic artifacts (4 questions); one general EFAST question; EFAST and lung ultrasonography (4 questions); EFAST and basic echocardiography (3 questions); and EFAST and sonography of the abdomen and pelvis (10 questions). Nineteen of the 29 questions were field tested (in English) in a previous study among US emergency medicine residents to ensure clarity and comprehensiveness before implementation.[13] One question from the US study was not used in the German study because its content was not clear to the majority of the US test takers, according to their comments after taking the posttest. Ten additional questions were added for the German study because it became apparent during analysis of the pilot study that a larger number of questions would provide a more meaningful distribution of test results.

Before administration, all Web-based pre- and posttests were reviewed by a German-speaking ultrasonographic instructor with expertise in the EFAST and not otherwise involved in the study to ensure language clarity and content validity. This reviewer's input led to minor grammatical changes in 2 test questions and correction of several technical problems in the projection of the questions on the computer screen. In addition to answers to the test questions, basic demographic data and questions about self-reported previous ultrasonographic training, access to ultrasonographic equipment, and satisfaction with training were obtained from study participants.

Outcome Measures and Primary Data Analysis

When data at specific points were compared in a cross-sectional manner, the statistical significance of the differences in mean scores between groups ("Class" and "Web") was determined with ANOVA. However, given the longitudinal nature of the data and the balanced design of the study, we also compared summary scores across groups and time by means of an analysis of response profiles. To this end, the required assumptions of normality and equality of variances were assessed prior to data analysis. Using the summary score as the outcome variable, we built a model that included testing occasion and group as fixed effects plus an interaction term. A likelihood ratio

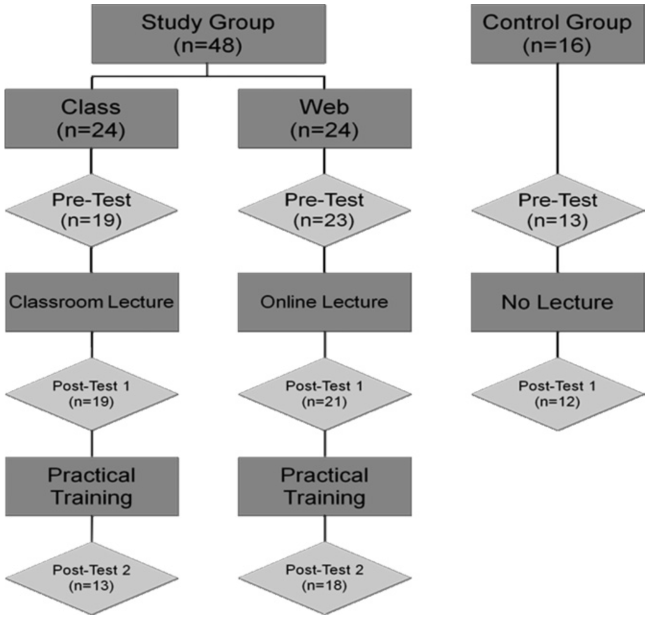

Figure 1. Flow diagram of enrolled study participants.

test between the full and a reduced model was then performed to test the null hypothesis that there is simultaneously no group effect and no group-time interaction, thus assessing whether the pattern of mean scores over measurement occasions was the same for the 2 groups. Results were considered statistically significant at the .05 level. All study participants were included in the analysis if they completed (ie, they answered 29 questions out of 29) a test in at least one of the 3 measurement occasions. Missing tests were limited in number, and no pattern could be determined regarding any of the variables of the study participants lost to follow-up. We performed analyses of response profiles and likelihood ratio tests to calculate whether the pattern of mean scores over measurement occasions was the same for different specialties and for different training levels. All models were constructed with an unstructured variance-covariance matrix.

All statistical calculations were performed with SAS software, version 9.1 (SAS Institute, Inc., Cary, NC).

RESULTS

Sixty-four subjects were enrolled, of whom 55 participated in the study and were included in the data analysis (85.9%) (Figure 1): 19 subjects in the classroom group, 23 in the Web group, and 13 in the control group. Of these, 6 subjects in the classroom group and 5 subjects in the Web group did not complete all 3 tests. Reasons for incomplete participation included limited Internet access, illness, and scheduling conflicts. Basic demographic data are summarized in Table 1; 63.6% of subjects were men, 79.6% were resident physicians, and 9.3% had no previous ultrasonographic training.

Both the classroom (n=19) and Web group (n=23) showed significant improvement in scores between the pre- and posttest 1 (Figures 2 and 3A and B), 75.9% (SD=10.7) versus 93.9% (SD=4.7), with a difference of 18.0% (95% confidence interval [CI] 12.5% to 23.5%), and 77.8% (SD=8.1) versus 92.5% (SD=6.2), with a difference of 14.7% (95% CI 10.2% to 19.2%), respectively ($P<.001$ for both). The differences in mean test scores between the classroom group and the Web group at each point were not found to be statistically significant: –1.9% (95% CI –5.2% to 1.4%) for the pretest, 1.4% (95% CI –0.6% to 3.4%) for posttest 1, and –0.3% (95% CI –3.9% to 3.3%) for posttest 2. Accordingly, when an analysis of response profiles during the entire course of the study was performed, no statistically significant difference could be detected in the pattern of mean scores over time between the 2 groups ($P=.57$), ie, we cannot reject the null hypothesis that there is no difference between the traditional and the Web-based educational methods. Although both the Web and classroom group showed a slight decrease in mean scores between the first and second posttest, scores were still significantly higher than

Table 1. Baseline characteristics by study group.*

Characteristic	Class, n=19	Web, n=23	Control, n=13
Women, No. (%)	4 (21.1)	11 (47.8)	5 (38.5)
Specialty			
Anesthesia	6 (31.6)	6 (26.1)	1 (7.7)
Surgery	7 (36.8)	4 (17.4)	2 (15.4)
Orthopedics	1 (5.3)	2 (8.7)	1 (7.7)
Internal medicine	5 (26.3)	11 (47.8)	9 (69.2)
Previous ultrasonographic training			
None	1 (5.3)	3 (13.1)	1 (7.7)
Lecture	10 (52.6)	6 (26.1)	3 (23.1)
Practical	1 (5.3)	7 (30.4)	2 (15.4)
Lecture and practical	7 (36.8)	7 (30.4)	7 (53.8)
Level of training			
Resident	14 (73.7)	18 (78.3)	12 (92.3)
Attending	5 (26.3)	5 (21.7)	1 (7.7)

*Percentages are calculated according to the number of subjects in each group.

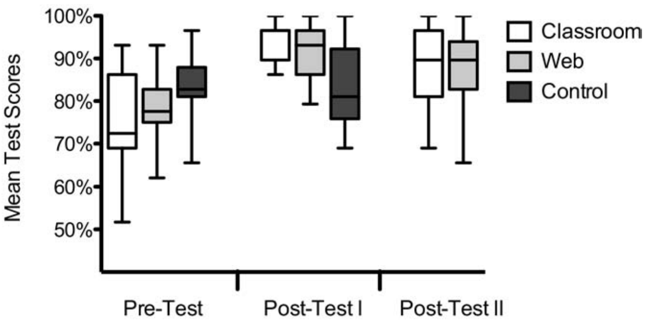

Figure 2. Test score distribution by didactic group. Distribution of test scores for the three groups for each test. Boxes represent the 25th and 75th percentiles of scores; whiskers, the range of scores by didactic group. Test score means are displayed as a horizontal line within each box.

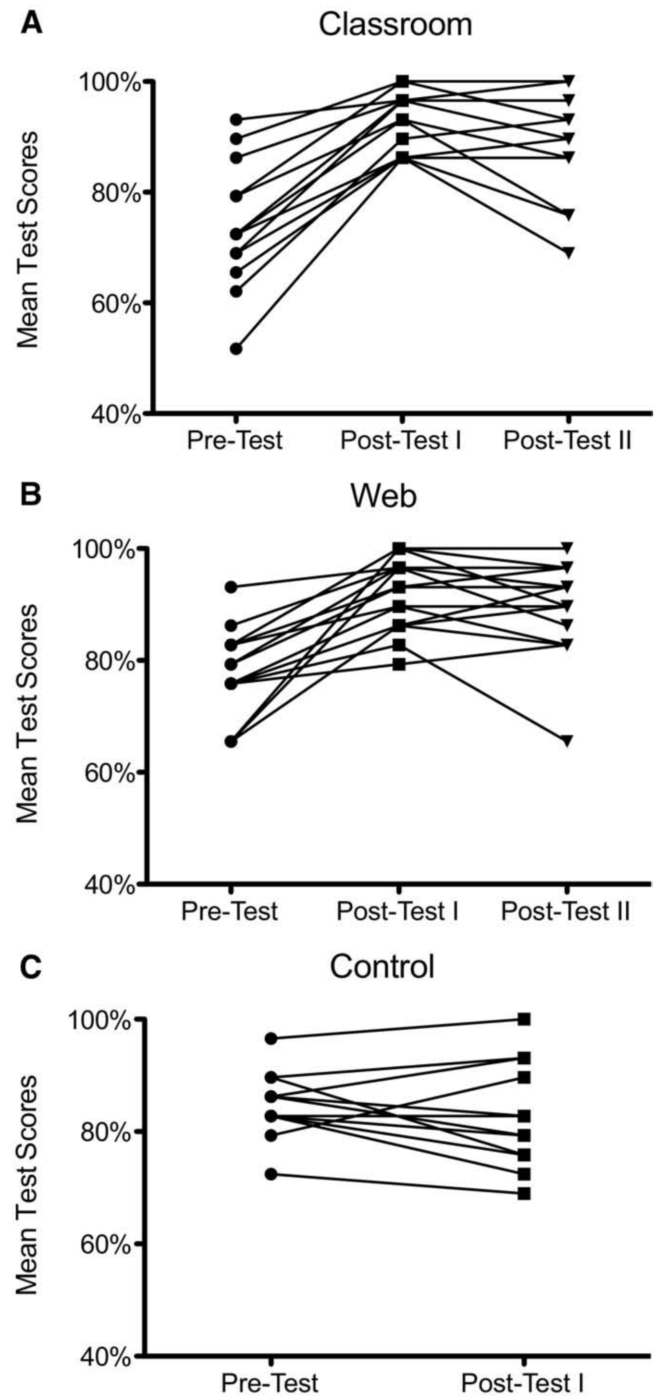

Figure 3. Classroom, Web, and control groups' individual test scores. *A,* Classroom group's test scores over the 3 tests. *B,* Web group's test scores over the 3 tests. *C,* Control group's test scores over the 2 tests.

before the intervention. The difference between posttest 2 and pretest mean scores was 12.8% (95% CI 5.1% to 20.4%) for the classroom group and 11.2% (95% CI 6.0% to 16.3%) for the Web group, $P<.0001$ for both, indicating that there was substantial knowledge retention in both groups even 8 weeks

Table 2. Participant satisfaction with didactic method and comfort of ultrasonographic use after didactic training.*

Participant Response	Rating[†]	Class, n=19	Web, n=21	*P*
Enjoyed didactic training, No. (%)	1	15 (79.0)	9 (42.9)	<.0001
	2	4 (21.0)	12 (57.1)	
	3	0	0	
	4	0	0	
Found didactics effective, No. (%)	1	18 (94.7)	13 (61.9)	<.0001
	2	1 (5.3)	7 (33.3)	
	3	0	1 (4.8)	
	4	0	0	
Comfort with EFAST after didactic training, No. (%)	1	1 (5.3)	2 (9.5)	.27
	2	13 (68.4)	12 (57.2)	
	3	5 (26.3)	7 (33.3)	
	4	0	0	

*Percentages are calculated according to the number of respondents in each group. The *P* values refer to the comparison between the 2 groups (Class and Web).
[†]Scale 1 to 4: 1=very much; 4=not at all.

after completion of the training (Figures 2 and 3C). The control group (n=13) did not show any significant change in test scores for pre- and posttest 1 (83.3% [SD=7.8] and 82.8% [SD=9.4]), with a difference of 0.5% (95% CI –6.6% to 7.7%; $P=.88$), indicating that there was no learning effect without intervention. The differences in mean test scores between residents and attending physicians at each point were also not found to be statistically significant: –1.1% (95% CI –4.7% to 2.5%) for the pretest, –2.2% (95% CI –5.2% to 0.8%) for posttest 1, and –1.8% (95% CI –5.7% to 2.1%) for posttest 2. Accordingly, there were no statistically significant difference in the pattern of mean scores over time between these 2 groups during the entire course of the study ($P=.51$). Finally, no statistically significant difference in the pattern of mean scores over measurement occasions was found between different specialties ($P=.27$).

All subjects in the Web group accessed the online lectures at least once. Only 2 subjects in the Web group observed that they had technical difficulties with either the online tests or lectures. The classroom group rated their enjoyment of the didactic training and their perception of its effectiveness slightly higher than the Web group. However, this difference might not be relevant in practice because subjects in both groups rated their enjoyment of the training either as "very high" or as "high." Both groups stated that their comfort with ultrasonographic use after the didactic training was similar (Tables 2 and 3).

There was no difference between the Web and classroom group in access to ultrasonographic machines or number of patients scanned by the participants after completion of the course. Thirty-one percent of Class group and 39% of Web group participants sought additional ultrasonographic education in the form of reading or by taking a course between the practical training and the second posttest. More than 90% of subjects in both groups reported their interest in emergency ultrasonography as very high.

Table 3. Participant satisfaction with didactic plus practical training and comfort of ultrasonographic use after practical training.*

Participant Response	Rating†	Class, n=13	Web, n=18	P
Found practical training effective, No. (%)	1	8 (61.5)	15 (83.3)	.12
	2	4 (30.8)	3 (16.7)	
	3	1 (7.7)	0	
	4	0	0	
Comfort with EFAST after practical training, No. (%)	1	1 (7.7)	0	.88
	2	7 (53.8)	13 (72.2)	
	3	5 (38.5)	5 (27.8)	
	4	0	0	
Used ultrasonography after practical training, No. (%)	<5 Patients	6 (46.1)	6 (33.3)	.84
	5–10 Patients	2 (15.4)	5 (27.8)	
	>10 Patients	2 (15.4)	3 (16.7)	
	No	3 (23.1)	4 (22.2)	
Access to ultrasonography, yes (%)		11 (84.6)	17 (94.4)	.38

*Percentages are calculated according to the number of respondents in each group. The *P* values refer to the comparison between the 2 groups (Class and Web).
†Scale 1 to 4: 1=very much; 4=not at all.

LIMITATIONS

Our study has several limitations. First, it was limited by a small sample size, and a larger group of study participants might have led to more precise estimates of test score improvement attributable to didactic technique.

Second, subjects in the study groups (Web and Class) were allocated according to the first initial of their last name, which represents a pseudorandomization design. A bias may have been introduced because of lack of concealment, because the allocation protocol was predictable by the personnel responsible for determination of eligibility and execution of group assignment.

Third, study participants of the Web-based group had access to the online presentations as frequently as desired, whereas the classroom group attended the presentations once. Although repeated access to Web-based presentations may present an advantage over one-time classroom lectures, in our study only a minority of Web group participants reported accessing the Web-based lectures more than once, supporting comparability of the 2 educational concepts.

Fourth, we were not able to track the time elapsed between viewing of the online lectures by the Web group and their completion of posttest 1, although all had to view the lectures and complete the test within 2 weeks. This inability might have resulted in a variable interval between didactic training and posttest 1 in this group, whereas in the class group all subjects completed the posttest 1 after attending the lectures. This potentially different interval in the 2 groups may have affected the test performance.

Fifth, the online pre- and posttests were open-book tests for all 3 groups. Study participants could have used additional resources to determine the correct answer or collaborated with other study participants to solve the questions. Only the Web group had access to the online lectures during the first posttest, whereas the classroom group completed this test in class after completion of the lecture. However, neither group had access to the online course during the pretest or the second posttest.

Sixth, more subjects in the Web group sought additional training after completion of the practical instruction and before taking posttest 2, which might have influenced their performance in posttest 2 and biased our results.

Seventh, the majority of study participants had undergone some form of ultrasonographic training in the past. Whether our findings are applicable to groups without previous ultrasonographic education warrants further investigation.

Last, although all physicians underwent hands-on instruction, this study did not assess practical competency in the performance of an EFAST examination. Although there is literature to support an association between operator confidence and accuracy of abdominal ultrasonography (including the Focused Assessment with Sonography for Trauma),[16,17] we are unaware of evidence that performance on multiple-choice tests is predictive of actual ultrasonographic competence and skill in practice. Our study results are therefore limited to assessment of didactic performance, and the effect on practical performance cannot be inferred.

DISCUSSION

Our hypothesis was that online lectures on the topics of basic ultrasonographic principles and the EFAST are as effective as traditional classroom lectures.

Our main results demonstrate a significant improvement in mean test scores after both the classroom and Web didactic interventions. There was no significant difference in improvement of mean test scores between the 2 groups, confirming our original hypothesis that the Web-based intervention results in an improvement of knowledge similar to that of the traditional classroom intervention. The lack of mean test score improvement in the control group, which did not receive any intervention, indicates that there was no learning effect in the act of retaking the test alone.

Most subjects had undergone some ultrasonographic instruction in the past. Ultrasonography is taught at most medical schools in Germany, and thus many physicians have undergone at least basic ultrasonographic training in the form of lectures before residency, probably because, in Germany, ultrasonographic examinations are not performed by technicians but rather by physicians.

Our subjects reported a high level of interest in emergency ultrasonography. With that, they represented a highly motivated group of learners, which likely affected our study results. Although all study participants were assured that their individual test results were treated confidentially, we cannot exclude that especially the resident physicians may have behaved differently under conditions characterized by participation in an educational research study than they would in their standard educational and practice environments.

Both groups had equal access to ultrasonographic machines and performed a similar number of EFAST examinations after completion of the course. Therefore, participants from both groups should not only have had similar experiences before taking the course but also similar capabilities to apply their newfound knowledge between the first and second posttest, allowing for equal conditions favoring knowledge retention.

In our study, there was no evidence that level of previous ultrasonographic training correlates with a higher or lower mean score improvement, indicating that the intervention was equally appropriate for practitioners with a range of experience. These findings stand in contrast to a US study in which 44 first-year emergency medicine and surgery residents completed a multiple-choice test before and after either a computer-based or a traditional classroom lecture.[13] In this study, computer-based instruction was not inferior to classroom instruction for interns without previous ultrasonographic training. Yet computer-based lectures were inferior to classroom lectures for interns with previous ultrasonographic training. Despite several similarities between these 2 studies, including content of the lectures and method of allocation of the study groups, there were substantial differences in the study population, design, and statistical analysis, which could provide potential explanations for the diverging results. In the US study, only interns at the beginning of their residency participated, not more advanced residents or attending physicians. All interns in the computer group were listening to lectures on individual computers simultaneously, whereas in our European study, subjects in the Web group could access lectures at their convenience. This method may have provided a better learning atmosphere for subjects in the Web group of the European study. As previously discussed, our pre- and posttests were translated into German and additional test questions were added, factors that may have influenced participants' performance on the tests. Because all interns in the US study had to undergo didactic training, no control group was used. Hence, assessment of whether improvement of test scores may have resulted from retaking the test could not be performed. Last, in the US study, an inferiority analysis was chosen, in contrast to that in the European study.

Literature evaluating Web-based training and blended learning for ultrasonographic instruction is sparse. Filippucci et al[18] investigated the feasibility of a blended learning curriculum for musculoskeletal ultrasonography. Sixty subjects participated in a 3-day residential course, followed by a 6-month period of Web-based tutoring and a subsequent 2-day course for assessment of competency. They concluded that e-learning methods might circumvent inherent barriers to teaching musculoskeletal ultrasonography to a wide audience. In our study, both the Web and the classroom group enjoyed the didactic training and found the method to which they had been assigned effective. Our findings therefore suggest that both teaching formats may be comparable with respect to these 2 aspects of learner perception.

Also relevant to our study, Chenkin et al[12] recently found that for 21 emergency medicine attending physicians and residents, a Web-based tutorial was at least as effective as a traditional lecture in the instruction of ultrasonographically guided vascular access. Both the Web and the classroom group demonstrated similar written test and objective structured clinical examination scores after training. Their findings suggest not only that, for simple ultrasonographically guided procedures, Web and classroom instruction might result in similar knowledge acquisition but also that additional face-to-face instruction for practical skills may be unnecessary. Whether this would hold true for complex sonographic assessments such as the EFAST examination has yet to be investigated.

Although we did not assess practical sonographic skills in our study, self-reported comfort with performance of the EFAST was similar after the didactic and the practical training in both groups, which may suggest that additional scanning of actual patients is needed after initial hands-on instruction on healthy subjects. Previous data on the EFAST learning curve and resultant guidelines for minimal training requirements are in line with this impression.[7]

As with any technologically driven educational endeavor, blended learning requires the target audience to have appropriate access to the teaching material. An awareness of the limitations of the target audience is therefore critical, and adjustments may be needed, such as the use of software that is compatible with the majority of basic computer systems. For these reasons, the concept of blended learning or e-learning is limited to countries and settings that are able to provide these necessary technologic capabilities to participants, who also require an appropriate level of computer literacy. We discussed with our participants both access to e-mail, through which links to the online lectures were distributed, and Internet access and software capable of supporting the lecture application as potential roadblocks to completing the course. Only 2 physicians in the Web group reported technical difficulties with either the online tests or lectures.

The importance of international collaboration and the role of academic emergency medicine in the development of emergency medicine as a specialty have recently been highlighted in several publications.[1,4,19] Distance learning, collaborative research, and the development of emergency medicine curricula were listed as key components in these endeavors. Alagappan et al[19] advocate the systematic evaluation of the efficacy of different distance learning systems in their analysis of the support of international emergency medicine by academic centers. In addition to the support our study provides for blended learning as an effective didactic tool in general, it also provides a specific example of successful international cooperation in teaching emergency medicine techniques to physicians of various specialties. The lectures used in this study were initially developed in English and used to train emergency medicine and surgery residents in the United States and then translated into German.[13] Despite apparent differences in the structure of emergency medical care in these 2 countries, the applicability of the ultrasonographic training and approval offered by our participants suggests that these should not be restrictive factors in sharing and distributing educational materials. As Germany and other European countries continue to expand their emergency medicine training, blended learning may well provide an opportunity for sharing information both conveniently and efficiently to train large groups of physicians.

In summary, Web-based learning provides the potential to teach physicians with greater flexibility than classroom instruction. Our data suggest that Web-based didactic training of basic ultrasonographic techniques and the EFAST may result in knowledge retention similar to that achieved through traditional classroom lectures.

The authors acknowledge Andrew McAfee, MD, MSc, and Susan Farrell, MD, MEd, for their advice regarding the design of this study, Brigitte Nyfeler, MD, for her constructive review of the multiple-choice tests, and Peter Studer, MD, for his assistance with the figure preparation.

Supervising editor: Peter C. Wyer, MD

Author contributions: E. Platz and KG conceived the study, designed the trial, and supervised the conduct of the trial and data collection. E. Platz obtained research funding. MC and CH undertook recruitment of participating centers and subjects. MM managed the data, including quality control. E. Parisini provided statistical advice on study design and analyzed the data. E. Platz drafted the article, and all authors contributed substantially to its revision. E. Platz takes responsibility for the paper as a whole.

Funding and support: By *Annals* policy, all authors are required to disclose any and all commercial, financial, and other relationships in any way related to the subject of this article that might create any potential conflict of interest. See the Manuscript Submission Agreement in this issue for examples of specific conflicts covered by this statement. This study was supported by the Esther B. Kahn Fund from the Department of Emergency Medicine, Brigham and Women's Hospital, Boston.

Publication dates: Received for publication September 27, 2009. Revisions received January 4, 2010; March 13, 2010; and April 10, 2010. Accepted for publication April 22, 2010. Available online June 11, 2010.

Reprints not available from the authors.

Address for correspondence: Elke Platz, MD, RDMS, Department of Emergency Medicine, Brigham and Women's Hospital, 75 Francis St, Neville House, Boston, MA 02115; 617-525-7932, fax 617-264-6848; E-mail eplatz@partners.org.

REFERENCES

1. Iserson KV. The REEME project: a cooperative model for sharing international medical education materials. *J Emerg Med.* 2008; 35:95-99.
2. Van Geloven AA, Luitse JS, Simons MP, et al. Emergency medicine in the Netherlands, the necessity for changing the system: results from two questionnaires. *Eur J Emerg Med.* 2003; 10:318-322.
3. Bey TA, Hahn SA, Moecke H. The current state of hospital-based emergency medicine in Germany. *Int J Emerg Med.* 2008;1:273-277.
4. Ban KM, Pini R, Sanchez LD, et al. The Tuscan Emergency Medicine Initiative. *Ann Emerg Med.* 2007;50:726-732.
5. Counselman FL, Sanders A, Slovis CM, et al. The status of bedside ultrasonography training in emergency medicine residency programs. *Acad Emerg Med.* 2003;10:37-42.
6. Scalea TM, Rodriguez A, Chiu WC, et al. Focused Assessment with Sonography for Trauma (FAST): results from an international consensus conference. *J Trauma.* 1999;46:466-472.
7. Emergency ultrasound guidelines. *Ann Emerg Med.*2009;53:550-570.
8. Kirkpatrick AW, Sirois M, Laupland KB, et al. Hand-held thoracic sonography for detecting post-traumatic pneumothoraces: the Extended Focused Assessment with Sonography for Trauma (EFAST). *J Trauma.* 2004;57:288-295.
9. Helm M, Kulla M, Lampl L. [Advanced trauma life support. A training concept also for Europe]. *Anaesthesist.* 2007;56:1142-1146.
10. Bouillon B, Kanz KG, Lackner CK, et al. [The importance of advanced trauma life support (ATLS) in the emergency room]. *Unfallchirurg.* 2004;107:844-850.
11. Rogers J. *Adults Learning.* 5th ed. London, UK: McGraw Hill; 2007.
12. Chenkin J, Lee S, Huynh T, et al. Procedures can be learned on the Web: a randomized study of ultrasound-guided vascular access training. *Acad Emerg Med.* 2008;15:949-954.
13. Platz E, Liteplo A, Hurwitz S, et al. Are live instructors replaceable? computer versus classroom lectures for EFAST training. *J Emerg Med.* 2009. In press.
14. Markova T, Roth LM. E-conferencing for delivery of residency didactics. *Acad Med.* 2002;77:748-749.
15. Cook DA, Beckman TJ. Reflections on experimental research in medical education. *Adv Health Sci Educ Theory Pract.* 2008. In press.
16. Davis DP, Campbell CJ, Poste JC, et al. The association between operator confidence and accuracy of ultrasonography performed by novice emergency physicians. *J Emerg Med.* 2005;29:259-264.
17. Jang T, Naunheim R, Sineff S, et al. Operator confidence correlates with more accurate abdominal ultrasounds by emergency medicine residents. *J Emerg Med.* 2007;33:175-179.
18. Filippucci E, Meenagh G, Ciapetti A, et al. E-learning in ultrasonography: a web-based approach. *Ann Rheum Dis.* 2007; 66:962-965.
19. Alagappan K, Schafermeyer R, Holliman CJ, et al. International emergency medicine and the role for academic emergency medicine. *Acad Emerg Med.* 2007;14:451-456.

Table E1. Teaching plan for face-to-face training.

Course Content	Time, min
Classroom groups (1-day course)	
Welcome and course overview	15
Pretest (online)	45
Break	15
Lecture: Ultrasonographic physics and instrumentation	40
Lecture: EFAST	50
Posttest 1 (online)	45
Break	45
Hands-on workshop	120
Web groups (half-day course)	
Welcome and course overview	15
Question and answer session	15
Hands-on workshop	120