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BREAKOUT SESSION

Evaluating Educational Interventions in Emergency Medicine

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Abstract

This article presents the proceedings of the 2012 *Academic Emergency Medicine* consensus conference breakout group charged with identifying areas necessary for future research regarding effectiveness of educational interventions for teaching emergency medicine (EM) knowledge, skills, and attitudes outside of the clinical setting. The objective was to summarize both medical and nonmedical education literature and report the consensus formation methods and results. The authors present final statements to guide future research aimed at evaluating the best methods for understanding and developing successful EM curricula using all types of educational interventions.

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The May 2012 *Academic Emergency Medicine* consensus conference "Education Research in Emergency Medicine: Opportunities, Challenges, and Strategies for Success" represented the culmination of the efforts of interested medical educators in determining the current state and future direction of research in emergency medicine (EM) education. This article summarizes the efforts of our breakout session evaluating current knowledge regarding educational interventions in EM and identifying prioritized future directions for research.

We reviewed the literature and outcome data on currently available teaching methods. Greatest importance was placed on higher-level outcome data using Kirkpatrick's evaluation model.[1] In this model, there are four levels of evaluation that roughly proceed from the easiest to measure to the most difficult and time-consuming. The first level is *reaction* and encompasses participant satisfaction and attitudes about the educational intervention. These outcomes are relatively easy to measure through questionnaires given to the participants and are thus common in evaluation studies. The second level is *learning*, which focuses on changes in knowledge, skills, and attitudes or values. These outcomes are commonly measured through tests and similar assessment tools. The third level is *behavior* as demonstrated in what the participants can do in the context of relevant tasks and situations. Common measures of this level of outcomes are standardized patient interactions, simulation, and case scenarios. The fourth level is *results* and is measured in the context of real-world practice. The current emphasis on work-based assessment[2,3] and multisource assessments[4] are examples of measures that seek to quantify these performance outcomes.

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Another widely cited framework is Miller's pyramid.[5] Like Kirkpatrick's framework, Miller's pyramid has four levels to describe different categories of outcomes. At the base of the pyramid is *"knows,"* where the learner can demonstrate knowledge of facts, typically assessed in the form of recall or recognition of factual information. The second level is *"knows how,"* which Miller describes as the *use* of knowledge, in other words, its application in some form of structured problem solving or task. The third level is *"shows how."* Miller describes this level of outcome as "performance" and emphasizes the integration of *"knowing"* and *"knowing how"* into some form of performance in a situation that approximates real-world practice. The apex of the pyramid is *"does,"* which characterizes performance in the real-world practice of medicine.

Although each of these frameworks has particular emphases, both highlight the range of outcomes that varies in utility as data for making evaluation judgments. Many position papers call for demonstrating outcomes like improvement in patient morbidity or mortality or at least improvements in practitioner performance. Patient outcome-based analysis could be applied to learners in EM through simulation outcome scenarios. However, patient outcome data may not accurately reflect individual learner performance, as actual patient care is directed by supervising physicians and takes place in a complex team-based setting. Patient outcomes are therefore influenced by a broad range of variables, extending well beyond the education of individual care providers.

At the opposite end of the spectrum, learner attitudes and satisfaction are extremely easy to measure and the data easy to obtain. However, these outcomes have a reputation for being of questionable utility in assessing other levels of educational outcomes. While learner reaction is a reasonable outcome to assess to ensure learner engagement in the activity, the utility of self-assessment for "higher-level" outcomes, such as performance, is limited. For example, the common practice of asking for learner self-assessments of their skill or knowledge has been demonstrated repeatedly as an inaccurate measure of "true" capability or performance.[6] In evaluating the available literature, we sought to determine if the outcome framework used in each study was appropriate for the desired measured outcome, and what level of significance this imparted, offering increased or decreased validity to the study.

As recommendations on future directions for research are made, it must be understood that different areas of research may require different outcome strategies. This intentional approach avoids the common convenience approach that uses whatever data are available (United States Medical Licensing Examination [USMLE] or shelf exam scores, faculty evaluations of residents, etc.) to represent outcomes that are not really appropriate to those data. By recognizing and planning for appropriate outcome measures, future studies will offer enhanced reliability and validity.

Therefore, the objectives for the session were to:

1. Review the literature regarding effectiveness of several types of educational modalities.
2. Reach consensus regarding perceived gaps in the current literature and set future research directions for evaluation of different teaching methods in EM.

LITERATURE REVIEW

Methods

The preconference group was formed by first soliciting interest from EM educators invited by the conference co-chair from a list of self-identified parties responding to an electronic message sent to the Council of Emergency Medicine Residency Directors (CORD) and Clerkship Directors in Emergency Medicine (CDEM) listserves. The final group, formed by the conference co-chair, was composed of medical educators including clerkship and course directors, residency program directors, simulation program directors, a vice-chair of education, and an acting associate dean for graduate medical education. Additional input was solicited from a PhD-trained expert in education.

The writing group worked online and by telephone to discuss the direction of the group, organize the content into subdomains, perform literature reviews, and create advance drafts of potential consensus statements. The writing group identified the following educational modalities to be assessed:

1. Web 2.0 teaching, in which the body of knowledge is created by users and presented in an environment where learners interact and change the content;
2. Web-based learning/asynchronous learning, in which the content is created by educators or subject matter experts;
3. Longitudinal curricula;
4. Simulation-based curricula;
5. Didactic presentations;
6. Group learning strategies, including problem-based learning (PBL), team-based learning (TBL), and small group learning.

For each of these six types of educational interventions, we conducted in-depth literature searches in the medical and educational literature with the aid of librarians at each of the writing group members' universities.

Consensus Formation. Participants self-selected to attend this track of the AEM consensus conference scheduled to take place as part of the annual meeting of the Society for Academic Emergency Medicine. There were no limits placed on who could attend the session.

RESULTS

Research Question 1: How Can We Optimize the Use of Web 2.0 Applications to Most Effectively Teach EM Trainees?

What Is Meant by the Term Web 2.0 and How Are Web 2.0 Applications Used in Teaching and Learning? Web 2.0 refers to the maturation of the Internet and its associated programs and applications from a "read-only" to a "read–write" interface. This maturation has transformed internet content itself. No longer is content simply viewable; instead, users can interface

with one another to actively contribute to content, reorder information, and develop new knowledge. The focus of Web 2.0 platforms and applications is to promote user connectivity, collaboration, and sharing.[7] Social software that promotes interaction among users can be harnessed to generate conversations, feedback, information sharing, and networking that leads to collaborative "remixability"—a process in which media is reorganized by users to build new concepts or ideas.[7]

Educators are using social media software and Web 2.0 applications across disciplines to promote teaching and learning among their students. Social software allows students greater freedom in how and what they learn, providing a self-directed learning environment that may better meet their own personal goals and needs. Learning also becomes a participatory and social activity that enhances the ability of the learner to generate new knowledge while engaged in a team or learning community.[8] This has led educators to define the related term, *Pedagogy 2.0*: the development of new educational agendas and priorities built on the technologic advances of social software.[7,8] Pedagogy 2.0 presumes that users must learn to learn, no matter the type of instructional activity. Reshaping educational objectives in this manner may result in improved connectivity and social rapport among learners, collaborative information discovery and sharing, content creation, knowledge and information aggregation, and continuous content modification.[7,8]

How Is Web 2.0 Teaching Used in Medical Education? Numerous Web 2.0 applications and social software media have been introduced across undergraduate and graduate medical education programs and nursing curricula over the past 10 years. Examples of Web 2.0 interfaces used in some medical education setting include wikis, blogs, streaming video services, social bookmarking, collaborative tagging (i.e., Folksonomies), tag clouds, social search engines, really simple syndication (RSS feeds), social networking, peer rating/community voting, collaborative filtering, virtual meetings, online gaming, and peer-to-peer media sharing utilities.[7–14] These platforms take advantage of the cultural phenomenon of social networking.

Current medical education literature has focused on two themes of social software: virtual classrooms and push technology.[10,11,13,14] Virtual classrooms can be created using course management software in which learners continuously interact over the course term to generate and solve problems, while learning basic concepts and core content. Problem-solving within a group leads to a de novo application of newly acquired knowledge, suggesting that learners can practice critical thinking skills while creating educational products that are of lasting value to both themselves and their learner group.[7] Course management systems and virtual classrooms are commonplace among undergraduate medical education (UME) programs, with less current application at the graduate or postgraduate level. Push technology is a much less interactive example of Web 2.0 technology, in which the user or learner subscribes to a continuous or scheduled feed of information from a single source of content. As opposed to pull technology, in which the learner makes a request for information, push technology disseminates smaller amounts of content on a frequent basis—with little or no discussion of that content mandated by individual learners.[10]

What Are the Limitations of Web 2.0 Teaching and What Challenges Are Commonly Encountered by Educators Using Web 2.0 Applications? The main limitations of using Web 2.0 platforms for teaching include a lack of familiarity of available social software products by both educators and learners, time and expertise needed to train educators and learners to use available products, cost (both personal cost of hardware for learner interfacing and programmatic cost of available software), quality of available applications or software, addiction and socially adverse uses of applications, and copyright issues.[7,8] Many of these limitations are related to the generational differences among teachers and learners, with "millennial learners" citing greater comfort and satisfaction with social software than "Gen X" or older instructors.[10–14]

Time may be the best method of overcoming many of these noted limitations, with expected advances in software functionality and user abilities over the coming decade. Perhaps more challenging are the obstacles to effective curriculum design using Web 2.0 products. With applications such as push technology, it is difficult to transcend simple knowledge acquisition in favor of higher order learning objectives. Social software products that allow for enhanced communication among learners can be designed to teach critical thinking and teamwork; however, strict goals and objectives must be linked to each group activity.[7] It may be even more difficult to link such online learning activities to improved health outcomes for patients or changes to behavioral norms by providers. There is a paucity of literature that examines the effectiveness of Web 2.0 products for medical education, with most studies starting with an assessment of learner and instructor satisfaction with the chosen teaching method or software product.[11–15]

Consensus Statement on Web 2.0 Learning. Social software and other Web 2.0 applications focus on creating communities of learners that can direct content in novel ways with the goal of enhanced collaboration, cooperative learning, and information sharing. These instructional aids represent a potential paradigm shift in the ways in which we define course content, teachers, and learners. Medical educators have used course management systems and push technology to enhance learner communication and knowledge translation in medicine. Limitations to widespread use are related to currently available software and products, as well as instructor and learner comfort with emerging media. Future projects in EM education should focus on options for curriculum design using various software or media, as well as an assessment of the effectiveness of Web 2.0 teaching strategies compared with standard instructional design. Such assessments of Web 2.0 teaching effectiveness should focus on learner-centered endpoints rather than shifts in normative group behaviors.

Future Research Questions on Web 2.0 Learning.

- Are teaching modalities that use Web 2.0 technology as effective as standard instructional methods?
- Which Web 2.0 software applications are the most effective for teaching new knowledge and/or skills to EM trainees? Which modalities are most effective for teaching higher-order decision-making?
- What Web 2.0 skills are a necessity for the modern medical educator and learner? How do we teach learners to critically appraise Web 2.0 content?
- How do we best link improvements in health outcomes to Web 2.0 teaching in order to assess effectiveness of instructional design?

Research Question 2: Is Web-based Asynchronous Learning an Effective Teaching Method for EM Training?

How Effective Is an Asynchronous Teaching Method and How Is That Effectiveness Measured? Asynchronous learning through an online educational model has shown itself to be an effective teaching method across many levels of education with a variety of course contents. Technology-based distance education and online learning is a growing trend among educators, starting with elementary education and continuing through secondary and higher levels of education. Modes of instruction that consist of entirely asynchronous online material, as well as blended models that combine online material with face-to-face interactions, have been shown to be viable alternatives to the more traditional classroom-based educational model.[15,16] Studies have shown these teaching modalities to be similar to classroom-based education in terms of learner satisfaction, faculty satisfaction, and knowledge gain for undergraduate and graduate degree programs.[17,18]

Does This Method of Teaching Allow for the Translation of Knowledge and Skills Required to Become a Successful Emergency Physician? Asynchronous education has been used in undergraduate and graduate medical education with a measurable degree of success,[19,20] including studies that are specific to EM education.[21–23] The asynchronous learning model has been shown to be feasible to implement, satisfying for learners, and effective, with improvement in knowledge scores that are similar to synchronous learning models when applied to specific content within EM. The literature is lacking in studies looking at higher-level outcome measures. Advantages to asynchronous learning are that it allows for individualized scheduling and pace of learning as well as individual practice improvement.

Should EM Didactics Include a Component of Web-based, Asynchronous Learning? There are many factors that must be considered prior to implementation of an asynchronous learning model. The next generation of EM learners is more technologically sophisticated, and flexibility in their educational offerings is important. Online, asynchronous teaching models are a way to help customize and maximize the education of these learners.[24] However, success of such a model depends heavily on learner motivation and discipline. The EM Residency Review Committee (RRC), the national oversight organization for residency training, requires that education have appropriate faculty supervision and have an evaluative component to measure resident participation and educational effectiveness. In 2008, the Council of EM Residency Directors and the RRC convened a workgroup to analyze conference requirements and make recommendations. They found that a mixture of synchronous and asynchronous learning activities is ideal, but further research is needed to define the educational activities that benefit from each type of learning.[24]

Consensus Statement on Asynchronous Learning. The flexibility of scheduling with a Web-based asynchronous teaching model, coupled with its similar effectiveness to "traditional" methods, makes it a very attractive adjunct to development of a well-balanced EM didactic curriculum. EM educators should focus on providing an appropriate balance of self-directed, asynchronous education with "real-time" interactive educational models. The asynchronous model is most likely best suited toward baseline medical knowledge and uniformly required core content, which would allow more flexibility with conference time for small groups, team learning, and interactive competencies such as professionalism and interpersonal communication skills. Future areas of research should focus on what content is best learned through the asynchronous model using study designs that focus on more rigorous outcomes than learner satisfaction.

Future Research Questions on Asynchronous Learning.

- Which asynchronous learning activities are most effective and best suited to EM education and how should they be incorporated?
- How should we track participation in asynchronous learning activities and measure their effectiveness?

Research Question 3: Are Longitudinal Curricula Effective and Applicable Training Methods for EM Educational Programs?

Is Longitudinal Education as Effective as Traditional Teaching Methods in Medical Education? Longitudinal education is an innovative method of training that integrates multiple fields of medicine to provide comprehensive training to learners over a long time period. The literature reveals that students are generally more satisfied and may actually learn and retain both knowledge and clinical skills better when trained in a longitudinal curriculum. Many satisfaction surveys have showed that learners prefer this method of training over traditional programs.[25,26] Moreover, outcome studies reveal that students trained in longitudinal models perform at least as well as their traditionally trained peers. From the Harvard program, students completing a longitudinal course performed at least as well as peers in traditional clerkships on the National Board of Medical Examiners subject exams and objective structured clinical exams and scored higher on year-end clinical skills self-assessment exams.[27,28] Poncelet et al.[29] found similar results with longitudinal students performing at least as well as their traditional counterparts on Step 2 USMLE tests. This evidence suggests that longitudinal

training may be an effective teaching modality in medical student education.

Is Longitudinal Training Applicable to Medical Education on a Large Scale? In contrast to training by traditional methods, longitudinal instruction requires a paradigm shift in teaching methods and new concepts and designs for the educators and institutions alike. Most studies on truly integrated longitudinal curricula were conducted on a relatively small scale.[28–30] The University of Missouri–Kansas City has employed nontraditional training methods including modified integrated experiences for all of its students with successful outcomes on national exam scores and residency placement for many years.[31] Future research is needed to determine if more widespread, larger-scale longitudinal programs involving substantial numbers of learners can be successfully implemented and can maintain their effective training outcomes.

What Role Can Longitudinal Education Play in Teaching EM Concepts to Medical Students and Residents? Standard longitudinal curricula are generally offered to third-year medical students and do provide some exposure to core clinical concepts in EM. Students in these programs acquire a strong platform of retained general clinical knowledge to begin their fourth year. However, with current designs, there is less exposure to key EM concepts, such as the acutely ill undifferentiated patient, in addition to a lack of exposure to the full breadth of EM core topics. Therefore, in their current form, longitudinal curricula cannot yet replace standard EM clerkships. Nonetheless, there may be a role for new and innovative integrated longitudinal training combining EM and critical care. In recent years, there has been a recognition that undergraduates and junior residents may be underprepared to care for acutely and critically ill patients.[32,33] In response, there have been a number of new initiatives to provide earlier exposure to EM and critical care core concepts and training and to create novel integrated programs. These longer programs than are currently standard could be considered short-term longitudinal exposures.[34,35] At the graduate medical education level, residents already perform longitudinal follow-up on their patients, although this could be much more standardized with regard to types of patients. Another potential role for integrated training involves combining residents from EM and other specialties as they learn about operational and administrative issues, such as quality improvement. Future innovation and research is needed to determine the role and efficacy of integrated longitudinal training and its application to EM education, both at the undergraduate and at the graduate levels.

Consensus Statement on Longitudinal Curricula. Longitudinal education is a novel and effective method in medical education. While most of the longitudinal curricula occur on a small scale at the undergraduate level, new research is needed to develop outcome measures for developing integrated programs exposing learners (undergraduates and junior residents) to acutely and critically ill patients.

Future Research Questions on Longitudinal Curricula.

- Is there a role for integrated, abbreviated, longitudinal learning in EM for medical students?
- Could longitudinal education be incorporated into graduate medical education in EM, and if so, in what form?
- Can the information required on resident follow-up logs be enhanced to reflect important learning properties found in traditional longitudinal education?

Research Question 4: Is Simulation an Effective Teaching Method for EM?

Is Simulation an Effective Educational Tool? What content is best acquired through simulation? There is an extensive body of literature demonstrating the effectiveness of simulation and its superiority to other educational methods for the attainment of certain learning objectives. Most studies compare simulation to traditional educational methods (didactics and/or supervised clinical experience) or presimulation to postsimulation performance. The improved outcomes attributed to simulation include adherence to cardiac arrest protocols,[36] performance of procedures and resuscitation interventions,[37–40] attitudes and self-perception,[41] and teamwork and communication behavior.[42–44] A common theme among these outcomes is that they all focus on measurable behaviors of participants, demonstrating that simulation is well suited to teaching specific skills. However, many of these studies also demonstrate the role of simulation in developing learner self-efficacy, attitudes, and application of knowledge.

What Are the Features of Simulation Programs That Lead to Effective Learning? Repetition and feedback have been identified as the two most important features of effective simulation,[45] and expert opinion favors accomplishing this through mastery learning or deliberate practice paradigms.[46] Deliberate practice refers to focused sessions wherein learners work toward defined objectives and receive feedback that informs further practice with the ultimate goal of mastery level performance. Mastery learning requires that all learners reach the same high standard of achievement, although the time needed may vary. Both techniques have been employed in numerous studies of simulation programs, invariably with promising results.[36,37,39,40,47–50] It is important to recognize that mastery learning and deliberate practice are loosely defined in the literature, and the precise methods by which educators operationalize these concepts are highly variable. The best techniques to implement repetition and feedback therefore remain to be identified.

Feedback in simulation takes place largely in the context of debriefing, and debriefing techniques are a major variable in simulation research. Many experts favor the "debriefing with good judgment" approach,[51] although other debriefing frameworks have been described as well,[52,53] all of which have been used successfully. However, there is a paucity of literature comparing debriefing techniques or defining elements of debriefing associated with effective learning.[54]

Do Knowledge, Skills, and Attitudes Acquired via Simulation Generalize to the Clinical Environment? If So, Do They Affect Patient Outcomes? Several studies have demonstrated translation of knowledge and skills acquired in the simulation lab to clinical practice. Simulation-trained teams performed better during in-hospital cardiac arrests,[55] trauma resuscitations,[43] and procedures.[47,49,56] Educational gains from simulation have been shown to be relatively resistant to decay.[57,58] Most importantly, simulation training has been associated with gains in patient safety, clinical outcomes, and cost-effectiveness. Simulation has been linked to improved neonatal and obstetric outcomes,[59,60] decreased operative and procedural complications,[61,62] and decreased cost.[63] Once again, the key features leading to the effectiveness of these programs remain to be defined. Lingering questions include how much simulation is required, how frequently it should be repeated, and how to facilitate translation of skills from the lab to clinical practice.

Consensus Statement on Simulation-based Medical Education. Simulation is clearly effective for improving learners' knowledge and skills in the simulation setting. There is evidence that these gains translate to actual clinical practice and that they have a favorable effect on important patient outcomes. While there is consensus and evidence indicating that repetitive practice and feedback are key features of effective simulation instruction, there is considerable uncertainty as to the optimal techniques for developing and delivering simulation-based curricula.

Questions for Future Research on Simulation-based Medical Education.

- What are the optimal techniques for delivering effective simulation? How should deliberate practice and mastery learning be operationalized? What is the ideal debriefing strategy? What methods help ensure translation of learning to clinical practice?
- What learning objectives should be emphasized in simulation? Is it best to use simulation to teach management of high-stakes, low-frequency events or "bread and butter" topics? Is there material that should not be taught using simulation?
- How much time should be devoted to simulation to achieve robust outcomes? How often should simulation be repeated to prevent decay of knowledge and skills? Should clinical time be exchanged for time in the simulation lab?
- Is simulation truly cost-effective? It produces superior results to other methods, but are the results sufficiently superior to justify the expense? If so, how can it be conducted most efficiently?

Research Question 5: Are Traditional Didactic Lecture Sessions Still Effective and Relevant Ways to Teach EM?

Should Didactic Lectures Remain as Integral Components of EM Teaching Programs? All areas of medicine have used didactic lectures as a major teaching method throughout the history of medical education since 1850.[64] This remains true in many EM educational programs, despite continued criticisms that this approach may not be the most popular or even the most effective way to transmit information to learners. Many educators have attempted to develop alternative teaching methods or have looked for ways to enhance didactic learning to increase effectiveness. However, as many educators try to move away from didactics, some continue to suggest that traditional lecture-based teaching still plays an important role in modern medical education programs.[64–67]

Should Didactic Lecture Sessions Be the Reference Standard Used for Evaluating Other Learning Modalities? Perhaps due to the popularity and pervasive use of didactic lectures for teaching, many recently published educational studies evaluate various methods of communicating information to learners by using standard didactic lecture sessions as the reference standard for comparison. While some authors have argued that various alternative teaching methods are superior to lectures,[68–70] many studies have demonstrated that these alternatives are merely equivalent or perhaps even inferior to didactic teaching.[71–80] Some educators believe that lectures by experts in specific areas of medicine may still have value, although some limited data suggest that expert guest speakers at grand rounds do not produce increased knowledge retention.[81]

What Strategies Are Available to Enhance Didactic Learning Sessions Within EM Programs and How Should Their Success Be Measured? As educators work to evaluate the role of didactic sessions in their educational programs, methods for determining effectiveness of various techniques are important. Research in this area is complicated by the fact that individual lecture style and experience may differ drastically between faculty members, which is difficult to control for and may affect learning outcomes. Many enhancements have been suggested for speakers to consider within didactic teaching activities. Using a "game format" to enhance learner interactions during a lecture activity has been favorably viewed by learners, but evidence is mixed regarding whether or not learning is enhanced.[69,82] Other methods to introduce an interactive learning environment within a lecture have also been viewed positively, although data to support increased knowledge retention are not conclusive.[83–85] Shortening lectures may be a way to streamline the delivery of content through didactic formats without decreasing test performance.[86] Others have suggested that videoconferencing technology,[71,87] or learning from digitally archived lectures,[88] are at least as effective as live didactic presentations at delivering information, which may give educators additional flexibility for the times and locations of learning activities. Defining the content of traditional didactic learning sessions may be important when designing future research studies, specifically determining whether such learning activities would include case presentations, morbidity and mortality conferences, and grand rounds presentations, in addition to core educational content.

Consensus Statement on Didactic Teaching

Didactic lecture activities are appropriate learning methods to include in a well-rounded EM educational program. Further research is needed to determine whether proposed alternative teaching methods are superior to lectures and whether enhancing lecture material with the addition of interactive components can improve learning. EM educators should evaluate the balance of didactic sessions with other learning modalities, to identify the optimal role for didactic learning sessions in EM educational programs. The type of material being presented, how learner knowledge will be assessed, and the appropriate reference standards for comparison of outcomes are all important aspects to consider when designing studies to evaluate educational effectiveness of didactic lectures or their alternatives.

Questions for Future Research on Didactic Lectures.

- What is the optimal balance of didactic learning sessions to other educational methods in EM training programs?
- What strategies are available to enhance didactic sessions within EM programs and how should their success be measured?
- Which proposed enhancements and alternative teaching methods best enhance the retention of knowledge when incorporated into large-group didactic learning sessions? Case-based discussions, interactive questions, game format activities, and other methods have been described but incompletely evaluated.
- What is the appropriate length for didactic learning activities to maximize learner attentiveness, knowledge acquisition, and long-term retention?

Research Question 6: Should EM Education Embrace Group Learning Strategies?

Should Small-group Education Be Used to Teach EM? Small-group learning theoretically offers an opportunity to increase learning effectiveness when compared to traditional lecture methods. Traditional lectures are typically passive learning experiences, while well-planned and well-implemented small-group sessions are more active interventions.[89] In addition to creating an active learning environment, small-group teaching is well aligned with principles of adult learning, in that learners are self-directed by nature, have life experiences that aid them in their learning, are eager to apply their newly learned knowledge, and are intrinsically motivated.[90] There are two popular small-group educational methods that are well described in the literature: PBL and TBL.

Is PBL an Effective Teaching Method for EM? PBL was introduced into health science education by the medical school at McMaster University in the 1960s and since then has been adopted in medical schools across the country and then around the world.[91] On review of the literature, there is no report of classic small group PBL teaching in EM clerkship or residency education programs. PBL, however, has been described in anesthesia, internal medicine, obstetrics and gynecology, and occupational medicine residency training programs.

In 1984, a project panel on the General Professional Education of the Physician and College Preparation for Medicine called for less lecture-based instruction and more emphasis on independent learning and problem solving.[92] PBL addresses a variety of key educational objectives: 1) structuring knowledge for use in clinical contexts, 2) developing an effective clinical reasoning process, 3) development of effective self-directed learning skills, and 4) increased motivation for learning.[93]

PBL implementation varies from one institution to another, but at the center of all PBL teaching is a clinical problem that students tackle in small groups under the supervision of a teacher who is generally a faculty member.[93] The effectiveness of PBL as a teaching method has received mixed reviews.[94–99] Studies of PBL do not demonstrate dramatic differences in cognitive outcomes. In fact, some researchers argue that PBL may hinder learners from developing a complete cognitive framework and limit the learner's ability to engage in forward reasoning.[96] In one Canadian study, graduates from a PBL medical school had higher rates of test ordering compared to other students who did not train in a PBL school. On a positive note, students find PBL challenging, motivating, and an enjoyable way to learn.[94–97] According to a meta-analysis, PBL appears to result in more self-directed learning.[95,100] PBL has not been studied in EM-specific settings.

Is TBL an Effective Teaching Method for EM? TBL is a structured approach to a class session originally developed for use in science and business courses with large student to instructor ratios. This method has increasingly been applied to medical training, as it combines the strengths of small group interactive learning with teacher-driven content delivery.[101]

The TBL approach involves three distinct educational components: preclass preparation, a short-multiple choice readiness assurance test taken first individually then as a small group, and last, a facilitator-led application of concepts session. This activity allows for a more engaged learning environment and promotes deeper understanding when compared to more traditional learning. This type of small group learning is used in some medical schools and residency programs but has not been reported in the literature for EM training programs.[101–103]

A 2003 report on the initial experience of 10 U.S. medical schools with TBL had three important conclusions for EM. First, TBL has a trusted reputation as an educational method in other professions, and there is no reason why it could not be used in medical education. Second, it can accommodate various teaching styles. Third, the responsibility for learning is placed on the individual and hence this promotes life-long learning.[103] In a 2004 study of family and community medicine, internal medicine, and pediatric residents, TBL learners had lower perceptions of the value of the educational session and ability to meet their learning objectives, even though they achieved the same knowledge and attitude gains as the control group.[104]

Does Using PBL or TBL Methods Result in Learners Who Are More Likely to Be Self-directed, Life-long Learners? As noted previously, both PBL and TBL offer theoretical evidence of improved competency in the domain of self-directed, life-long learning skills. In both of these educational environments, learners are expected to research clinical questions and apply their newly acquired knowledge to a clinical scenario. The hope is that this knowledge acquisition skill is sustained and used throughout the individual's career. However, this has not been substantiated in the literature.

Consensus Statement on Small-group Learning Methods. Small-group methods offer active learning opportunities and are enjoyable for learners. Given that the ACGME requires a minimum of 5 hours of educational time each week, it seems reasonable to identify teaching strategies that engage the learner. The use of active learning activities rather than passive learning activities should be the goal. It is unclear whether small group methods are more effective than traditional modalities for acquisition and retention of knowledge, necessitating that educational outcomes of small-group interventions be monitored closely. Since EM is practiced in a team environment, small-group teaching has the theoretical added benefit of preparing the learner to function more effectively in the clinical environment by helping to develop teamwork skills. In addition, research suggests that this method of teaching may promote life-long learning skills, although further results in this area are needed.

Questions for Future Research on Small-group Learning.

- What EM content should be taught using small group teaching methods?
- What are the best small-group methods for teaching EM content?
- What is the best balance between small-group learning and other educational methods in an EM curriculum?

CONSENSUS PROCESS

Methods

The session began with a 15-minute didactic presentation summarizing the literature review to ensure all participants were operating with similar levels of background exposure to the most critical information. Next, attendees rotated at each of six tables, representing each of the six subdomains. The tables were moderated by the corresponding writing group member and an education expert in that domain. Moderators ensured, through open-ended discussion, that no important content areas or potential research priorities were missed. The sessions were recorded electronically.

The breakout session closed with attendees affixing three stickers to the proposed research questions upon which they placed the most priority. These results were tabulated and arranged in order of most to fewest votes and the top six were deemed to be the most crucial research questions for future research, as support for the remaining questions fell off significantly after the first six.

At the end of the day, the breakout track's findings of top five priorities were presented to all of the attendees at the consensus conference. At this session, the large group also voted on their acceptance of three broad statements regarding next steps in educational interventions research, which were formulated in advance by the writing group. The proceedings were organized into manuscript form by the original eight-member writing group.

RESULTS

Conference participants represented many roles in EM education, including UME, GME, continuing medical education, medical school deans, clinician-educators, residents, and medical students. The top six specific priorities identified for future research in the breakout groups were (in order of support):

1. What strategies are available to enhance didactic sessions within EM programs and how should their success be measured?
2. Which asynchronous activities are best suited to EM education and how should they be incorporated?
3. In simulation, how much time and repetition is required to achieve robust outcomes?
4. What content is best taught with simulation?
5. What content is best taught in a small-group format?
6. Which Web 2.0 modalities are most effective for teaching new knowledge, skills, and higher-order decisions?

A majority of large-group participants agreed with the following statements:

1. Research into educational methods should be outcomes-based, with emphasis on objective measurements of learning, as opposed to learner satisfaction or self-assessment (95% yes).
2. Outcomes-based research on educational methods should be prioritized, with emphasis on demonstrating measurable changes in learner behavior, changes in clinical performance, and ultimately improvements in patient health outcomes (96% yes).
3. Although novel educational modalities are increasingly available and enjoyed by learners, these need to be studied in comparison to traditional teaching methods to determine whether they deliver at least a comparable educational outcome (76% yes).

CONCLUSIONS

There are numerous teaching modalities that are employed in current medical education, both at the graduate and at the undergraduate level. A detailed literature review of each reveals that most of these training methods have evidence of successful outcomes, indicating their utility. Our subcommittee identified six primary methods of instruction, each of which has individual benefits and drawbacks, as we have discussed.

The consensus conference identified six key areas of perceived gaps in the current literature, and future research directions for evaluation of different teaching

methods in EM, with additional questions explored above. The six critical areas identified are as follows. 1) Which Web 2.0 modalities are most effective for teaching new knowledge, skills, and higher-order decisions? 2) What content is best taught in a small-group format? 3) Which asynchronous activities are best suited to EM education and how should they be incorporated? 4) What content is best taught with simulation? 5) How much time and repetition must be done to achieve competence in simulation? 6) What strategies are available to enhance didactic sessions within EM programs and how should their success be measured?

As researchers consider these questions, attention must be given to the focus on measurable outcomes to achieve the highest Kirkpatrick level possible in future educational research. Education researchers should take these findings into account when designing their next studies.

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References

1. Kirkpatrick DL, Kirkpatrick JD. Evaluating Training Programs, 3rd ed. San Francisco, CA: Berrett-Koehler Publishers, 2006.
2. Norcini J, Burch V. Workplace-based assessment as an educational tool: AMEE Guide No. 31. Med Teach. 2007; 29:855–71.
3. Norcini JJ. Work-based assessment. BMJ. 2003; 326:753–5.
4. Berk RA. Using the 360 degrees multisource feedback model to evaluate teaching and professionalism. Med Teach. 2009; 31:1073–80.
5. Miller GE. The assessment of clinical skills/competence/performance. Acad Med. 1990; 65:S63–7.
6. Eva KW, Regehr G. Self-assessment in the health professions: a reformulation and research agenda. Acad Med. 2005; 80:S46–54.
7. McLoughlin C, Lee MJ. Social Software and Participatory Learning: Pedagogical Choices with Technology Affordances in the Web 2.0 Era. Proceedings Ascilite Singapore 2007. Available at: http://www.ascilite.org.au/conferences/singapore07/procs/mcloughlin.pdf. Accessed Sep 15, 2012.
8. Kamel Boulos MN, Wheeler S. The emerging Web 2.0 social software: an enabling suite of sociable technologies in health and health care education. Health Info Libr J. 2007; 24:2–23.
9. Van De Belt TH, Engelen LJ, Berben SA, Schoonhoven L. Definition of Health 2.0 and Medicine 2.0: a systematic review. J Med Internet Res. 2010; 12:e18.
10. Bahner DP, Adkins E, Patel N, Donley C, Nagel R, Kman NE. How we use social media to supplement a novel curriculum in medical education. Med Teach. 2012; 34:439–44.
11. Chu SK, Woo M, King RB, Choi S, Cheng M, Koo P. Examining the application of Web 2.0 in medical-related organisations. Health Info Libr J. 2012; 29:47–60.
12. George DR, Dellasega C. Use of social media in graduate-level medical humanities education: two pilot studies from Penn State College of Medicine. Med Teach. 2011; 33:e429–34.
13. Sandars J, Homer M, Pell G, Crocker T. Web 2.0 and social software: the medical student way of e-learning. Med Teach. 2008; 30:308–12.
14. Lemley T, Burnham JF. Web 2.0 tools in medical and nursing school curricula. J Med Libr Assoc. 2009; 97:50–2.
15. Moloney JF, Oakley B. Scaling online education: increasing access to higher education. J Asynchron Learn Netw. 2010:14:55–70. Available at: http://www.eric.ed.gov/ERICWebPortal/contentdelivery/servlet/ERICServlet?accno=EJ909842. Accessed Sep 15, 2012.
16. U.S. Department of Education. Evaluation of Evidence-based Practices in Online Learning: A Meta-analysis and Review of Online Learning Studies. Available at: http://www2.ed.gov/rschstat/eval/tech/evidence-based-practices/finalreport.pdf. Accessed Sep 15, 2012.
17. Larson CK, Sung CH. Student performance: online versus blended versus face-to-face. J Asynchron Learn Netw. 2009; 13:31–42.
18. Fasse R, Humbert J, Rappold R. Rochester Institute of Technology: analyzing student success. J Asynchron Learn Netw. 2009; 13:37–48.
19. Lovell K, Vignare K. MSU medical colleges blended learning for first year science courses: uniting pedagogy to maximize experience and real world limitations. J Asynchron Learn Netw. 2009; 13:55–63.
20. Howlett D, Vincent T, Gainsborough N, et al. Integration of a case-based online module into an undergraduate curriculum: what is involved and is it effective? E-Learning. 2009; 6:372–84.
21. Burnette K, Ramundo M, Stevenson M, Beeson MS. Evaluation of a web-based asynchronous pediatric emergency medicine learning tool for residents and medical students. Acad Emerg Med. 2009; 16(Suppl 2):S46–50.
22. Gisondi MA, Lu DW, Yen M, et al. Adaptation of EPEC-EM curriculum in a residency with asynchronous learning. West J Emerg Med. 2010; 11:491–9.
23. Lund A, Lam K, Parks P. Disaster medicine online: evaluation of an online, modular, interactive, asynchronous curriculum. CJEM. 2002; 4:408–13.
24. Sadosty AT, Goyal DG, Gene Hern H Jr, Kilian BJ, Beeson MS. Alternatives to the conference status quo: summary recommendations from the 2008 CORD Academic Assembly Conference Alternatives workgroup. Acad Emerg Med. 2009; 16(Suppl 2):S25–31.
25. Ko PY, Scott JM, Mihai A, Grant WD. Comparison of a modified longitudinal simulation-based advanced cardiovascular life support to a traditional advanced cardiovascular life support curriculum in third-year medical students. Teach Learn Med. 2011; 23:324–30.
26. Papageorgiou A, Miles S, Fromage M, Kemmy J, Leinster SJ. Cross-sectional evaluation of a

longitudinal consultation skills course at a new UK medical school. BMC Med Educ. 2011; 11:e55.
27. Hirsh D, Gaufberg E, Ogur B, et al. Educational outcomes of the Harvard Medical School-Cambridge integrated clerkship: a way forward for medical education. Acad Med. 2012; 87:643–50.
28. Ogur B, Hirsh D, Krupat E, Bor D. The Harvard Medical School-Cambridge integrated clerkship: an innovative model of clinical education. Acad Med. 2007; 82:397–404.
29. Poncelet A, Bokser S, Calton B, et al. Development of a longitudinal integrated clerkship at an academic medical center. Med Educ Online. 2011;16: doi: 10.3402/meo.v16i0.5939.
30. Norris TE, Schaad DC, DeWitt D, Ogur B, Hunt DD, Consortium of Longitudinal Integrated Clerkships. Longitudinal integrated clerkships for medical students: an innovation adopted by medical schools in Australia, Canada, South Africa, and the United States. Acad Med. 2009l; 84:902–7.
31. Drees BM, Arnold L, Jonas HS. The University of Missouri-Kansas City School of Medicine: thirty-five years of experience with a nontraditional approach to medical education. Acad Med. 2007; 82:361–9.
32. Abuhusain H, Chotirmall SH, Hamid N, O'Neill SJ. Prepared for internship? Ir Med J. 2009; 102:82–4.
33. Smith CM, Perkins GD, Bullock I, Bion JF. Undergraduate training in the care of the acutely ill patient: a literature review. Intensive Care Med. 2007; 33:901–7.
34. Laack TA, Newman JS, Goyal DG, Torsher LC. A 1-week simulated internship course helps prepare medical students for transition to residency. Simul Healthc. 2010; 5:127–32.
35. Teo AR, Harleman E, O'Sullivan PS, Maa J. The key role of a transition course in preparing medical students for internship. Acad Med. 2011; 86:860–5.
36. Wayne DB, Butter J, Siddall VJ, et al. Mastery learning of advanced cardiac life support skills by internal medicine residents using simulation technology and deliberate practice. J Gen Intern Med. 2006; 21:251–6.
37. Barsuk JH, Shubhada NA, Cohen ER, et al. Mastery learning of temporary hemodialysis catheter insertion by nephrology fellows using simulation technology and deliberate practice. Am J Kidney Dis. 2009; 54:70–6.
38. Wayne DB, Barsuk JH, O'Leary KJ, et al. Mastery learning of thoracentesis skills by internal medicine residents using simulation technology and deliberate practice. J Hosp Med. 2008; 3:48–54.
39. Oermann MH, Kardong-Edgren S, Odom-Maryon T, et al. Deliberate practice of motor skills in nursing education: CPR as exemplar. Nurs Educ Perspect. 2011; 32:311–5.
40. Sawyer T, Sierocka-Castaneda A, Chan D, et al. Deliberate practice using simulation improves neonatal resuscitation performance. Simul Healthc. 2011; 6:327–36.
41. Stevens LM, Cooper JB, Raemer DB, et al. Educational program in crisis management for cardiac surgery teams including high realism simulation. J Thorac Cardiovasc Surg. 2012; 144:17–24.
42. Thomas ET, Williams AL, Reichman EF, et al. Team training in the neonatal resuscitation program for interns: teamwork and quality of resuscitations. Pediatrics. 2010; 125:539–46.
43. Steinemann S, Berg B, Skinner A, et al. In situ, multidisciplinary, simulation-based teamwork training improves early trauma care. J Surg Educ. 2011; 68:472–7.
44. Yee B, Naik VN, Joo HS, et al. Nontechnical skills in anesthesia crisis management with repeated exposure to simulation-based education. Anesthesiology. 2005; 103:241–8.
45. Issenberg SB, McGaghie WC, Petrusa ER, et al. Features and uses of high-fidelity medical simulations that lead to effective learning: a BEME systematic review. Med Teach. 2005; 27:10–28.
46. McGaghie WC, Issenberg SB, Cohen ER, et al. Medical education featuring mastery learning with deliberate practice can lead to better health for individuals and populations. Acad Med. 2011; 86: e8–9.
47. Giglioli S, Boet S, De Gaudio AR, et al. Self-directed deliberate practice with virtual fiberoptic intubation improves initial skills for anesthesia residents. Minerva Anestesiologica. 2012; 78:1–6.
48. Price J, Naik V, Bodhwani M, et al. A randomized evaluation of simulation training on performance of vascular anastomosis on a high-fidelity in vivo model: the role of deliberate practice. J Thorac Cardiovasc Surg. 2011; 142:496–503.
49. Kessler DO, Auerbach M, Pusic M, et al. A randomized trial of simulation-based deliberate practice for infant lumbar puncture skills. Simul Healthc. 2011; 6:197–203.
50. Zendejas B, Cook DA, Hernandez-Irizarry R, et al. Mastery learning simulation-based curriculum for laparoscopic TEP inguinal hernia repair. J Surg Ed. 2012; 69:208–14.
51. Rudolph JW, Simon R, Dufresne RL, et al. There's no such thing as "nonjudgmental" debriefing: a theory and method for debriefing with good judgment. Simul Healthc. 2006; 1:49–55.
52. Zigmont JJ, Kappus LJ, Sudikoff SN. The 3D model of debriefing: defusing, discovering, and deepening. Semin Perinatol. 2011; 35:52–8.
53. Kuiper RA, Heinrich C, Matthias A, et al. Debriefing with the OPT model of clinical reasoning during high fidelity patient simulation. Int J Nurs Educ Scholarsh. 2008; 5:Article17.
54. Raemer D, Anderson M, Cheng A, et al. Research regarding debriefing as part of the learning process. Simul Healthc. 2011; 6(Suppl):S52–7.
55. Wayne DB, Didwania A, Feinglass J, et al. Simulation-based education improves quality of care during cardiac arrest team responses at an academic teaching hospital: a case-control study. Chest. 2008; 133:56–61.
56. Cohen J, Cohen SA, Vora KC, et al. Multicenter, randomized, controlled trial of virtual-reality simulator training in acquisition of competency in colonoscopy. Gastrointest Endosc. 2006; 64:361–8.

57. Barsuk JH, Cohen ER, McGaghie WC, et al. Long-term retention of central venous catheter insertion skills after simulation-based mastery learning. Acad Med. 2010; 85(10 Suppl):S9–12.
58. Crofts JF, Bartlett C, Ellis D, et al. Management of shoulder dystocia: skill retention 6 and 12 months after training. Obstet Gynecol. 2007; 110:1069–74.
59. Draycott TJ, Crofts JF, Ash JP, et al. Improving neonatal outcome through practical shoulder dystocia training. Obstet Gynecol. 2008; 112:14–20.
60. Phipps MG, Lindquist DG, McConaughey E, et al. Outcomes from a labor and delivery team training program with simulation component. Am J Obstet Gynecol. 2012; 206:3–9.
61. Zendejas B, Cook DA, Bingener J, et al. Simulation-based mastery learning improves patient outcomes in laparoscopic inguinal hernia repair: a randomized controlled trial. Ann Surg. 2011; 254:502–9.
62. Barsuk JH, McGaghie WC, Cohen ER, et al. Simulation-based mastery learning reduces complications during central venous catheter insertion in a medical intensive care unit. Crit Care Med. 2009; 37:2697–701.
63. Cohen ER, Feinglass J, Barsuk JH, et al. Cost savings from reduced catheter-related bloodstream infection after simulation-based education for residents in a medical intensive care unit. Simul Healthc. 2010; 5:98–102.
64. Matheson C. The educational value and effectiveness of lectures. Clin Teach. 2008; 5:218–21.
65. Olson CA, Tooman TR. Didactic CME and practice change: don't throw that baby out quite yet. Adv Health Sci Educ Theory Pract. 2012; 17:441–51.
66. Carter MB, Wesley G, Larson GM. Lecture versus standardized patient interaction in the surgical clerkship: a randomized prospective cross-over study. Am J Surg. 2006; 191:262–7.
67. Carter MB, Wesley G, Larson GM. Didactic lecture versus instructional standardized patient interaction in the surgical clerkship. Am J Surg. 2005; 189:243–8.
68. Subramanian A, Timberlake M, Mittakanti H, Lara M, Brandt ML. Novel educational approach for medical students: improved retention rates using interactive medical software compared with traditional lecture-based format. J Surg Educ. 2012; 69:253–6.
69. Khan MN, Telmesani A, Alkhotani A, Elzouki A, Edrees B, Alsulimani MH. Comparison of jeopardy game format versus traditional lecture format as a teaching methodology in medical education. Saudi Med J. 2011; 32:1172–6.
70. McCoy CE, Menchine M, Anderson C, Kollen R, Langdorf MI, Lotfipour S. Prospective randomized crossover study of simulation vs. didactics for teaching medical students the assessment and management of critically ill patients. J Emerg Med. 2011; 40:448–55.
71. Haney M, Silvestri S, Van Dillen C, Ralls G, Cohen E, Papa L. A comparison of tele-education versus conventional lectures in wound care knowledge and skill acquisition. J Telemed Telecare. 2012; 18:79–81.
72. Bensalem-Owen M, Chau DF, Sardam SC, Fahy BG. Education research: evaluating the use of podcasting for residents during EEG instruction: a pilot study. Neurology. 2011; 77:e42–4.
73. Wang CL, Schopp JG, Petscavage JM, Paladin AM, Richardson ML, Bush WH. Prospective randomized comparison of standard didactic lecture versus high-fidelity simulation for radiology resident contrast reaction management training. AJR Am J Roentgenol. 2011; 196:1288–95.
74. Behar S, Upperman JS, Ramirez M, Dorey F, Nager A. Training medical staff for pediatric disaster victims: a comparison of different teaching methods. Am J Disaster Med. 2008; 3:189–99.
75. Chenkin J, Lee S, Huynh T, Bandiera G. Procedures can be learned on the Web: a randomized study of ultrasound-guided vascular access training. Acad Emerg Med. 2008; 15:949–54.
76. Diachun LL, Dumbrell AC, Byrne K, Esbaugh J. … But does it stick? Evaluating the durability of improved knowledge following an undergraduate experiential geriatrics learning session. J Am Geriatr Soc. 2006; 54:696–701.
77. Hoag K, Lillie J, Hoppe R. Piloting case-based instruction in a didactic clinical immunology course. Clin Lab Sci. 2005; 18:213–20.
78. White M, Michaud G, Pachev G, Lirenman D, Kolenc A, FitzGerald JM. Randomized trial of problem-based versus didactic seminars for disseminating evidence-based guidelines on asthma management to primary care physicians. J Contin Educ Health Prof. 2004; 24:237–43.
79. Zitzmann MB. Comparing the learning outcomes of lecture and self-instruction methods in a senior clinical laboratory science course. Clin Lab Sci. 1996; 9:198–201.
80. Abraham GJ, Dhume VG, Diniz RS. Comparison of didactic lecture, self-reading and self-instruction as learning methods in medical students of western India. Med Educ. 1981; 15:222–5.
81. Agee N, Komenaka IK, Drachman D, Bouton ME, Caruso DM, Foster KN. The effectiveness of grand rounds lectures in a community-based teaching hospital. J Surg Educ. 2009; 66:361–6.
82. Shiroma PR, Massa AA, Alarcon RD. Using game format to teach psychopharmacology to medical students. Med Teach. 2011; 33:156–60.
83. Hessheimer HM, Rogo EJ, Howlett B. Use of questioning during lectures in a dental hygiene didactic course. J Dent Educ. 2011; 75:1073–83.
84. Rubio E, Bassignani MJ, White MA, Brant WE. Effect of an audience response system on resident learning and retention of lecture material. AJR Am J Roentgenol. 2008; 190:W319–22.
85. Costa ML, van Rensburg L, Rushton N. Does teaching style matter? A randomized trial of group discussion versus lectures in orthopaedic undergraduate teaching. Med Educ. 2007; 41: 214–7.
86. Bryner CL Jr. Learning as a function of lecture length. Fam Med. 1995; 27:379–82.

87. Markova T, Roth LM, Monsur J. Synchronous distance learning as an effective and feasible method for delivering residency didactics. Fam Med. 2005; 37:570–5.
88. Solomon DJ, Ferenchick GS, Laird-Fick HS, Kavanaugh K. A randomized trial comparing digital and live lecture formats. BMC Med Educ. 2004; 4:e27.
89. Kelly PA, Haidet P, Schneider V, Searle N, Seidel CL, Richards BF. A comparison of in-class learner engagement across lecture, problem-based learning and team learning using the STROBE classroom observation tool. Teach Learn Med. 2004; 17:112–8.
90. Knowles MS. Andragogy, not pedagogy. Adult Leadership. 1968;16:350–352, 386.
91. Neufeld VR, Barrows HS. The McMaster philosophy: an approach to medical education. J Med Educ. 1974; 49:1040–50.
92. Muller S (Chairman). Physicians for the twenty-first century: report of the project panel on the general professional education of the physician and college preparation for medicine. J Med Educ. 1984; 59(11 Pt 2):1–208.
93. Barrows HS. A taxonomy of problem-based learning methods. Med Educ. 1986; 20:481–6.
94. Berkson L. Problem-based learning: have the expectations been met? Acad Med. 1993; 68:S79–88.
95. Vernon DT, Blake RL. Does problem-based learning work? A meta-analysis of evaluative research. Acad Med. 1993; 68:550–63.
96. Albanese MA, Mitchell S. Problem-based learning: a review of literature on its outcomes and implementation issues. Acad Med. 1993; 68:52–81.
97. Norman GR, Schmidt HG. Effectiveness of problem-based learning curricula: theory, practice and paper darts. Med Educ. 200; 34:721–8.
98. Colliver JA. Effectiveness of problem-based learning curricula: research and theory. Acad Med. 2000; 75:259–66.
99. Distlehort LH, Dawson E, Robbs RS, Barrows HS. Problem-based learning outcomes: the glass half-full. Acad Med. 2005; 80:294–9.
100. Blumberg P, Michael JA. Development of self-directed learning behaviours in a partially teacher-directed problem-based learning curriculum. Teach Learn Med. 1992; 4:3–8.
101. Haidet P, O'Malley KJ, Richards B. An initial experience with "team learning" in medical education. Acad Med. 2002; 77:40–4.
102. Touchet BK, Coon KA. A pilot use of team-based learning in psychiatry resident psychodynamic psychotherapy education. Acad Psych. 2005; 29: 293–6.
103. Haidet P, Morgan RO, O'Malley K, Moran BJ, Richards BF. A controlled trial of active versus passive learning strategies in a large group setting. Adv Health Sciences Educ. 2004; 9:15–27.
104. Searle NS, Haidet P, Kelley A, Schneider VF, Seidel CL, Richards BF. Team learning in medical education: initial experience at ten institutions. Acad Med. 2003; 78:S55–8.