Bronchoscopy Education
An Experiential Learning Theory Perspective

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KEYWORDS

• Bronchoscopy • Education • Experiential learning theory • Flipped classroom model
• Problem-based learning • Checklists • Simulation

KEY POINTS

- The experiential learning theory model addresses various learning styles and should be used for designing continuing medical education programs.
- Problem-based learning improves knowledge retention compared with traditional lectures.
- The flipped classroom model is preferred by students because it enhances active learning.
- Immediate, honest, and objective feedback can be delivered by using checklist and assessment tools.
- Spaced education strategies that improve knowledge gain and retention should be implemented after a live course.

Tell me and I forget. Teach me and I remember. Involve me and I learn.
—Benjamin Franklin

INTRODUCTION

Constantly evolving modern-day health care systems demand that physicians deliver state-of-the-art medicine in a safe and responsible manner. The content, mode of instruction, and styles of learning in the age of mass information have had a direct impact on medical education. Traditional educational strategies, however, have not necessarily translated into meaningful change in learning or physicians' behavior.[1] The traditional one-size-fits-all didactic learning model is fading as more emphasis is placed onto self-directed active learning. The challenge for curriculum developers is to bridge this divide. It is relevant for educators to know how best to design a curriculum whereby knowledge is delivered in an environment that fosters active learning.[1,2] Regarding bronchoscopy education, it is the authors' belief that any valid training program should demonstrate improvements in cognitive and technical knowledge and also lead to positive changes in clinicians' practice. This article describes the rationale and methodology of implementing experiential learning theory into bronchoscopy education programs. The experiential learning theory could be applied globally in bronchoscopy training programs because it addresses various learning styles affected by distinct personality traits and cultural factors.

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PARADIGM SHIFTS IN MEDICAL EDUCATION

While designing an educational program, it is important to recall that continuing medical education (CME) literature increasingly demonstrates significant differences in the way people learn.[1] The traditional lecture-based instruction model, however, fails to account for these differences. Traditional lectures have minimal active audience participation, and usually educators are inclined to simply review data rather than truly educate. Lectures may thus be perceived as overwhelming and may burden the learners with excessive information. For any type of substantial learning to occur, more interactive teaching methods must be used.

Lecture-based CME programs have proven inadequate for changing physician behaviors.[1] Poor knowledge gain and retention rate after such programs may be a potential explanation.[1] Published evidence suggests that students retain only 20% of transmitted didactic information.[3] There are ongoing questions about the content of medical education, the various methods of instruction, and the connection between different personality styles and teaching. The key to meaningful education is the understanding of how learning occurs in an individual. Incorporating varied learning styles in an educational encounter seems the most desirable way of approaching teaching programs.[1] This method has the potential to influence individual learning as well as the core components of medical education, from individual lectures or hands-on activities to entire courses.[1]

Several learning theories have been proposed but the one that the authors believe is particularly relevant to physicians with various cultural, personality, and training backgrounds is David Kolb's experiential learning model (ELM). This model remains one of the most popular in medical education.[1] David Kolb theorized that the way people perceive and process an experience explains how they learn.[4] The emphasis on experience playing a central role in the learning process differentiates the experiential approach from other learning theories. His model encourages incorporating learning formats that are conducive to most learners.[5] Importantly, learners' preferred styles may differ, but that should not matter because this model's implementation incorporates all learning styles.[1] A truly effective educational model facilitates an individual's ability to harness knowledge by incorporating different learning styles into the curriculum.

According to Kolb, 2 dimensions are necessary for learning to occur. The first dimension is described as perceiving a medium, whereas the second is a transformation, or processing of the medium.[4] Learning results from the way people interact with these dimensions and thereby create their own personal knowledge.[1] In Fig. 1, the vertical axis represents perception. At one extreme lies a concrete experience, such as an event or interaction, whereas an abstract conceptualization, such as an idea or theory, represents the other range of the perception spectrum. The horizontal axis represents transformation. Experiences can be transformed into knowledge by reflective observation on the one extreme or active experimentation on the other. These 4 learning styles also correlate with personality characteristics, such as the introverted/extraverted traits

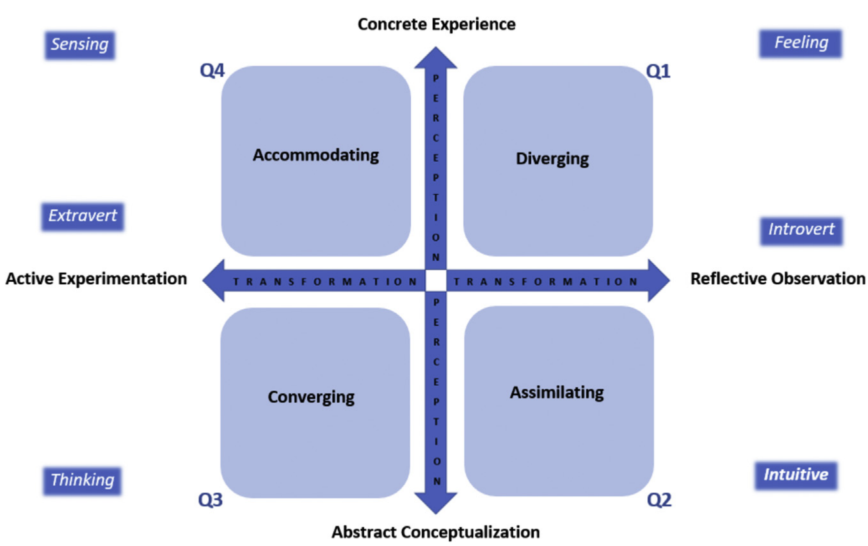

Fig. 1. David Kolb's learning styles. Q, quadrant.

described by Jung or the feeling/thinking dimensions elucidated by Myers and Briggs.[1]

Approximately 40% and 20% of physicians prefer converging and accommodating styles of learning, respectively. Thus, the majority but not all physicians wish to experiment with newly acquired information gained during these programs.[1] These styles of learning have been shown to have an impact on specialization and occupational interests.[1] In medical education, this information not only provides a deeper understand of learning styles but also gives the range and flexibility to develop enhanced systems for curriculum development. For instance, during a bronchoscopy course at the *CHEST* headquarters in Chicago, Illinois, a survey showed that a majority of learners (90%) preferred to experiment with newly acquired information; their learning style was congruent with Kolb's third and fourth quadrants. Thus, that program focused on simulation but the needs of the other learners (10% who preferred learning styles to the right of the transformation axis) were also addressed in the curriculum through the interactive didactic sessions.

Curriculum developers implementing ELM believe that the ideal instructional design requires learners to advance from quadrants 1 to 4 in sequence to accommodate learners of all types.[1] In a sense, they journey from characterization of personal understanding and needs to the acquisition of new knowledge.[1] This is followed by synthesis and ultimately extension of the learning material into practical application involving patient care. These classifications are not mutually exclusive because there is often overlap in learning styles. Rather, they serve as a methodological framework for learning by using the various tools at their disposal to improve and build on existing knowledge. In the following sections, we illustrate how Kolb's learning theory can be implemented in bronchoscopy education to provide learners with an enhanced and more valuable experience that can result in longer-term retention and change in practice.

QUADRANT 1: DIVERGING STYLE

Any training program should start by an understanding of the diverse learners' opinions and perspectives. Teachers gain an appreciation of the collective wisdom of the crowd. This can be achieved using surveys, a pretest, multidisciplinary discussion group, and feedback solicited via audience response systems (ARSs). These modalities familiarize the instructor with the learners and compel the instructor to care about participants as individuals. By means of engagement and reflection of what they already know and understand, the participants ready themselves to actively listen and synthesize the new information provided by the course. The diverging style applies to those learners who prefer to reflect on new information acquired through a concrete experience. This can be implemented through an interactive case-based session using an ARS or other techniques of engaging the learners (ie, think-pair-share). The technique of responding to answers generated via ARSs must be learner-centered and address the correct but especially the incorrect answers. After a discussion of the available answer choices, the rationale for the correct answer choice is presented in subsequent supporting slides. This quadrant, because it involves a concrete experience, may also include workshops where instructors demonstrate and learners observe. This format of simulation, in which the teachers demonstrate and the learners observe and reflect on what they see, is not the optimal way of implementing simulation.

QUADRANT 2: ASSIMILATING STYLE

The assimilating style can be addressed via a group interaction involving didactic lectures, references to published studies, and guideline reviews. The experience grasped and reflected on is more abstract and refers to theories and concepts (eg, theory of airflow limitation in tracheobronchomalacia). An efficient way to implement this in an engaging format is also through an interactive, ideally multidisciplinary, panel discussion. This style promotes reflection on the content presented, allowing time for a learner's engagement with the faculty. The interaction, however, is dependent on a learner's personal understanding of the material. If a lecture style is necessary for addressing this learning style, it is paramount that the lecture material is engaging. Use of bullet points, concise slides, and regular audience participation via ARSs can keep participants interested.[6] Presenting information in a quiz format improves retention, likely because of the effort put into the learning process.[7] This style can be incorporated into lectures by using ARS participation. Group breakout sessions, quizzes at the end of lectures, and summarizing information at the end of a presentation (ie, take-home points) are other means to capture a learner's attention.[6]

QUADRANTS 3 AND 4: APPLICATION OF KNOWLEDGE

From the authors' observations and surveys at procedure-based training programs, these are the learning styles preferred by most bronchoscopists. These represent a shift from thinking to doing—moving from thought to action. The challenge for instructors is to create opportunities for learners to experiment with their new knowledge in a safe environment. This can be accomplished by testing new ideas and skills in problem-based learning (PBL) exercises and game-based learning simulation. Learners can build on existing knowledge by incorporating new evidence and applying theory into practice.[1,8] Experimentation and risk-taking in a safe and controlled environment allows physicians to expand their armamentarium. Several bronchoscopy courses attempt to follow this model using PBL and simulation by structuring the workflow to engage each participant. Simulation laboratories mimic real-life scenarios to test newly acquired skills. Participants can analyze the impact of new knowledge and skills and evaluate the results. This cycle of learner-faculty interaction aims to provide new insight. Initially, the understanding and mastery of a skill can be incomplete and repetition is often required to minimize deficiencies. A stepwise practical approach to implementing simulation is as follows:

1. Clearly describe the objectives and distribute handouts prior to the simulation session.
2. Review the tutorial materials prior to the hands-on session.
3. Assign specific tasks and roles, such as bronchoscopist, first assistant, second assistant, and checklist reader, to keep every learner engaged.

This workflow assumes a low teacher-to-learner ratio of approximately 1:4 and is fundamentally different from the traditional model, through which, for learning to occur, the learner had to conform to the style and methods of the instructor. Applying a structured workflow and keeping learners engaged individualize learning to meet the needs of students. Learners are engaged from the beginning by personalizing individual goals. These goals can be accomplished by first identifying the aims and objectives of the curriculum. Learning instruments like surveys and pretests help establish a baseline for learners. As the course advances, these metrics help learners and instructor focus on specific areas of improvement. Simulation and PBL exercises are key components of the flipped classroom model described later.

The Inverted Classroom Model

The inverted classroom model is a shift in medical education philosophy and is offered by what has been called *disruptive innovations*, where the traditional style of learning gives way to a more interactive and inclusive learning model. An example of this phenomenon is the flipped classroom or inverted classroom model. It is an integral part of ELM and directly applicable to Kolb's quadrants 3 and 4 (**Fig. 2**).

Because people tend to lose focus over time, keeping learners engaged is challenging with didactic lectures.[6,9] One method to address this issue is to provide the learners with the lecture material in advance.[10] This gives the learners the opportunity to reflect and analyze new information from their own perspective.[11] During classroom time, they can engage the instructor, and learning occurs via discussion, either during the interactive question-and answer sessions or the PBL exercises. Learners can intuitively attempt integration of new concepts into their current practice. This concept has gained traction with the advent of Web-based technologies that offer massive open online courses, enabling learners to gain access to lecture material via online portals. It was initially introduced for high school students who missed their classroom lessons. Since then, this model has been tried and tested with other demographics and is gaining acceptance with undergraduate and graduate learning programs as well as several medical schools.[11–13] It provides an opportunity for learners to review the lecture material online in Portable Document Format (PDF), slide format, or multimedia presentations prior to meeting in the actual classroom. Interactive techniques have been shown to improve retention of knowledge in health care employees and have increased participant satisfaction.[14–16] This is a dynamic learning model where traditional lectures can be provided to students online for reading at leisure, leaving actual student-teacher interaction for engaging in PBL and critical analysis of the lecture content.[17] The flipped classroom model increases active learning for the student compared with traditional classroom-based instruction.[13] Improved test scores have been observed in graduate students along with increased class attendance.[11,13] In the flipped classroom model, transmission of facts is performed by reviewing the learning material outside of the classroom setting, usually in the form of articles (less preferred), slide presentations, voice-over lectures, videos, or even augmented reality platforms (most preferred). This precourse material can be administered online and constitutes the self-directed learning component of the model. Prior to the start of the course, collection of data occurs through surveys and pretests designed to match the specific learning objectives. During formal

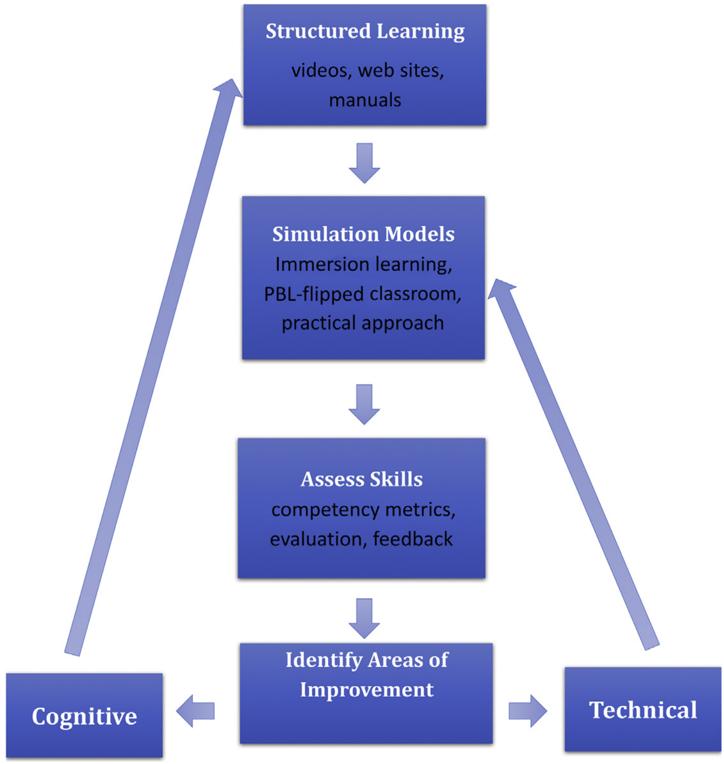

Fig. 2. Implementation of the flipped classroom model.

live teaching at the time of the live event, an instructor facilitates student-driven discussion of the material via case-based scenarios allowing for exchange of ideas and thoughtful analysis (quadrants 1 and 2, discussed previously). Assimilation of knowledge is seen via complex problem solving (quadrant 3, PBL, discussed previously), question-and-answer sessions, and peer interaction, all of which contributes to a deeper understanding of the concepts. Knowledge acquisition can be assessed in the classroom using quizzes, thereby identifying deficits and personalizing improvement strategies for the learners.

The goal of this model is to accelerate learning by emphasizing critical thinking, analytic reasoning, and eventual mastery of a topic.[10] The advent of Web-based learning is preferred by millennials because it provides an opportunity for self-paced learning, whereas online discussion forums provide an interface for instructor and peer-to-peer communication. Self-directed Web-based learning is noninferior to the traditional lecture style of learning with regard to knowledge retention.[18] Classroom time (ie, a live bronchoscopy course) can then be focused on assimilation of knowledge and improvement in communication and clinical decision-making skills. A meta-analysis by the United States Department of Education demonstrated that this blended model of online and classroom learning was superior to exclusive online or classroom learning.[19] Evidence also suggest that medical residents' perception and preference for the flipped classroom improves after experience with this model.[20] Supporters of this model propose that a successful flipped classroom program should have 3 goals[21]:

1. Allow learners to become critical thinkers
2. Engage learners and instructors
3. Incorporate concepts via a thorough understanding of the material

This model of bronchoscopy education has been globally implemented by the World Association for Bronchology and Interventional Pulmonology (WABIP) and the American College of Chest Physicians (ACCP). Implementation of the flipped classroom model in several medical schools and residency rotations was associated with improved learner satisfaction and more effective knowledge acquisition.[20,22–24] The emphasis is not simply on transmitting information. Rather, the goal is to assist learners integrate knowledge and apply that information to clinical practice.

Existing courses may have to be redesigned, and new curricula should be taught by dedicated instructors.[17] In this model, the instructors' role is changed. Their active involvement is increased, and as such, faculty development is crucial for sustainability of this learning model. The success of this model is also built on the foundation of time and effort invested by the learners in studying the precourse material prior to classroom time.[11]

Educators must recognize the need to tailor teaching to specific generational needs. They need to be cognizant of their audience and that increasingly they are not educating the baby boomer generation. Individuals have different learning styles and varying attitudes toward learning.[25] These habits are driven by technology and impacted by social values and access to resources.[25] Teaching techniques should relate to the learning habits of the student. It is important for curriculum planners to be inclusive and sensitive to the preferences of the learner who are broadly classified in 3 major categories: baby boomers (1943–1960); Generation X (1960–1980), and Millennials (1981–2002).[6] In general, the baby boomers are autodidacts and may prefer to learn on their own. This generation witnessed the dawn of technological advancement impact on their traditional homes and society.[6] They prefer learning styles where learners are collective participants for faculty to address and thus are more accustomed to lecture-based learning (ie, quadrants 1 and 2).[6] Generally, they adapt well to teaching habits that tailor personal growth and development.[25] They find it difficult to adjust to instant learning, however, because of unfamiliarity with activity-based learning. Thoughtful analysis and understanding for this cohort is a passive process.[6] Generation X is more apt to challenging conventional wisdom and norms with openness to learning new habits.[25] It is easy for them to transition from didactic learning to incorporating technology in their learning habits (ie, ARSs and multimedia). They are more independent in thought and prefer critical judgment.[6] Millennials are even more technologically driven. They are well familiarized with Web-based advancements and frequently use smartphones and tablets to instantly access information.[6] For example, the use of app-based learning in third-year medical students on a surgery rotation was effective in achieving high scores on standardized tests.[26] Millennials may prefer learning using smartphone apps, podcasts, and other electronic platforms. They prefer mobile learning, favor cyber communication with peers, and can multitask in a computer-generated environment. This generation orients to experiential learning involving active participation and structured learning, while relying on instant and regular feedback.[6] Compared with traditional tools of knowledge transmission, such as notes and videos, augmented reality using virtual 3-D models resulted in less time spent acquiring knowledge and improved metacognitive perception.[27] This is especially relevant to bronchoscopy education because sophisticated 3-D models help physicians navigate airways, understand anatomic locations of mediastinal lymph nodes, and simulate complex case scenarios, enabling learners to potentially translate their virtual experience into the delivery of quality care. In the ELM, however, most opportunities for critical thinking and application of knowledge are offered through PBL exercises.

The Rationale for Problem-Based Learning Exercises

The driving principle of PBL is attempting to solve a problem before being taught the solution. This leads to superior learning even if errors are made in the process. PBL participants have a higher perceived educational value compared with traditional didactic learners.[28] Learning scientists believe that effective learning environments should emphasize a learning culture where ideas are deliberated and problem-solving skills are enhanced.[5] During PBL discussions, learners are made aware of additional possibilities and required to actively listen and contribute to class synthesis of a clinical case via the class members' integration of the group's knowledge. The aim is to encourage teamwork for the diagnosis and management of a certain clinical problem. For example, newly diagnosed lung cancer requires input and feedback from different team members, with each contributing to a specific aspect of patient care. Some of the areas that may be discussed in this scenario include diagnostic interventions, staging of the disease, specimen acquisition, and handling and processing for cytology, histology, and molecular testing. This type of exercise has already been widely implemented by the ACCP through the more than 40 national and international GAIN (enGAging an Interdisciplinary team for the Non-small cell lung cancer diagnosis) lung cancer education programs.

During PBL, learners benefit from analyzing and expanding existing beliefs. Creative enhancement is seen by articulation and exploration of new concepts. Active engagement with learning material by challenging specific ideas leads to thoughtful analysis and proper understanding. This teaching modality has a background in the philosophic concept of constructivism, in which understanding depends not only on the content of the material and goals of the learner but also context and activity.[17] There must be a stimulus for learning, and learning is better in an interactive group activity.[17] PBL has evolved in medical education over the past 4 decades and is now being incorporated into curricula for medical, business, law, architecture, and engineering education.[17,29] This model assumes learners have basic background knowledge based on prior experience and study of precourse materials. This is an essential component of the flipped classroom model. Learners take full responsibility for their learning.[11,17]

Implementation of Problem-Based Learning Exercises

One way to incorporate PBL in bronchoscopy education is to follow the practical approach model (**Box 1**), which was developed by Henri Colt but inspired by Albert Jonsen and colleagues' work on clinical ethics. This model helps systematically analyze the steps involved in execution of procedural decisions.[30] The 4-box approach template in **Box 1** was developed to guide a learner through the proper approach to bronchoscopy and related pulmonary procedures in a methodical manner (www.bronchoscopy.org). It covers all the relevant aspects of a case, helps simplify procedure-related consultation into its basic elements, and allows deconstruction of a case into its basic components. It also complements Accreditation Council for Graduate Medical Education recommendations that encourage training programs to follow a systematic method while approaching patient care.[17] For example, it requires trainees to perform a complete initial evaluation, review procedural technique, strategize, and individualize a patient-centered care plan that encompasses education of the patient and family members.[17] Bronchoscopy International uses this model to approach clinical cases on its Web site and is available to users free of charge (www.bronchoscopy.org). When incorporated into a PBL model, the case scenarios are designed to ensure an authentic learning environment, such that the analytic skills required in this process are consistent with the cognitive demands of real-life patients. The learners work through the clinical scenario in a group. Working through a case-based exercise helps learners contemplate patient and procedure-related issues in a structured fashion. It also incorporates working with other health care professionals from other disciplines, as has been done in the numerous GAIN programs on lung cancer education.[17]

Box 1
Four domains of the practical approach model

Initial evaluation

- Examination and functional status
- Significant comorbidities
- Support systems
- Patient preferences and expectations

Techniques and results

- Anesthesia and perioperative care
- Techniques and instrumentation
- Results
- Procedure-related complications

Procedural strategies

- Indication and contraindications
- Team experience
- Risk-benefit analysis and therapeutic alternatives
- Informed consent

Long-term management

- Outcome assessment
- Follow-up tests and procedures
- Referrals
- Quality improvement

The Role of Faculty During Problem-Based Learning

The facilitation of PBL exercises must be in a manner where the learner takes ownership of the problem at hand. Learning is improved when the subject matter is considered to be important by the learner. For deeper and durable learning to occur, effort is required. By being an inclusive model, the practical approach provides an opportunity for team members' input. Thus, productivity is enhanced because the tasks are shared among peers. All through this endeavor, the instructor guides the learners in a systematic fashion to help drive the task home. This method helps the faculty test and critique the ability of the learner to adapt to real life clinical situations. A controlled learning environment permits the application of new knowledge, experimentation, and innovation. Adaptive expertise is a phenomenon whereby the learner enhances creativity by adapting to novel situations. In a PBL setting, it is the application of newly acquired cognitive skills toward a task.[17] The learner explores new alternatives with the help of effective collaboration and feedback from team members. This acts as a stimulus for exchange of ideas and creates an effective active learning environment. Faculty are expected to facilitate a meaningful dialogue within the group and model but not dictate the thinking process.

FEEDBACK

ELM provides numerous opportunities for feedback. Immediate feedback and corrective measures can be discussed collectively in a large group or small group (question-and-answer session and PBL, respectively) or on an individual basis (during the simulation sessions). Direct and immediate feedback is a strong motivating tool. This has been shown to improve student perception in clinical settings.[31] It provides an opportunity to highlight areas of improvement. There are different modes of feedback. Continuous feedback is used each time a student performs a task, whereas differential feedback is offered each time a learner performs better. One advantage of differential feedback is the emphasis on improvement, thereby giving learners an opportunity for recognizing their accomplishments. Immediate feedback is a potent tool for change.[32] This was demonstrated to have a positive impact on performance in surgical clerkship students.[33] Regardless of the method, providing honest feedback is essential for meaningful education. Dishonest, positive feedback can be detrimental to learners because praise, self-esteem, and performance rise and fall together.[34]

Kruger-Dunning Effect and the Importance of Providing Feedback

Justin Kruger and David Dunning[35] proposed that low-percentile performers lack insight into their limitations. There is a false perception of individual performance and the inability to recognize one's own shortcomings. While working in a group setting, low-percentile performers overestimate their performance, and high-percentile performers underestimate their performance. This enhancement of the self gives the learner a false sense of accomplishment.[35] In the authors' opinion, this is a common phenomenon among participants at bronchoscopy courses and is supported by published evidence.[36] The overinflated illusion of self-grandeur limits critical thinking and mastery of a skill. This eventually can affect patient care. Procedural complications are often a result of this phenomenon. An example of this can be seen with endobronchial ultrasound (EBUS)-related complications involving hilar and mediastinal lymph nodes biopsies with resultant intramural hematoma and hemomediastinum.[37]

Humans' ability to monitor their own thinking is called metacognition. The troubling pattern with poor judgment is that individuals seldom recognize their ineptitude despite the execution of flawed actions and poor outcomes.[38] Because learners lack the tools to estimate their own skills, it is critical for educators to provide constructive and corrective feedback. Lack of negative feedback can lead to failure to understand why errors happen and thereby limit implementation of corrective measures. Negative feedback should, however, be considered only in a manner that brings meaningful results.[38]

The Curse of Knowledge and the Importance of Checklists

In ELM, teaching methods must be balanced. Learners should not be overwhelmed with information nor should the instructor assume too much and withhold important material. Knowledge bias is a faculty trap where an educator's self-knowledge leads to believing the same of the learner.[39] It is the implicit failure of recognition of faculty's own skills leading to the projection of the bias on the learner. The curse of expertise (also known as the curse of knowledge) is a miscalibration or inability to recognize what tools may be required for a learner to learn a task or master a skill.[40] One way to curb this bias is for instructors to systematically follow checklists, such as the one shown in **Fig. 3**, while teaching procedural skills. This ensures that learners are cognizant of all the involved steps needed for mastery of a procedural task.

Learning is a holistic, pluralistic, and cooperative endeavor. Learners have varied perspectives and, as such, have a wide range of reference points. Thus, critiques, feedback, and explanations must be individualized.[41] This can be objectively achieved by using checklists and assessment tools. These competency metrics can assist curriculum planners in making content relevant for the learners. Use of assessment skills and checklists can easily be incorporated in simulation laboratories by following a structured workflow during the hands-on sessions. They are dynamic learning tools and offer numerous opportunities for delivering objective feedback.

Application of Checklists and Assessment Tools in Simulation-Based Training

Simulation training has been shown to improve cognitive and technical skills competency of fellows and residents.[42] Advancement in practical skills like scope maneuvering, lymph node sampling, and navigating pulmonary anatomy are

PERCUTANEOUS DILATATIONAL TRACHEOSTOMY
SKILLS AND TASKS 10 point ASSESSMENT TOOL
PDT-STAT

Learner ______________________________ Faculty______________________________

Items 1–10 each scored separately Each item is 10 points	Satisfactory Yes / No
1. Patient safety: pre-procedural pause [] Patient's identity confirmed [] Consent obtained [] Indications and contraindications reviewed [] Coagulation markers and anticoagulants reviewed [] Local analgesics, sedatives and/or anesthetics available	Yes / No
2. Patient positioning [] Supine with neck hyper-extended; [] Use one-two rolled towels, pillows or bolster between the scapulae; []Head of bed can be elevated to 20 degrees to reduce venous engorgement	Yes / No
3. Equipment preparation: [] The cuff is checked for integrity with 10–20 mL of air, then deflated; [] The # 26 (for Shiley 6) or # 28 (for Shiley 8) dilators are lubrified and inserted inside the corresponding tracheostomy tube; [] Lidocaine mixed with epinephrine is withdrawn in the syringe; [] The cone dilator is lubrified and placed over the stiffening catheter	Yes / No
4. Exploratory tracheocenetesis [] Select the proper tracheal entry site: anterior, midline, between the 2nd–3rd tracheal rings or 3rd–4th rings; [] Identify the site by palpation after localizing the thyroid cartilage, the cricoid and the first ring; [] Mark the site and prepare the sterile field [] Local analgesia at the entry site subcutaneously in four quadrants [] Use the finder needle at the entry site; [] Once the finder needle is confirmed bronchoscopically in the desired location, the large bore needle/angiocath is introduced adjacent to it and then the finder needle is removed	Yes / No
5. Guidewire placement [] Once the large bore needle is clearly visualized via the bronchoscope, advance the guidewire with the tip oriented inferiorly, then once inside, remove the large bore needle [] Make the incision: one centimeter above and one below the entry port to the subcutaneous fat; use the # 11 scalpel available in the kit;	Yes / No
6. **Inter-cartilaginous space dilatation** [] Subcutaneous and initial inter-cartilaginous space dilation: use the small blue dilator after lubrication [] Dilate the inter-cartilaginous space: use the cone dilator over the stiffening catheter and the guidewire; once inside, and once the thick black line is visualized, remove the dilator but leave the guidewire and stiffening catheter	Yes / No
7. Tracheostomy tube placement [] The tracheostomy tube and its indwelling dilator are advanced over the guidewire and the stiffening catheter; [] Once the cuff is completely inside the airway and confirmed by bronchoscopy, the guidewire, the stiffening catheter and the dilator are removed en-block; [] Inner cannula is placed inside the tracheostomy tube, the cuff is inflated and the ventilation is switched to tracheostomy tube	Yes / No
8. Remove the ETT and confirm tracheostomy tube: [] On bronchoscopy, the larynx is examined during extubation to document airway findings and measure distance from the stoma to the cords; [] The swivel adaptor is connected to the tracheostomy tube; [] Bronchoscopy is performed to clean the airway from hemorrhagic secretions and measure the distance from the carina to the tip of the tracheostomy tube	Yes / No
9. Secure the tracheostomy tube: [] Four stitches are placed over the tracheostomy flange to secure it to the skin; a trache tie is used as well around the neck; [] Allow space for two fingers between the tie and the neck	Yes / No
10. Post procedure care [] Nursing and family education is provided; [] Supplies are offered prior to discharge; [] Follow up per protocol for decannulation [] Follow up per protocol for tracheostomy tube change	Yes / No

FINAL GRADE: PASS FAIL SCORE:_______/100

Fig. 3. Percutaneous dilatational tracheostomy checklist.

documented with the use of simulation.[43] Procedural improvement has been validated by studies exposing trainees to simulation training.[44] Training programs have designed quality metrics to predict better procedural outcomes in pulmonary fellowships.[45] The Bronchoscopic Skills and Tasks Assessment Tool (BSTAT) and EBUS Skills and Tasks Assessment Tool (EBUS-STAT) are 2 examples of competency-based assessment tools shown to change physician behavior while performing bronchoscopy.[46] A recent systematic review confirmed the effectiveness of using checklists, such as EBUS-STAT, for evaluating trainees during simulation-based training.[47] A threshold score for the EBUS-STAT tool has even been identified, indicating which trainees may benefit from additional simulation exposure.[48]

Checklists, which can also be used as assessment tools, are essential for providing immediate and direct, personalized specific feedback. For some physicians, this is a moment of awareness. It has become evident over the years that bronchoscopy skills vary among individuals based on prior access to simulation laboratories, training environment, and logistics. Because physician competency has an impact on safety and patient care, training programs are challenged to incorporate simulation-based training and objective measurement of procedural skills. The eventual goal is to standardize bronchoscopy training and assess competency through gained cognitive and technical skills, not on numbers of procedures performed. For training programs to better monitor effectiveness of their curricula, the performance status of their trainees must be tracked. This can be done for fundamental bronchoscopy (ie, BSTAT), EBUS–Transbronchial Needle Aspiration (ie, EBUS-STAT), and even for rigid bronchoscopy. The Rigid Bronchoscopy Tool for Assessment of Skills and Competence, for example, is a 23-point validated rigid bronchoscopy performance tool.[49]

The goals of these checklists and assessment tools are to emphasize the execution of important tasks needed for procedural success but at this time they are not used for competency assessment by national and international professional and credentialing organizations. Recommendations have been made by organizations like ACCP, the American Thoracic Society, and the European Respiratory Society regarding a specific number of procedures required in the training of graduates. These are merely expert opinions for now. For example, at least 100 flexible bronchoscopies and 50 EBUSs are recommended for traditional pulmonary fellows, whereas interventional pulmonology fellows should also complete at least 20 rigid bronchoscopies according to general society guidelines.[49] A recent article highlights the required number of procedures for American Association for Bronchology and Interventional Pulmonology interventional pulmonology fellowship accreditation (**Table 1**).[50]

Table 1
Recommended number of procedures for American Association for Bronchology and Interventional Pulmonology interventional pulmonology fellowship accreditation

Procedure Type	Requisite Annual Institutional Case Volume
Rigid bronchoscopy	50
Endobronchial stenting	20
Thoracoscopy	20
Bronchoscopic navigation	20
Endobronchial ablation	50
EBUS	100
Tunneled pleural catheter placement	20
Percutaneous dilational tracheostomy	20
Bronchial thermoplasty	6
Image-guided thoracostomy tube placement	20

SPACED EDUCATION

Spaced education is a strategy shown to improve knowledge gain and retention. This is comprised of *spacing effect*, through which knowledge content is delivered over time, and *testing effect*, through which information is presented in a question/test format. Online spaced education for medical residents has shown improved retention for up to 2 years.[51] Spaced education in 1 cohort of urology residents increased long-term learning efficiency by 4-fold.[52] During multiday courses, opportunities for spaced learning should be encouraged by reiterating important points to increase knowledge retention. Periodic emails after a live course or using a Web platform are other ways of engaging learners with review of the relevant material. The retrieval of information from memory interrupts forgetfulness and has been shown to be efficacious among medical students.[53] Combining in-class training with spaced education increased participant performance and satisfaction in procedural tasks.[54] Spaced learning is frequently seen with CME programs that are increasingly designing e-learning modules to deliver medical literature to physicians in practice.[55]

SUMMARY

The application of ELM to bronchoscopy training is learner centered and faculty intense. Bronchoscopy programs implementing ELM set up workshops to build and enhance their technical skills using low-fidelity and high-fidelity simulators or cadaveric-based models. The curriculum design provides access to slide presentations, multiple choice questions, and interactive didactic learning material to improve cognitive learning, whereas simulation sessions focus on mastery of technical skills, thus providing a comprehensive learning experience. PBLs help improve critical decision making and communication. Together, these modalities contribute to active engagement, which in turn leads to durable learning. All methods described herein, including interactive question-and-answer sessions, PBLs, and simulation, are teaching modalities preferred by learners. They require not only content experts but also trained faculty dedicated to learner-centered teaching. Faculty development programs are thus an essential component for genuine bronchoscopy education. WABIP and CHEST are among the organizations that have led initiatives to help bronchoscopy educators gain in-depth familiarity with curriculum design and meet adequate standards to better train health care professionals who seek to improve their bronchoscopy skills.

REFERENCES

1. Armstrong E, Parsa-Parsi R. How can physicians' learning styles drive educational planning? Acad Med 2005;80:680–4.
2. Freeman S, Eddy SL, McDonough M, et al. Active learning increases student performance in science, engineering, and mathematics. Proc Natl Acad Sci U S A 2014;111:8410–5.
3. Hartley J, Cameron A. Some observations on the efficiency of lecturing. Educ Rev 2006;20:30–7.
4. Kolb DA. Experiential learning: experience as the source of learning and development. Englewood Cliffs (NJ): Prentice Hall; 1984.
5. Sternberg R, Zhang L. Perspectives on thinking, learning, and cognitive styles. Mahwah (NJ): Lawrence Erlbaum Associates; 2000.
6. Sandhu S, Afifi TO. Theories and practical steps for delivering effective lectures. J Comm Med Health Edu 2012;2:158–62.
7. Butler A, Phillmann K-B, Smart L. Active learning within a lecture: assessing the impact of short, in-class writing exercises. Teach Psychol 2009;28:257–9.
8. McCoy L, Pettit RK, Lewis JH, et al. Developing technology-enhanced active learning for medical education: challenges, solutions, and future directions. J Am Osteopath Assoc 2015;115:202–11.
9. Stuart J, Rutherford RJ. Medical student concentration during lectures. Lancet 1978;2:514–6.
10. Tolks D, Schäfer C, Raupach T, et al. An introduction to the inverted/flipped classroom model in education and advanced training in medicine and in the healthcare professions. GMS J Med Educ 2016;33:Doc46.
11. McLaughlin JE, Roth MT, Glatt DM, et al. The flipped classroom: a course redesign to foster learning and engagement in a health professions school. Acad Med 2014;89:236.
12. Bonnes SL, Ratelle JT, Halvorsen AJ, et al. Flipping the quality improvement classroom in residency education. Acad Med 2017;92:101.
13. Tune JD, Sturek M, Basile DP. Flipped classroom model improves graduate student performance in cardiovascular, respiratory, and renal physiology. Adv Physiol Educ 2013;37:316–20.
14. Javadi M, Kargar A, Gholami K, et al. Didactic lecture versus interactive workshop for continuing pharmacy education on reproductive health: a randomized controlled trial. Eval Health Prof 2015;38:404–18.
15. Lin Y, Zhu Y, Chen C, et al. Facing the challenges in ophthalmology clerkship teaching: is flipped classroom the answer? PLoS One 2017;12:e0174829.
16. Sarayani A, Naderi-Behdani F, Hadavand N, et al. A 3-armed randomized controlled trial of nurses' continuing education meetings on adverse drug reactions. J Contin Educ Health Prof 2015;35:123–30.
17. Fielding DI, Maldonado F, Murgu S. Achieving competency in bronchoscopy: challenges and opportunities. Respirology 2014;19:472–82.
18. Lüdert T, Nast A, Zielke H, et al. E-learning in the dermatological education at the Charité: evaluation of the last three years. J Dtsch Dermatol Ges 2008;6:467–72.
19. Means B, Toyama Y, Murphy R, et al. Evaluation of evidence-based practices in online learning: a meta-analysis and review of online learning studies. Washington, DC: US Department of Education; 2009.
20. Stephenson CR, Wang AT, Szostek JH, et al. Flipping the continuing medical education classroom: validating a measure of Attendees' perceptions. J Contin Educ Health Prof 2016;36:256.
21. Gillispie V. Using the flipped classroom to bridge the gap to generation Y. Ochsner J 2016;16:32–6.
22. Lew EK. Creating a contemporary clerkship curriculum: the flipped classroom model in emergency medicine. Int J Emerg Med 2016;9:25.
23. Liebert CA, Lin DT, Mazer LM, et al. Effectiveness of the surgery core clerkship flipped classroom: a prospective cohort trial. Am J Surg 2016;211:451–7.e1.
24. O'Connor EE, Fried J, McNulty N, et al. Flipping radiology education right side up. Acad Radiol 2016;23:810–22.
25. Holyoke L, Larson E. Engaging the adult learner generational mix. J Adult Education 2009;38:12–21.
26. Smeds MR, Thrush CR, Mizell JS, et al. Mobile spaced education for surgery rotation improves National Board of Medical Examiners scores. J Surg Res 2016;201:99–104.
27. Ferrer-Torregrosa J, Jiménez-Rodríguez MÁ, Torralba-Estelles J, et al. Distance learning ects and flipped classroom in the anatomy learning: comparative study of the use of augmented reality, video and notes. BMC Med Educ 2016;16:230.

28. White M, Michaud G, Pachev G, et al. 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.
29. Mast L. Application of the problem-based learning model for continuing professional education: a continuing medical education program on managed care issues–Part II. Am J Manag Care 1997;3:77–82.
30. Jonsen AR, Siegler M, Winslade WJ. Clinical ethics. Blacklick (OH): McGraw-Hill Professional Publishing; 2006.
31. Cherry-Bukowiec JR, Machado-Aranda D, To K, et al. Improvement in acute care surgery medical student education and clerkships: use of feedback and loop closure. J Surg Res 2015;199:15–22.
32. Hodder RV, Rivington RN, Calcutt LE, et al. The effectiveness of immediate feedback during the objective structured clinical examination. Med Educ 1989;23:184–8.
33. Garner MS, Gusberg RJ, Kim AW. The positive effect of immediate feedback on medical student education during the surgical clerkship. J Surg Educ 2014;71:391–7.
34. Dweck CS. Mindset: the new psychology of success. New York: Random House; 2006.
35. Kruger J, Dunning D. Unskilled and unaware of it: how difficulties in recognizing one's own incompetence lead to inflated self-assessments. J Pers Soc Psychol 1999;77:1121–34.
36. Miller RJ, Mudambi L, Vial MR, et al. Evaluation of appropriate mediastinal staging among endobronchial ultrasound bronchoscopists. Ann Am Thorac Soc 2017;14:1162–8.
37. Al-Ajam MR, Kalanjeri S, Haas AR, et al. Endobronchial ultrasound. When to venture into the vasculature. Ann Am Thorac Soc 2013;10:393–5.
38. Kim YH, Chiu CY, Bregant J. Unskilled and don't want to be aware of it: the effect of self-relevance on the unskilled and unaware phenomenon. PLoS One 2015;10:e0130309.
39. Wieman C. The "curse of knowledge" or why intuition about teaching often fails. Am Phys Soc News 2007;16:1–5.
40. Fisher M, Keil FC. The curse of expertise: when more knowledge leads to miscalibrated explanatory insight. Cogn Sci 2016;40:1251–69.
41. Kruglikova I, Grantcharov TP, Drewes AM, et al. The impact of constructive feedback on training in gastrointestinal endoscopy using high-fidelity Virtual-Reality simulation: a randomised controlled trial. Gut 2010;59:181–5.
42. Wahidi MM, Silvestri GA, Coakley RD, et al. A prospective multicenter study of competency metrics and educational interventions in the learning of bronchoscopy among new pulmonary fellows. Chest 2010;137:1040–9.
43. Stather DR, Maceachern P, Rimmer K, et al. Assessment and learning curve evaluation of endobronchial ultrasound skills following simulation and clinical training. Respirology 2011;16:698–704.
44. Davoudi M, Colt HG. Bronchoscopy simulation: a brief review. Adv Health Sci Educ Theory Pract 2009;14:287–96.
45. Wahidi MM, Herth FJ, Ernst A. State of the art: interventional pulmonology. Chest 2007;131:261–74.
46. Davoudi M, Colt HG, Osann KE, et al. Endobronchial ultrasound skills and tasks assessment tool: assessing the validity evidence for a test of endobronchial ultrasound-guided transbronchial needle aspiration operator skill. Am J Respir Crit Care Med 2012;186:773–9.
47. Sehgal IS, Dhooria S, Aggarwal AN, et al. Training and proficiency in endobronchial ultrasound-guided transbronchial needle aspiration: a systematic review. Respirology 2017;22(8):1547–57.
48. Scarlata S, Palermo P, Candoli P, et al. EBUS-STAT subscore analysis to predict the efficacy and assess the validity of virtual reality simulation for EBUS-TBNA training among experienced bronchoscopists. J Bronchology Interv Pulmonol 2017;24:110–6.
49. Mahmood K, Wahidi MM, Osann KE, et al. Development of a tool to assess basic competency in the performance of rigid bronchoscopy. Ann Am Thorac Soc 2016;13:502–11.
50. Mullon JJ, Burkart KM, Silvestri G, et al. Interventional pulmonology fellowship accreditation standards: executive summary of the multisociety interventional pulmonology fellowship accreditation committee. Chest 2017;151:1114–21.
51. Kerfoot BP. Learning benefits of on-line spaced education persist for 2 years. J Urol 2009;181:2671–3.
52. Kerfoot BP, Fu Y, Baker H, et al. Online spaced education generates transfer and improves long-term retention of diagnostic skills: a randomized controlled trial. J Am Coll Surg 2010;211:331–7.e1.
53. Kerfoot BP, DeWolf WC, Masser BA, et al. Spaced education improves the retention of clinical knowledge by medical students: a randomised controlled trial. Med Educ 2007;41:23–31.
54. Boespflug A, Guerra J, Dalle S, et al. Enhancement of customary dermoscopy education with spaced education e-learning: a prospective controlled trial. JAMA Dermatol 2015;151:847–53.
55. CHESTonline store. Available at: https://www.chestnet.org/Store/Products/Standard-Products/eLearning/Tunneled-Indwelling-Pleural-Catheter-TIPC-Checklist. Accessed October 1, 2017.