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From Socrates to Virtual Reality: A Historical Review of Learning Theories and Their Influence on the Training of Anesthesiologists

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INTRODUCTION

Evolution in the process of becoming a board-certified anesthesiologist is deeply intertwined with the origins of American medical education. Over the last 200 years, insights from learning theorists have implicitly and explicitly transformed the training of anesthesiologists. In this article, we explore the origins of American medical education. We provide an overview of learning theories and examine their impact on anesthesia education in the 20th century. We then explore how learning theorists' adult-centered teaching strategies influenced anesthesia training in the 21st century, and the impact of technological advances on the future of learning strategies.

Although Hippocrates is often credited with the origin of modern medicine, Socrates strongly influenced modern medical education. Socrates posed questions to activate critical thinking skills.¹ This technique, known as the *Socratic method*, was integral to medical education in America dating to informal anatomy classes in the 1750s in Philadelphia.² Thomas Bond, a founder of Pennsylvania Hospital, realized that books and lectures alone were insufficient for medical training. He taught bedside medicine by dedicating 130 inpatients to student learning via an apprenticeship model.^{2,3} Questioning learners at the bedside—essentially using the Socratic method—subsequently grew into the dominant education style in America

and has been passed down generationally from physicians without formal training in learning theories.¹ While Socrates may have posed questions to facilitate critical thinking, medical practitioners of the Socratic method often use questioning for the additional purpose of scrutiny. Without formal training in learning theories, many academic physicians may misinterpret the original intention of the Socratic method when adopting questioning for medical training purposes.

As medicine divided into various specialties, medical education split into specialty-specific training programs. Though the first public demonstration of general anesthesia is attributed to a dentist at Massachusetts General Hospital in 1846, anesthesia did not gain traction as a field requiring formal medical training until the 20th century.^{4,5} In line with the traditions of other training programs, specialty programs were predominantly taught under an apprenticeship model often using the Socratic method.

Throughout the 20th century, learning theorists indirectly influenced medical education. We argue that this is changing; learning theory is becoming central to modern thinking about medical education. Recent shifts in medical and anesthesia training have been facilitated by physician interest in formal education training programs. In 1996 there were 7 advance education programs (Certificate, Masters,

PhD) for health professionals to advance knowledge and skills related to adult learning theory, practice, and application.⁶ By 2012, this number had risen to 76 programs around the world, with 15 in North America.⁶ As a result, physicians seeking anesthesia training today receive a radically transformed education. One of the aims of this article is to exemplify this shift of learning theories from the implicit periphery to the center of medical training, which has been led by physicians with advanced education training.

Medical credentialing agencies have grown increasingly cognizant of learning theories. The Association of American Medical Colleges (AAMC), the Accreditation Council for Graduate Medical Education (ACGME), and American Board of Anesthesiology (ABA) comprise the 3 main accreditation bodies that oversee the education of anesthesiologists, from medical school, through residency, and into continuing education, respectively. The AAMC has led an evolution in medical education toward earlier clinical experiences, integration of basic and clinical sciences, and problem-based learning (PBL) instruction. The PBL instruction has been integrated into medical school education for decades; however, with the recent development of new technologies such as recorded classrooms and virtual anatomy labs, it has experienced enhanced use and

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acceptance by instructors and students.⁷ The ACGME-governed anesthesia residencies have implemented electronic tablets that augment the learning environment, high-fidelity medical simulation in freestanding centers, and immersive technologies like virtual reality as both learning adjuncts and anxiolytics for patients.^{8,9} Furthermore, the ACGME and ABA have transitioned to a self-directed learning approach.¹⁰

As contemporary trends in adult learning theories merge with technology in medical school and anesthesia training programs, medical education has been significantly refined. The aim of this historical perspective is to explore the dominant learning theories that have inspired anesthesia training in America today.

20th Century Learning Theories and Anesthesia Training

An Introduction to Learning Theories

Throughout the 20th century, psychological and educational scientists published theories related to learning and teaching. Three distinct views emerged: (1) the behaviorist/empiricist, (2) cognitive/rationalist, and (3) situative/pragmatist-sociohistoric (SPS).¹¹

The behaviorist/empiricist view considers students to be intrinsically motivated, with new knowledge being constructed and assembled into previously held beliefs, truths, and concepts.¹¹ Associations between new and old concepts allow for application of knowledge into new situations, similar in theory to operant conditioning. Students' incentive for learning is focused on feeling competent in new situations. In the 1930s and 1940s, prominent behaviorists, Skinner, Guthrie, and others proposed the stimulus-response association theory, emphasizing that behavior is a response to stimuli and stimulus-prompted responses are altered by a learner's experiences (Table 1).^{12,13}

The cognitive/rationalist perspective on knowledge acquisition divided learning into different domains of reasoning, planning, problem solving, and language.¹¹ Theorists including Piaget believed that, in contrast to the behaviorist view, teachers should foster learners' intrinsic motivations and interests.¹⁴ Learner interests depend on metacognition, the capacity to reflect

on one's thinking to monitor and manage it.¹¹ Cognitivists aligned with Gestalt psychology, emphasizing the importance of structured knowledge building. Piaget's research on cognitive development in the 1930s and 1940s was the foundation for much of this perspective.¹⁴ His work is evidenced today in the efforts to organize science in a manner that emphasizes successive learning of principles and concepts.¹¹ The rationalist perspective provided the foundational theory behind PBL, which has become omnipresent in medical and anesthesia training (Table 1).¹⁵

The SPS learning theorists endorse a holistic approach to learning and knowledge.¹¹ The interaction of learners with their environments promotes learning, referred to as participating in *practices of community*.¹¹ In environments that are rich with support structures, students thrive. Knowledge is shared within the student's community, and the community similarly imparts knowledge to the student. Whole-class discourse with rich student interactions stimulates the learning of not only individual students but the entire class.¹¹ While behaviorist and cognitive perspectives had impacts on past thinking about medical training, the SPS learning theory is having the greatest impact on the current state of medical and anesthesia training (Table 1).

Evolution of Anesthesia Training From Informal to Professional

Although anesthesia was publicly demonstrated in the mid-1800s, the path to becoming a specialty-trained anesthesiologist was nonexistent until the next century. During this period, anesthesia was practiced by apprenticed and self-taught physicians and nurses, including Dr James Gwathmey. He wrote the first book on anesthesiology in 1914 and was the first president of the American Association of Anesthetists.^{5,16,17} Without residencies in anesthesiology, physician anesthesiologists received their training during medical school, which at the time were highly influenced by Abraham Flexner, an American educational reformer.¹⁸

Flexner founded and directed a private school that aligned with cognitive/rationalist and SPS learning theories.^{2,19} At his school, students were not offered a

standard curriculum that taught toward examinations and grades. Rather, the school used PBL techniques that focused on student development without longitudinal academic records.²⁰ While Flexner was directing his private school with these novel approaches, the majority of American medical schools in the late 1890s to 1900s accepted students from high school with no college training.¹⁸ Medical schools offered a repeating curriculum wherein the same topics were taught annually for 2 to 3 years. This approach aligned with the behaviorist/empiricist theorists who suggested that repeated practices facilitates optimal learning retention.^{3,18} Interested graduates would learn anesthesia informally during and after medical school.

Leading up to 1910, medical schools started to shift toward 4-year graded curricula, but there was heterogeneity in the quality and content of instruction.^{18,21} In 1908, Henry Pritchett, president of the Carnegie Foundation, in collaboration with the American Medical Association and AAMC, commissioned Flexner to complete an evaluation of medical schools.^{18,22} Between 1908 and 1910, Flexner evaluated the learning environments of 155 medical schools, culminating in a report recommending an overhaul of the American medical education system.^{2,22} Flexner's report provided 4 main recommendations that would serve as the foundation for American medical schools for the majority of the 20th century: (1) prerequisite college education in biology, chemistry, and physics; (2) didactic and laboratory curricula that progress over 2 preclinical years; (3) active student participation in the clinical care of patients under physician supervision in their clinical years; and (4) salaried faculty dedicated to basic and clinical sciences.^{2,18}

Regarding his first recommendation, Flexner proposed a shift away from the behaviorist/empiricist learning approach prevalent in medical schools. In place of repeated instruction, Flexner leaned on a cognitive/rationalist theory of curriculum development.^{3,11} Flexner believed that students entering medical school required a foundation in the sciences, and that the medical sciences would build upon the fundamentals of undergraduate biology,

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chemistry, and physics. These prerequisites were broadly adopted by medical schools. By 1920, 90% of medical schools required at least 2 years of college prerequisite courses, compared with only 20% in 1910.¹⁸

Flexner's second recommendation emphasized the importance of a laboratory component and diversity of courses that did not repeat. Similar to the training offered at his private school, Flexner recognized the importance of PBL and the implicit learning that developed from rich conversational environments. These tenets were rooted in the cognitive/rationalist and SPS learning theories that became more formalized in the latter half of the 20th century.

Flexner's third recommendation reemphasized the importance of an apprenticeship model in which students are directly involved in patient care in the clinical setting. In 1905, there were 129 medical schools in America, with many lacking hospital affiliations or university support.¹⁸ Again, Flexner recognized the importance of environments that stimulated learning in alignment with the SPS learning theory. The faculty-apprentice model during the clinical years of medical school would solidify the Socratic method of teaching in medicine.¹ Flexner's fourth recommendation supported his third, as medical schools that were not affiliated with hospitals or universities would lack financial capability to support faculty salary. Within 10 years of his report, 30% of medical schools had closed.¹⁸

Physicians who became anesthesiologists in the 1920s benefited from Flexner's recommendations. His drive to include college prerequisites, preclinical didactics, and laboratory sciences provided students with the foundational knowledge to study the field's enigmatic pharmacological mechanisms of action. The field's first journal, *Current Researches in Anesthesia and Analgesia*, was released in 1922.²³ In 1927 the first residency program for anesthesia was established by Ralph Waters at the University of Wisconsin, Madison.⁵ Waters' residency program became a model for others in the country, emphasizing resident education in the basic and clinical sciences, similar to Flexner's recommendation for medical schools.²⁴

In 1938, the American Board of Medical Specialties approved the ABA, and a year later the ABA issued 9 certificates.⁵

Anesthesia residency in the mid-20th century was similar to other medical residencies, with apprenticeship models that followed cognitive and behaviorist perspectives. As a relatively novel specialty, anesthesia training pathways were altered by World War II.²⁴ Because female nurse anesthetists were not considered combat ready, coupled with a lack of male physician anesthesiologists, the US military began training soldiers as anesthesiologists.²⁴ The ABA encouraged this military training by waiving 1 year of anesthesia residency for soldiers who served as anesthesiologists during the war.²⁴ Wartime anesthesia practice was marked by the SPS learning environment.¹¹ The anesthesiologists developed makeshift supplies from their surrounding environment and learned new techniques for delivering anesthesia in low resource settings.^{24,25} This experiential learning, highly influenced by abstract conceptualization with experimental application, was reminiscent of themes the educational theorist David Kolb would study in years to come.²⁶ Military-trained anesthesiologists returned to America with sophisticated techniques, a passion for anesthesiology, and a thirst for formal education.⁵

Given rapid scientific discoveries and medical innovations during the mid-century, anesthesia residency programs increased from 37 in 1940 to 217 in 1950.²⁴ While physicians provided only 18% of anesthesia services in 1940, by 1962 physicians provided over 75% of anesthesia services. By the late 1900s, the ABA issued more than 35 000 board certifications from physicians graduating from nearly 140 residency programs.⁵

The Pedagogy-Andragogy Continuum

Throughout much of the 20th century, higher education was influenced by classical learning theories born out of the study of pedagogy.¹¹ Malcom Knowles was one of the first theorists to propose a difference between pedagogy, which refers specifically to child learning, and andragogy, or adult learning.²⁷ The traditional pedagogic approach imagines a teacher with students who implicitly perform tasks and

assignments at the teacher's request. An andragogic teaching approach reimagines the teacher as a mentoring facilitator, guiding adult students toward collaborative assignments that have tangible and obvious benefits to the students. In the 1980s, Knowles proposed 5 attributes of adult learners that influence an educator's approach toward teaching adults: (1) independence with a preference for self-directed learning; (2) various degrees of experience that should be incorporated into instruction; (3) preference to integrate learning into daily life; (4) preference toward problem-centered approaches; and (5) derivation of greater motivation from internal rather than external factors (Table 1).^{28,29} Andragogy, as proposed by Knowles, encapsulates characteristics of adult learners with guidelines for instructional planning.²⁷

Two other adult theories would soon become recognized within medical training.^{30,31} First reported in 1970, Howard McClusky's theory of margin described adulthood as a balance between load (demands of life on an individual), power (the resources available to that individual), and the margin between them (Table 1).³¹ Adult learners who may have competing employment and families choose to increase their *load* when engaging in formalized learning settings, despite other demands in life. The success of these adult students is strongly influenced by the power or autonomy provided to them to maintain their *margins*.²⁷ Described in 1980, Alan Knox's proficiency theory assumes that adult learning is developmental and transactional.^{27,30} Given the opportunity, adults can become proficient using a combination of knowledge, skills, and abilities (KSA; Table 1).³⁰ Adult learners periodically assess their competencies and reorganize their training to achieve proficiency. The evaluation of adult learners' KSA would later have strong influences on anesthesia trainee assessments.

In 1981, Jack Mezirow described his transformational adult learning theory, arguing that adult education changes consciousness through psychological understanding of the self, revision of convictions, and changes in behavior (Table

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1).^{27,32} Mezirow believed that learning in adulthood did not simply add to a knowledge repository, but transformed adults with newly acquired perspectives.^{27,32} In 1984, Kolb's experiential learning theory aimed to combine experience, perception, cognition, and behavior.²⁶ Kolb proposed that learning may begin at any of the following 4 stages, but that the stages tend to follow in sequence: (1) concrete, active experience; (2) conscious reflective observation on the experience; (3) abstract conceptualizing a theory or model to what was observed; and (4) active experimentation to test the theory or model. Experiential learning would later have strong influences on newly designed medical school curricula in the 21st century.

Anesthetic Implications of Andragogic Learning Theories

Andragogic Influences on Medical School Curricula

Although Flexner's model medical school remained relatively unchanged for the better part of the 1900s, andragogic learning theories began to influence traditional medical school structures in the early 2000s. The typical 4-year program has given way to professional training that encompasses other areas, often leading to medical schooling for 5 to 8 years. In 2005, 86% (107/125) of medical schools offered MD-PhD programs and 51% (64/125) offered MD-MPH programs.³³ Students have embraced the autonomy provided by medical schools to pursue additional degrees and research.³⁴ Although some students pursue these opportunities to increase their residency competitiveness, 65% (161/249) of students seeking advanced training state they would do so even if already assured their top residency position.³⁴ This shift in medical school toward a student-centered, semiautonomous curriculum supports Knowles' assumption that adult learners are intrinsically motivated to pursue learning opportunities when given the autonomy to do so.²⁸ Redefining medical school to include not just physician training but also transformative professional development is also consistent with Mezirow's transformative adult learning theory.

Born from the rationalist perspective, PBL techniques promoted by Knowles'

assumption that adult learners prefer immediate discovery of problem-based curricula have become ubiquitous in medical schools.^{28,35} However, the effectiveness of PBL has not been demonstrated, even in comprehensive reviews.³⁵ In order to promote self-directed curriculum, aligning with one of Knowles' core assumptions of adult learners, 15% of American medical schools in 2000 offered students web-based learning modalities, and that percentage has continued to increase.³⁶ Aligned with McClusky's theory of margin, these distance curricula allow students to modulate their course load depending on their other commitments.³¹

Increasingly, active learning methodologies such as PBL, team-based learning, simulation, and concept mapping have significantly changed undergraduate medical education (as well as graduate medical education). Team-based learning, a structured form of small-group learning emphasizing student preparation outside of class and knowledge application within class, has gained popularity in medical education. It is specifically characterized by 3 components: individual advance student preparation, individual and team readiness assurance tests, and the majority of in-class time devoted to decision-based application assignments done in teams.³⁷ In one study, medical students overwhelmingly preferred team-based learning to PBL.³⁸ Simulation-based medical education has also been increasingly recommended and widespread.³⁹ Overall, medical schools have been transitioning away from traditional lecture-based instruction in favor of learner-centered active learning methodologies.

Andragogic Influences on Anesthesiology Residencies

Anesthesia residencies were standardized to 3 years in 1964.⁵ As andragogic learning theories began to influence medical schools, a similar effect permeated anesthesia residencies. In 2009 and 2012, the ABA approved combined anesthesia residencies with pediatrics and internal medicine, respectively.^{5,40} As early as 2007, combined anesthesiology residencies and fellowships, included anesthesiology and critical care were also offered. This increased flexibility and departure from over 50 years of a standard 3-year program follow adult

learning techniques that foster autonomy and intrinsic motivation to seek greater educational opportunities.

Assessment of trainees with constructive feedback has been an additional area of focus. Traditional assessments during anesthesia residencies were based on clinical evaluation of performance and standardized testing, which followed the behaviorist/empiricist learning theories of the early and mid-20th century.^{5,11} Given the lack of correlation between clinical performance and standardized examinations, in 1999 the ACGME developed 6 core competencies for trainee assessment.⁵ These competencies were revisited, and in 2014, the ACGME initiated the New Accreditation System (NAS), which assessed trainees' outcomes through educational milestones.⁵ Borrowed from Knox's proficiency theory, the areas assessed by the NAS include KSA in multiple domains that help determine proficiency in anesthesiology.

Clinical anesthesia was long taught through a Socratic, apprenticeship model and the adage, *see one, do one, teach one*.²⁹ Techniques have evolved. Introduced in 2001, alternative skill teaching strategies derive from Kolb's theory on experiential learning and proposes: (1) introduction to the skill's utility to appeal to the learner's intrinsic motivation; (2) demonstration without commentary to allow thoughtful observation; (3) demonstration with comment; (4) learner verbalization of the skill; and (5) learner practice supplemented with feedback (Table 1).^{26,41} These andragogic influences have changed the notion of the apprentice model. In 1992, Roger Neighbor proposed the concept of medical trainees embodying the *Inner Apprentice*.^{29,32,42} Building off Mezirow's transformative learning theory, Neighbor describes that trainees are intrinsically self-educating given an environment that cultivates learning with practical teaching at the moment of inquiry, which is reminiscent of SPS learning theories.⁴²

Given the infiltration of andragogic learning theories into trainee education, the Socratic method itself has come under scrutiny. The Socratic method as used by most physicians often decays the learning environment by suppressing candid intellectual questions,

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creating hostile learning atmospheres, and dehumanizing medical trainees.^{1,43} Despite these criticisms, teaching trainees through a series of questions and answers can still be successfully used. Instead of abusive questioning, physician educators should seek purposeful questions posed just above the trainees' level of ability to help elucidate areas of improvement, with incorrect answers prompting reflective inquiry instead of embarrassment.^{1,44} This approach uses Vygotsky's concept of the zone of proximal development, which states that students can perform above their actual development level with guidance and encouragement from a teacher.⁴⁵ Such proposed evolution of the Socratic method may be more appropriate than abandoning it, since the final step to becoming an ABA-certified anesthesiologist includes an oral examination.⁴⁶ Although it provides an opportunity to test critical decision making, the oral exam has also been subjected to criticisms of bias as far back as 1976.⁴⁷ Reflective of new methods of assessment that align with the NAS, in 2018 the ABA added an objective structured clinical examination to complement the oral board examination. During the objective structured clinical examination, board eligible physicians participate in 7 stations that assess proficiency in 7 of 9 predetermined skills, aligning with assessment values of the cognitive/rationalist perspective.

Andragogic Influences on Continued Anesthesiology Education

As andragogic learning theories gained influence in medical schools and anesthesia residencies, they also affected continued medical education in anesthesiology. The American Society of Anesthesiologists (ASA) developed PBL programs for its annual meetings as early as 1992, establishing anesthesiology as a pioneer among medical specialties for its use of PBL.⁴⁸ These initial ASA PBL discussions, which included case objectives, model discussion outlines, and references as part of a finite education experience, gained success due to the inculcation of PBL principles. The PBL discussions remain an important component of faculty development at the annual ASA conference,

and they have become prevalent learning tools for anesthesiologists at all levels, from medical school clerkships through fellowships. The ASA PBL discussions were first introduced by Philip Liu, who was a founder and inaugural president of the Society for Education in Anesthesia (SEA). Founded in 1985, SEA has had significant impact on education within anesthesiology, ranging from medical students to faculty. The SEA offers opportunities for clinical educators to learn about teaching and expand as academic educators.

Technology Meets Andragogy

The internet has transformed education, leading to the development of new learning theories. The collaborativist theory (also known as *online collaborative learning*) focuses on learning networks and the augmentation of human agency through technology (Table 1).⁴⁹ The theory of connectivism asserts that learning occurs not solely within an individual, but also outside a person as specialized information sets are interconnected to each other, thus resulting in knowledge accumulation.^{50,51} Connectivism learning theory is particularly relevant to medical education as technology becomes fully integrated into medical curricula.⁵⁰

Today's medical schools use technology extensively. Computers and their applications are commonly used for delivery of instruction and course management.³³ Blended classes using videos, podcasts, and online assessments have become conventional.⁵² First-year and second-year medical students have the option to watch didactic lectures online, which has been associated with less discontentment among students and higher scores on examinations compared with those who attended class in-person.⁵²⁻⁵⁴ Online lectures allow for greater flexibility and learner independence, aligning with Knowles' assumptions of adult learners.²⁸ Offering a variety of different instructional tools allows students to align their learning styles with the offered formats.⁵² Although asynchronous learning has the potential to reduce collaboration and connectivity with other learners, careful use of online discussion forums and synchronous PBL online small group sessions counter this potential. Many of these techniques were urgently refined as medical schools

shifted their curricula online during the shelter-in-place guidelines during the 2020 COVID-19 pandemic.

Technology has also been integrated into anesthesia residencies. Electronic tablets have increased residents' reporting of teaching quality.⁹ Immediate access to information with electronic tablets or computers aligns with Knowles' assumption that adult learners prefer immediate discovery.²⁸ Nearly 90% of anesthesiologists report using a variety of electronic applications, including medical calculators, drug reference applications, and journal and textbook references.⁵⁵ Use of electronic decision support has improved adherence to best practice recommendations.^{56,57} The ABA has radically transformed its recertification to align with adult learning techniques. Instead of a written examination every decade, anesthesiologists now complete 30 questions every 3 months on a smartphone application.¹⁰ The ABA has shifted the focus of its previous 10-year examination, which followed the style of behaviorist/empiricist assessments, to self-directed learning through its app-based questions that provide real-time feedback.¹⁰ Coupling the yearly knowledge assessments with requirements to participate in quality improvement projects and continuing medical education, the ABA's recertification process aligns with Mezirow's transformative adult learning theory.³²

Immersive technologies such as virtual reality and augmented reality have been propelled into educational environments by reduced costs and increased capabilities. Medical students have used virtual reality to simulate crises in a way that written examinations cannot replicate.⁵⁸ Augmented reality overlays holographic images onto the real world so students and instructors can continue to interact directly with each other in an augmented world. Some medical schools have used augmented reality to teach anatomy and ultrasonic image interpretation.⁵⁸ Within anesthesia residency programs, immersive technologies have been used to simulate rare experiences and augment teaching of regional nerve blocks.⁵⁹⁻⁶¹ Influenced by Kolb's experiential learning theories,

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immersive technologies create enhanced learning environments that allow learners to engage and experiment without patient risk.²⁶

CONCLUSION

The historical journey to modern-day anesthesiology training has been uniquely influenced throughout the centuries by educational theory, popular beliefs, and the culture of medical care (Figure 1). In the early years, nurses, surgeons, and dentists learned the practice as an additional craft to be used during minor surgical procedures.⁶² As surgeries became more complex, the need for safer and more reliable anesthesia prompted renewed investigation into skills required to be an adept anesthesiologist.^{5,62} Pedagogical learning theories in the early and mid-20th century profoundly influenced the medical school curriculum born from the Flexner Report. In the later 20th century, the introduction of andragogic learning theories redefined curriculum development for medical students and anesthesia trainees.

As medical knowledge continues to expand faster than it can be acquired, integration of technologies into learning environments promotes andragogic learning.⁶³ The technological revolution is altering how medical students and residents are trained. As telemedicine tools continue to develop, trainees will require formal training in remote patient care. They will learn the promises and pitfalls of artificial intelligence and how to integrate artificial intelligence tools into existing clinical workflows. As patient health data from various sources (including wearables, home monitoring, personal genomics, etc) are collected at scale, it becomes critical for physicians to become fluent in data analysis. In the operating room, anesthesiologists will increasingly encounter robotic surgery and artificial-intelligence-based clinical decision support. New technologies not only enable anesthesiologists to be trained in novel ways, but also require new learning theories and teaching models to be developed. As new learning theories, including multimedia and humanistic approaches emerge, future studies will explore how these can be applied to the training of anesthesiologists.

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Abstract

Over the past couple of centuries, the training of American physicians, and anesthesiologists in particular, has undergone a radical transformation. The revolution of medical training has been and continues to be fueled by insights from learning theorists. In this historical review, we discuss the origins of American medical education in the 1700s and continue through the centuries illustrating the impact of learning theories on the education and training of anesthesiologists. In particular, we explore the impact of learning theories of the 1800s and the adult-centered teaching strategies of the 1900s. We also discuss the role of learning theories in molding medical education in the modern technological age.

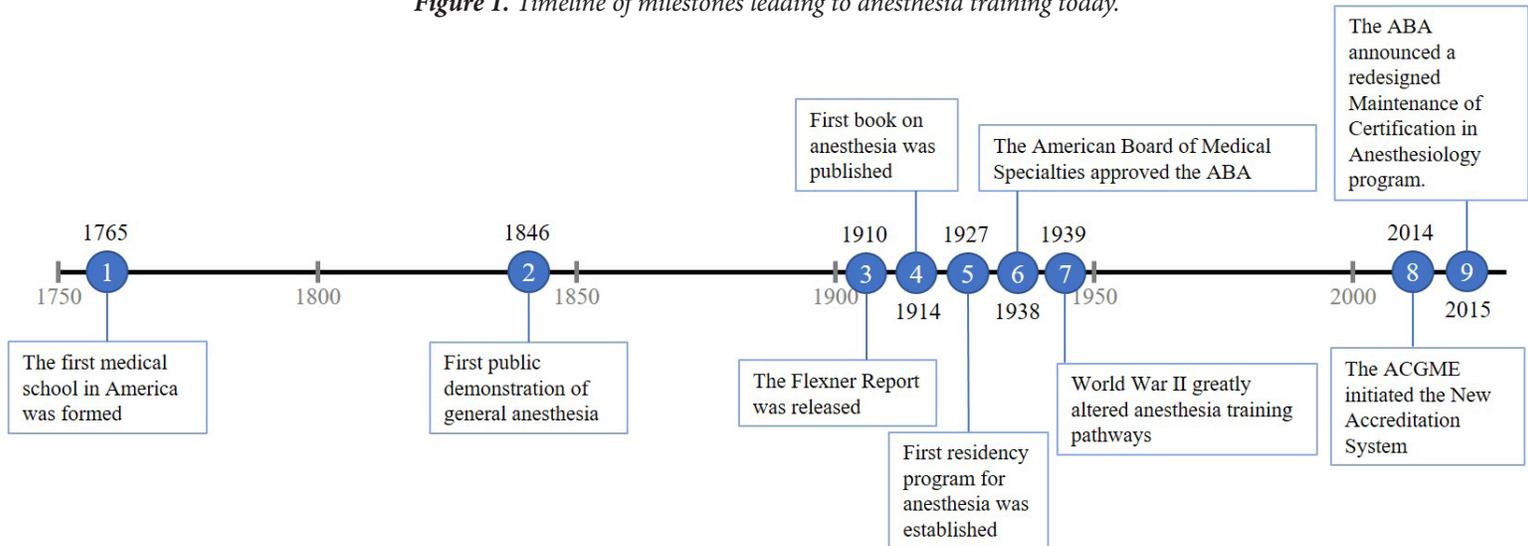
Keywords: Medical education, continuing education, teacher training, preceptorship, anesthesiology

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Figure

Figure 1. Timeline of milestones leading to anesthesia training today.



1. 1765—The first medical school was formed by Dr John Morgan and Dr William Shippen Jr at the College of Philadelphia. This has since become the University of Pennsylvania Perelman School of Medicine. Thomas Bond, a founder of Pennsylvania Hospital, realized that books and lectures alone were insufficient for medical training. He taught bedside medicine by dedicating 130 inpatients to student learning, who learned from doctors via an apprenticeship model.
2. 1846—Dentist William T.G. Morton performed the first public demonstration of anesthesia at Massachusetts General Hospital.
3. 1910—Abraham Flexner released the influential Flexner Report. Flexner's report provided 4 main recommendations that would continue to serve as the foundation for American medical schools for the majority of the 20th century: (1) prerequisite college education in biology, chemistry, and physics; (2) didactic and laboratory curricula that progress over 2 preclinical years; (3) active student participation in the clinical care of patients under physician supervision in their clinical years; and (4) salaried faculty dedicated to basic and clinical sciences.
4. 1914—Dr James Gwathmey, who was the first president of the American Association of Anesthetists, wrote the first book on anesthesia, titled *Anesthesia*.
5. 1927—Ralph Waters established the first residency program for anesthesia at the University of Wisconsin, Madison. This residency program became a model for others in the country, and it emphasized resident education in the basic and clinical sciences, similar to Flexner's recommendation for medical schools.
6. 1938—In 1938, the American Board of Medical Specialties approved the American Board of Anesthesiology (ABA) and a year later, the ABA issued 9 certificates.
7. 1939 to 1945—Anesthesia training pathways were greatly altered by World War II. The US military began training soldiers as anesthesiologists. The ABA encouraged this military training by waiving 1 year of anesthesia residency for soldiers who served as anesthesiologists during the war. Wartime anesthesia practice was marked by the situative/pragmatist-sociohistoric learning environment. The anesthesiologists developed makeshift supplies from their surrounding environment and learned new techniques for delivering anesthesia in low resource settings. This experiential learning, highly influenced by abstract conceptualization with experimental application, was reminiscent of themes that educational theorist David Kolb would study in years to come.
8. 2014—The Accreditation Council for Graduate Medical Education (ACGME) initiated the New Accreditation System, which assessed trainees' outcomes through educational milestones. Borrowed from Knox's Proficiency theory, the areas assessed by the New Accreditation System include knowledge, skills, and abilities in multiple domains that help determine proficiency in anesthesiology.
9. 2015—The ABA announced a redesigned Maintenance of Certification in Anesthesiology program. The ABA has shifted the focus of its previous 10-year examination, which followed the style of behaviorist/empiricist assessments, to self-directed learning through its app-based questions that provide real-time feedback with learning points. Coupling the yearly knowledge assessments with requirements to participate in quality improvement projects and continuing medical education, the ABA's recertification process aligns with Mezirow's transformative adult learning theory.

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Table

Table 1. Summary of the Various Learning Theories That Have Influenced Medical Education and Anesthesia Training

Learning Theory	Description	Illustrative Example
Behaviorist/ empiricist	Considers students to be intrinsically motivated, with new knowledge building upon previously known ideas. Associations between new and old concepts allow for application of knowledge into new situations.	Before the Flexner Report was published in 1910, medical schools used a repeating curriculum wherein the same topics were taught every year for 2 to 3 years, based on the idea that repeated practices facilitate optimal learning retention.
Cognitive/ rationalist	Divided learning into different domains, eg reasoning, planning, problem solving, and language. In contrast to the behaviorist view, teachers should foster learners' intrinsic motivations and promote structured and successive learning of concepts.	The rationalist perspective provided the foundational theory behind problem-based learning, which has become omnipresent in medical and anesthesia training.
SPS	Endorse a holistic approach to learning and knowledge. The interaction of learners with their environments promotes learning. Knowledge is shared within the student's community, and the community similarly imparts knowledge to the student.	SPS learning theory has had the greatest impact on medical and anesthesia training. For example, Flexner's emphasis of the importance of an apprenticeship model (direct patient care in clinical settings) was based on SPS view that environments stimulate learning.
Pedagogy	Refers to learning that is generally hierarchically focused with a teacher as the instructional leader. This type of learning is traditionally found in typical elementary and secondary education classrooms. The student is dependent upon the instructor for learning, resulting in a highly influential role of the instructor. Teachers dictate the curriculum, and students are generally motivated by external influences.	The pedagogic contrast to andragogy has been highly useful in designing medical training. For example, some medical schools have removed preclinical grades and honor societies to allow students to learn based on internal motivation instead of external pressures.
Andragogy	Described difference between pedagogy and andragogy. Andragogic approach reimagines the teacher as a mentoring facilitator, guiding adult students toward collaborative assignments that have tangible and obvious benefits to the students.	First-year and second-year medical students have the option to watch didactic lectures online. Online lectures allow for greater flexibility and learner independence, aligning with Knowles' assumptions of adult learners.

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Theory of margin	Described adulthood as a balance between load, power, and the margin between them. The success of adult students is strongly influenced by the power or autonomy provided to them to maintain their margins.	Medical schools have increasingly offered web-based learning. Aligned with McClusky's Theory of Margin, these distance curricula allow students to modulate their course load depending on their other commitments.
Proficiency theory	Assumes that adult learning is developmental and transactional. Given the opportunity, adults can become proficient using KSA.	In 2014, the ACGME initiated the NAS, which assessed trainees' outcomes through educational milestones. Borrowed from Knox's Proficiency theory, the areas assessed by the NAS include KSA in multiple domains that help determine proficiency in anesthesiology.
Transformational	Argued adult education changes consciousness through psychological understanding of the self, revision of convictions and beliefs, and changes in behavior and lifestyle. Learning in adulthood did not simply add to a knowledge repository, but transformed adults with newly acquired perspectives.	Coupling the yearly knowledge assessments with requirements to participate in quality improvement projects and continuing medical education, the ABA's recertification process aligns with Mezirow's transformative adult learning theory.
Experiential	Proposed that learning may begin at any of the following 4 stages, but the stages tend to follow in sequence: (1) concrete, active experience; (2) conscious reflective observation on the experience; (3) abstract conceptualizing a theory or model to what was observed; (4) active experimentation to test the theory or model.	Some medical schools have used augmented reality to teach anatomy and ultrasonic image interpretation. Within anesthesia residency programs, immersive technologies have been used to simulate rare experiences and augment teaching of regional nerve blocks. Influenced by Kolb's experiential learning theories, immersive technologies create enhanced learning environments that allow learners to engage and experiment without patient risk.
Collaborativism	Also known as <i>online collaborative learning</i> . Focuses on learning networks and the augmentation of human agency and knowledge through technology.	The use of forums on online learning platforms and communication apps by medical students during preclinical courses facilitates asynchronous peer-to-peer discussion, debate, and engagement with the material.
Connectivism	Asserts that learning occurs not solely within an individual, but also outside a person as specialized information sets are connected to each other to result in knowledge accumulation.	Medical students and anesthesia trainees use online communities including social media to promote learner engagement, feedback, and collaboration. For example, the use of Twitter for academic purposes is common in medicine.

Abbreviations: ABA, American Board of Anesthesiology; ACGME, Accreditation Council for Graduate Medical Education; KSA, knowledge, skills, and abilities; NAS, New Accreditation System; SPS, situative/pragmatist-sociohistoric.