

## The Flipped Classroom in Graduate Medical Education

Heather French, MD, MEd,\* AnnaMarie Arias-Shah, MD,<sup>†</sup> Carly Gisondo, DO,<sup>‡</sup> Megan M. Gray, MD<sup>§</sup>

\*Department of Pediatrics, Perelman School of Medicine at the University of Pennsylvania, Philadelphia, PA

<sup>†</sup>Division of Neonatology, Department of Pediatrics, Baylor College of Medicine, Houston, TX

<sup>‡</sup>Division of Neonatology, Department of Pediatrics, University of Michigan, Ann Arbor, MI

<sup>§</sup>Division of Neonatology, University of Washington School of Medicine, Seattle, WA

### Abstract

Andragogy, the art and science of helping adults learn, is a learner-centric conceptual framework that considers adult learner characteristics and their motivations for learning. These motivations range from internal will, readiness to learn, and relevance to one's own life. The flipped classroom, an increasingly popular educational method for both learners and educators, aligns with an andragogical approach as it uses classroom time for application of knowledge and critical thinking rather than for a passive didactic lecture. The growing body of educational research demonstrating increased performance and knowledge retention using this method has led to its incorporation into graduate medical education materials, including the National Neonatology Curriculum. In this article, the authors review how the flipped classroom, an active educational method that embraces the tenets of adult learning theory, may be more effective in graduate medical education compared with traditional lecture.

### Objectives After completing this article, readers should be able to:

1. Recognize the different learning needs and preferences of adult learners.
2. Explain the benefits of active educational methods, such as the flipped classroom, for adult learners.
3. Describe the educational research supporting the development of the National Neonatology Curriculum.

### AN INTRODUCTION TO ADULT LEARNING THEORY

Pedagogy, the art and science of teaching children, is a teacher-centric educational approach in which the teacher has full responsibility for decision-making and the learning environment. Pedagogical approaches to education are the predominant form of instruction in higher education in the United States for both children and

**AUTHOR DISCLOSURE** Drs French, Arias-Shah, Gisondo, and Gray have disclosed no financial relationships relevant to this article. This commentary does not contain a discussion of an unapproved/investigative use of a commercial product/device.

#### ABBREVIATIONS

ABP	American Board of Pediatrics
FC	flipped classroom
GME	graduate medical education
NNC	National Neonatology Curriculum
NNCC	National Neonatology Curriculum Committee
NPM	neonatal-perinatal medicine
ONTPD	Organization of Neonatal-Perinatal Medicine Training Program Directors
PD	program director
RCT	randomized controlled trial

adults. Pedagogy places the student in a submissive role, actively promoting dependence on the instructor. As adults mature, they are increasingly motivated by a desire to solve problems and be self-directed. The pedagogical model does not consider the different developmental needs of adults, which can lead to tension, resentment, and resistance to learning.

Malcolm Knowles, a professor of adult education at Boston University, introduced the idea of andragogy, the art and science of helping adults learn. (1) Andragogy is a learner-centric conceptual framework consisting of 6 assumptions of adult learner characteristics and their motivations for learning (Fig 1). The 6 assumptions that underlie andragogy are: 1) adults are internally motivated and 2) self-directed, choosing what they want to learn, when they want to learn, and how they want to learn; 3) adults bring personal experience to learning; 4) their readiness to learn depends on their need for knowledge; 5) relevance of information for one's personal or professional life; and 6) the usefulness of the information to solve problems. These assumptions of andragogy highlight the differences between child and adult learning in 3 areas: context, learner, and learning processes (Table). (2)(3) Effective educational methods will consider the differences between child and adult learning needs and respect the adult's autonomy.

Pedagogy and andragogy represent the 2 ends of a learning continuum and the use of both teaching approaches may be appropriate for specific topics, regardless of the learner's age. (1) A skilled educator will know when direct instruction, or a pedagogical approach, is best for learners, such as the introduction of new concepts to novice learners, as opposed to when an andragogical approach is best, such as in applying known concepts to complex problems. Capitalizing on an individual's preexisting knowledge

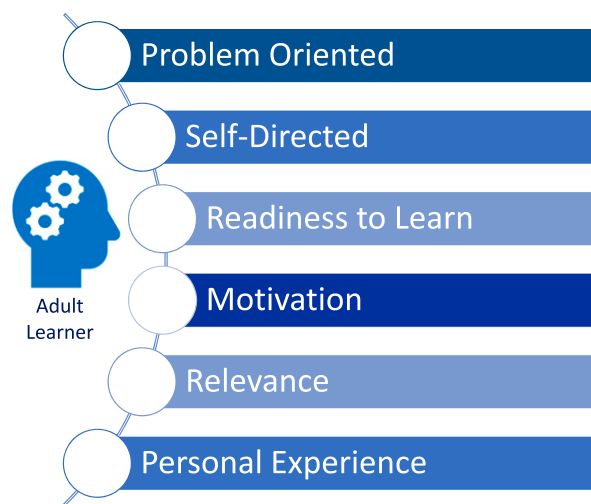


Figure 1. Knowles' assumptions of adult learners.

allows educators to become facilitators of learning for independent and self-directed learners, rather than transmitters and evaluators of knowledge. (4) Thus, the selection of the educational method is very important for learners to more effectively acquire and retain knowledge. The modified cone of learning (Fig 2), based on research by Edgar Dale, (5) shows the progression of learning experiences from passive to active and suggests that students are capable of retaining 90% of what they learn if educational materials are delivered using active teaching methods.

Effective educational practices in graduate medical education (GME) must consider the following: the learner is an active contributor in the learning process; learning occurs both independently and in collaboration with others in the learning community; preexisting knowledge and past experience provides a framework for acquisition of new knowledge; learning should relate to the understanding and management of real-life problems; placing new knowledge into real-world context enhances learning; and the ability to reflect on knowledge application is critical to the development of lifelong learning skills. Medical educators need to shift learning activities toward approaches that promote higher-level thinking, active learning, and application of learned concepts for highly motivated adult learners. The Accreditation Council for Graduate Medical Education "emphasizes the value of enhancing the quality and quantity of formal teaching, a challenging task due to increasing time constraints for both trainees and faculty members." (6) New strategies, including the "flipped classroom" (FC), have been used in a growing number of medical educational settings.

## THE FLIPPED CLASSROOM

The FC approach to education "flips" the traditional classroom approach on its head. (7) Instead of a didactic lecture for knowledge acquisition followed by independent assignments/homework, the learner performs independent, self-paced didactic learning for knowledge acquisition followed by classroom-based group assignments, discussion, and/or problem-based learning. (7) Learner-centric group discussions or problem-based learning facilitated by an educator helps create a community of learning and allows for peer-to-peer teaching, dialogue, and support.

In a traditional didactic classroom, the majority of classroom-based time is spent in the bottom 2 levels of Bloom's taxonomy: remember and understand. (8) In the FC approach, classroom-based time is spent in the higher levels of Bloom's taxonomy: apply, analyze, and evaluate (Fig 3). In the FC approach, adult learners are able to apply knowledge gained through independent study to cases or other

**TABLE. Differences Between Child and Adult Learning**

	CHILDREN	ADULTS
Context	<ul style="list-style-type: none"> <li>• Dependent on others</li> <li>• Learning is main job</li> <li>• Need generalized skills</li> </ul>	<ul style="list-style-type: none"> <li>• Independent of others</li> <li>• Learning is one of many jobs</li> <li>• Need situation-specific skills</li> </ul>
Learner	<ul style="list-style-type: none"> <li>• Requires direction</li> <li>• External motivation</li> <li>• Application to general problems</li> </ul>	<ul style="list-style-type: none"> <li>• Self-directed</li> <li>• Internal motivation</li> <li>• Application to relevant problems</li> </ul>
Learning process	<ul style="list-style-type: none"> <li>• Pace of learning dependent on teacher</li> <li>• Tasks are not always obviously meaningful</li> <li>• External motivation required to learn</li> </ul>	<ul style="list-style-type: none"> <li>• Pace of learning dependent on competing demands</li> <li>• Tasks must be meaningful</li> <li>• Internal motivation required to learn</li> </ul>

problem-based discussions during instructor-facilitated, learner-centered activities. (9) These adult learner-centric classroom sessions improve understanding and increase clinical application of acquired knowledge in addition to gaining critical lifelong learning skills. (10)(11)

Educators who participate in FC sessions develop skills as facilitators of learning rather than simply being teachers who transmit knowledge didactically. The interactive nature of the discussions provides the educator with insight into the learners' baseline understanding of the material and provides an opportunity to correct cognitive errors. Depending on the learners' understanding of the material gained in independent study, the facilitator has the ability to target the classroom sessions to the learners' needs, moving the classroom session up or down Bloom's taxonomy.

This approach to education is in alignment with andragogic methodology in its commitment to self-direction, relevance, and orientation to problem-based learning. (12) The FC approach allows adult learners to engage in knowledge acquisition when they are internally motivated, or as

needed, based on the relevance of the information to solve clinical problems. The FC allows the learner to participate in knowledge acquisition when it is most convenient for the individual based on internal motivation, clinical schedules, and personal or professional time constraints. The self-directed learner can review assigned materials as many times as necessary to fully understand a concept.

Although there are many benefits of learning in an FC, transitioning to an FC model can be challenging for both learners and educators. The FC is most effective when learners have completed their prework and are prepared to participate actively in classroom-based discussions. This differs from the traditional didactic model where learners are dependent on educators for knowledge acquisition and class preparation is rarely necessary. Ensuring that busy learners are prepared for class can be challenging and requires learners to have internal motivation.

Effective FCs require educators to create a safe learning environment where learners can ask questions of their

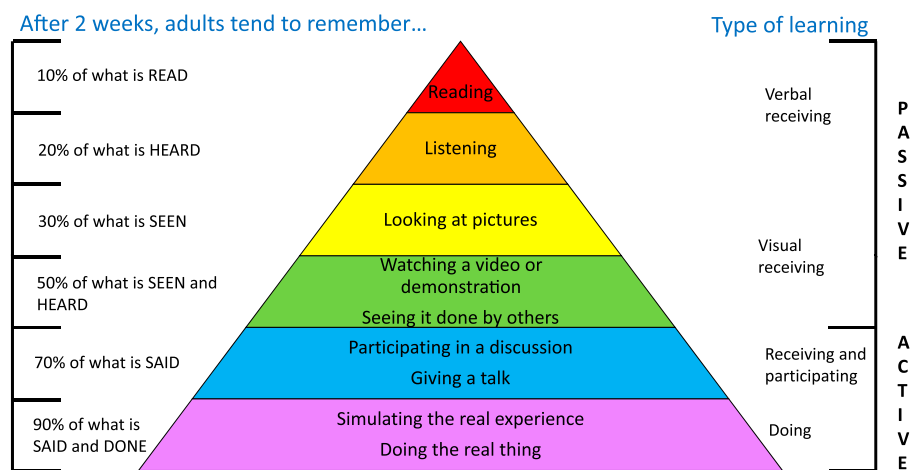


Figure 2. Modified cone of learning based on the original research by Edgar Dale. [5]

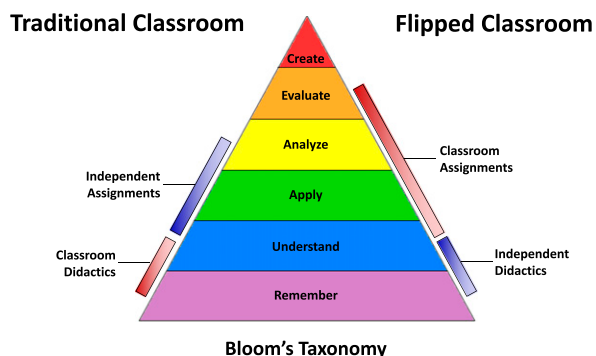


Figure 3. Learning in traditional vs flipped classroom and Bloom's taxonomy.

peers and the educator to clarify concepts. Thus, educator preparation is equally important. Because of the more free-form structure of class time, questions can be asked that expose holes in the educator's knowledge. The educator must be prepared to participate in information gathering during class alongside the learners. Educators must also be prepared to adopt new educational modalities and teaching styles. In the FC, an educator becomes a facilitator of group discussion and asks probing and open-ended questions that promote critical thinking and application of knowledge gained from independent knowledge acquisition. For this to be successful, educators act as a "guide on the side" instead of the traditional "sage on the stage." Making this transition to a new teaching approach can be difficult for some educators.

Converting educational materials into an FC model can be time intensive for educators, depending on the availability of prework activities. Prework activities can include assigned reading, videos, and podcasts. Classroom-based activities need to challenge learners but not be so difficult as to require significant educator explanation. Educator awareness of the learner's fund of knowledge is necessary to plan classroom exercises that reinforce existing knowledge and encourage application of that knowledge in new environments and situations. To encourage collaborative discussion with broad participation, rearrangement of the classroom setup from rows of chairs into a horseshoe or circular setup is beneficial.

### Educational Research and Analysis of FCs

The existing research associated with the FC approach has shown growth in both quantity and quality in recent years. A systematic review by Chen et al (9) demonstrated how initial studies on FC efficacy were broad and focused more on evaluating qualitative outcomes. The authors reviewed 9 controlled studies, 8 of which included medical students

and 1 involved interns, and concluded that students preferred the FC training method over traditional didactics. (9) However, effects on learning were inconsistent and more studies were deemed necessary. No studies involved subspecialty fellowship learners.

The past few years have shown a rapid increase in research using the FC approach for GME. The growing body of literature suggests popularity of this method among trainees and wide consensus from educators that more rigorous research is needed to determine whether there is evidence for or against the use of FC in medical education. Specifically, studies have shifted from outcomes relating to learner satisfaction or descriptive data to evaluation of knowledge and performance. The metric often evaluated for improved knowledge and performance is immediate posttest scores. Residents in emergency medicine (13) and internal medicine (14) had improved immediate posttest scores with the FC approach. Though promising, the next question posed by educators was whether these effects were sustained. Studies involving residents in internal medicine (14) and anesthesiology (15) demonstrated that improved knowledge acquisition was sustained after several months. Furthermore, one study demonstrated that application of the FC approach to an anatomy course resulted in higher performance both in anatomy and in a subsequent kinesiology course, demonstrating long-term retention and transfer of critical thinking skills to subsequent courses. (16)

Physiology education is an area of study that can benefit from spending class time on clinical application rather than a traditional lecture. FC was shown to be highly effective for reinforcing concepts in cardiovascular, respiratory, and renal physiology as medical students scored significantly higher on standardized examinations. (17) An FC physiology curriculum applied to neonatal-perinatal medicine (NPM) fellowship programs was preferred by both fellows and educators over traditional physiology lectures. Faculty who participated in those FCs found the educational experience to be an effective, useful, and efficient method to apply learning in a supportive environment. (10)

There still remain some mixed results about improved long-term outcomes with use of the FC approach. However, some authors argue that discrepancies in outcomes could be more of a reflection of assessment questions being poorly calibrated to test at high cognitive levels based on Bloom's level of cognition. (18) Regardless, the literature consistently suggests that learners and educators prefer FC methods over traditional didactics. Such findings at least warrant a reevaluation of educational methods for GME curricula and whether they facilitate andragogy.

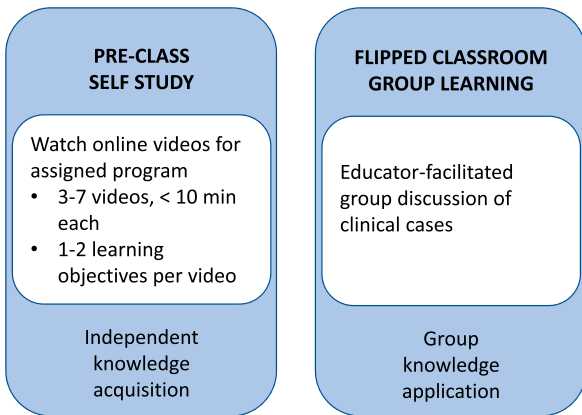


Figure 4. The National Neonatology Curriculum (NNC) flipped classroom approach.

### The National Neonatology Curriculum

In 2016, the Organization of Neonatal-Perinatal Medicine Training Program Directors (ONTPD), NPM fellowship program directors (PDs) and associate PDs reviewed their shared concerns about the development, maintenance, implementation, and effectiveness of educational materials. The group created the ONTPD National Neonatology Curriculum Committee (NNCC) to standardize educational materials with a high-quality physiology curriculum that provided accessible, evidence-based teaching for all NPM fellowship training programs using an FC model. As a first step, the NNCC surveyed PDs and associate PDs nationally to determine their interest in FC education, perceived barriers to FC for neonatology education, and to confirm that physiology was an appropriate initial target for piloting the FC approach. In addition to enthusiasm for the FC project, this survey identified a significant need for educational modalities to address gaps in the quality of fellow education, demands on faculty time, and learner and educator engagement in the learning community.

The NNCC uses high-quality, peer-reviewed educational materials in the form of online videos for independent knowledge acquisition paired with the FC approach for knowledge application. Using the American Board of Pediatrics (ABP) content specifications outline for NPM, programs covering different physiology topics (ie, respiratory distress syndrome, pulmonary function testing) were created by a content expert (neonatologist, perinatologist, or another pediatric subspecialist) and subsequently peer-reviewed/edited by 3 to 4 academic faculty from across the United States. Each program contains 3 to 7 online videos that are short (<10 minutes in duration) and cover 1 to 2 learning objectives each (Fig 4). These online videos are accessible on both desktop and mobile platforms at [www.MedEdOnTheGo.com](http://www.MedEdOnTheGo.com) using the search term “Neo Flip.” This educational delivery system allows learners to acquire knowledge at the place and time that best suits their learning needs. The videos can be watched multiple times to allow for thorough knowledge acquisition at an individual pace. Each program is paired with a “flipped classroom guide” for interactive classroom discussion and clinical problem solving facilitated by a faculty educator. The FC guide is case-based to place educational content into a clinical context. The guide can easily be individualized based on local or institutional practice and the complexity can be scaled to meet the needs of individual learners.

To date, programs covering respiratory and gastroenterology/bilirubin physiology topics have been completed. Programs in maternal-fetal medicine, neurology, and neurodevelopment are under development. The NNCC has a goal to complete the development of all topics covered by the ABP content outline in NPM within the next 5 years. In addition, an extracorporeal membrane oxygenation course will soon be available. An NPM simulation curriculum is

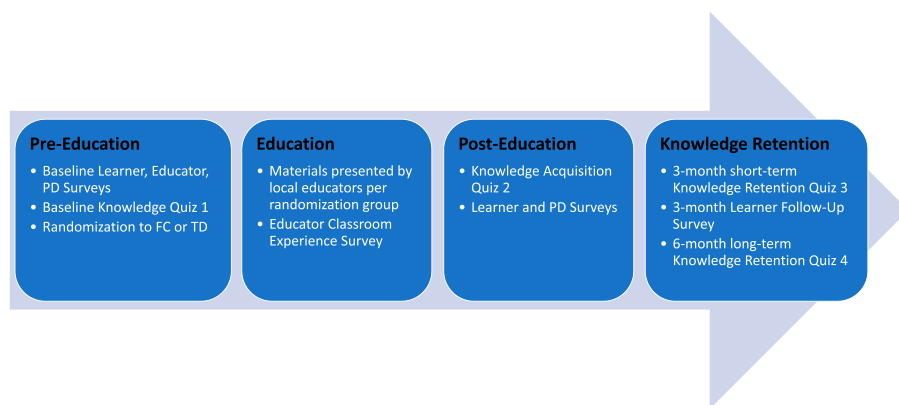


Figure 5. NNC Randomized Controlled Trial Timeline. PD=program director; FC=flipped classroom; TD=traditional didactic.

also under development, and many simulation exercises will help reinforce key physiologic concepts.

### The ONTPD NNC Randomized Controlled Trial

The ONTPD NNCC is committed to rigorous educational research to determine the best approach to fellowship education on a national level. Following a successful pilot (10) and roll-out of the respiratory physiology section (11) of the NNC, a randomized controlled trial (RCT) was launched to study the FC approach for NPM fellow physiology education. The NNC RCT aims to compare knowledge acquisition and retention of fellows taught neonatal gastroenterology and bilirubin ABP NPM board content via the FC approach with those taught using a traditional slide-based didactic approach.

To ensure that the trial could answer important questions about the impact of the FC model, the educational content was standardized across groups but delivery of the material varied. Knowledge acquisition, a primary goal for fellows attending physiology teaching, is being measured via multiple choice questions directly mapped to the learning objectives of the curriculum. Although performance on multiple choice tests does not provide a full picture of an individual's knowledge about a topic, it does closely align with an important performance metric for fellows: performance on the subspecialty in-service and board examinations. (19) Measuring test performance before and right after a series of educational conferences allows for timely collection of other measures of curriculum performance (Fig 5).

NPM learners, educators, and fellowship PDs all provided information on their educational practices and preferences before and after the NNC trial content was taught. Baseline usage of different education modes and ratings of fellowship education will allow for cross-sectional analysis of the variation in educational practices across NPM fellowships. An assessment of barriers to teaching core topics, measures of time investment, and the relative importance of different qualities of the educational environment will provide important information to understand how a national curriculum can best address the needs of both adult learners and educators.

All knowledge degrades with time but learning theory holds that knowledge more deeply understood at the time of acquisition will degrade at a slower rate. (12) To evaluate whether the initial educational modality affects knowledge retention and degradation, the NNC RCT includes follow-up knowledge assessments 3 and 6 months after the educational intervention. Understanding the pattern of knowledge retention in fellow level learners will further help to

inform educational programs that support the mission of developing neonatologists with a deep understanding of physiology and the skills to remain lifelong learners.

## American Board of Pediatrics Neonatal-Perinatal Content Specifications

- Understand the basic principles of adult learning theory (eg, adult learners are self-directed, goal-oriented, practical; need to feel respected, build on life experiences; learn best when learning is based on an existing framework).
- Understand the attributes of an effective learning environment.
- Understand the importance of "reflective practice" in teaching and learning.
- Identify strategies that motivate learners.
- Understand the strengths and weaknesses of various teaching methods (eg, lecture, small group discussion, bedside teaching, simulation).
- Understand that individuals may learn more effectively with certain teaching methods (eg, reading, hearing, doing) than with others.
- Recognize the strengths and weaknesses of various educational outcome measures (eg, participant satisfaction, acquisition of knowledge and skills, behavioral change, patient outcomes).
- Understand the role of needs assessment in educational planning.

## References

1. Knowles MS. *Andragogy in Action: Applying Modern Principles of Adult Learning*. San Francisco, CA: Jossey-Bass; 1984
2. Kaufman DM, Mann KV. Teaching and learning in medical education: how theory can inform practice. In: Swanwick T, ed. *Understanding Medical Education: Evidence, Theory and Practice*, 2nd ed. West Sussex, United Kingdom: Wiley Blackwell; 2014
3. Merriam SB, Caffarella RS, Baumgartner LM. *Learning in Adulthood: A Comprehensive Guide*, 3rd ed. San Francisco, CA: Jossey-Bass; 2007
4. Taylor B, Kroth M. Andragogy's transition into the future: meta analysis of andragogy and its search for a measurable instrument. *J Adult Educ*. 2009;38(1):1-11
5. Dale E. *Audiovisual Methods in Teaching*. 3rd ed. New York, NY: Holt, Rinehart, and Winston, Inc; 1969
6. Nasca TJ, Philibert I, Brigham T, Flynn TC. The next GME accreditation system: rationale and benefits. *N Engl J Med*. 2012;366(11):1051-1056
7. Young TP, Bailey CJ, Gupta M, Thorp AW, Thomas TL. The flipped classroom: a modality for mixed asynchronous and synchronous learning in a residency program. *West J Emerg Med*. 2014;15(7):938-944
8. Bloom BS. *Taxonomy of Educational Objectives: The Classification of Educational Goals*. New York: Longmans, Green; 1956

9. Chen F, Lui AM, Martinelli SM. A systematic review of the effectiveness of flipped classrooms in medical education. *Med Educ.* 2017;51(6):585-597
10. French H, Gray M, Gillam-Krakauer M, et al. Flipping the classroom: a national pilot curriculum for physiology in neonatal-perinatal medicine. *J Perinatol.* 2018;38(10):1420-1427
11. Izatt S, Gray M, Dadiz R, French H. Development and implementation of a national neonatology flipped classroom curriculum. *J Grad Med Educ.* 2019;11(3):335-336
12. Knowles MS. *The Modern Practice of Adult Education: From Pedagogy to Andragogy*. 2nd ed. New York: Cambridge Books; 1980
13. Rose E, Claudius I, Tabatabai R, Kearl L, Behar S, Jhun P. The flipped classroom in emergency medicine using online videos with interpolated questions. *J Emerg Med.* 2016;51(3):284-291.e1
14. Graham KL, Cohen A, Reynolds EE, Huang GC. Effect of a flipped classroom on knowledge acquisition and retention in an internal medicine residency program. *J Grad Med Educ.* 2019;11(1):92-97
15. Martinelli SM, Chen F, DiLorenzo AN, et al. Results of a flipped classroom teaching approach in anesthesiology residents. *J Grad Med Educ.* 2017;9(4):485-490
16. Day LJ. A gross anatomy flipped classroom effects performance, retention, and higher-level thinking in lower performing students. *Anat Sci Educ.* 2018;11(6):565-574
17. Tune JD, Sturek M, Basile DP. Flipped classroom model improves graduate student performance in cardiovascular, respiratory, and renal physiology. *Adv Physiol Educ.* 2013;37(4):316-320
18. Morton DA, Colbert-Getz JM. Measuring the impact of the flipped anatomy classroom: The importance of categorizing an assessment by Bloom's taxonomy. *Anat Sci Educ.* 2017;10(2):170-175
19. Althouse LA, McGuinness GA. The in-training examination: an analysis of its predictive value on performance on the general pediatrics certification examination. *J Pediatr.* 2008;153(3):425-428