

Medical Student Education

“Flipping” the Introductory Clerkship in Radiology:

Impact on Medical Student Performance and Perceptions

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Rationale and Objectives: Among methods of “blended learning” (ie, combining online modules with in-class instruction), the “flipped classroom” involves student preclass review of material while reserving class time for interactive knowledge application. We integrated blended learning methodology in a “flipped” introductory clerkship in radiology, and assessed the impact of this approach on the student educational experience (performance and perception).

Materials and Methods: In preparation for the “flipped clerkship,” radiology faculty and residents created e-learning modules that were uploaded to an open-source website. The clerkship’s 101 rising third-year medical students were exposed to different teaching methods during the course, such as blended learning, traditional lecture learning, and independent learning. Students completed precourse and postcourse knowledge assessments and surveys.

Results: Student knowledge improved overall as a result of taking the course. Blended learning achieved greater pretest to post-test improvement of high statistical significance (P value, .0060) compared to lecture learning alone. Blended learning also achieved greater pretest to post-test improvement of borderline statistical significance (P value, .0855) in comparison to independent learning alone. The difference in effectiveness of independent learning versus lecture learning was not statistically significant (P value, .2730). Student perceptions of the online modules used in blended learning portions of the course were very positive. They specifically enjoyed the self-paced interactivity and the ability to return to the modules in the future.

Conclusions: Blended learning can be successfully applied to the introductory clerkship in radiology. This teaching method offers educators an innovative and efficient approach to medical student education in radiology.

Key Words: Flipped classroom; blended learning; radiology education; clerkship; e-learning.

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The current model of medical education in the United States has been challenged in recent years on issues of quality and efficiency. In Cooke’s 2010 publication, which has been dubbed “the second Flexner Report,” shortcomings of the current system are described in terms of inefficiency, inflexibility, and lack of learner centeredness (1). Many of the ongoing efforts for curriculum reform reflect a shift from the current teacher-centered product-based approach to a learner-centered process-based approach to medical education (2). In recent years, the “flipped classroom” (FC) model has become a leading strategy to facilitate this

transition from passive to active and more integrated learning. This method, also referred to as “blended learning,” uses the delivery of instructional content before class (eg, videos and readings), with class time reserved for interactive application of knowledge (case-based learning, audience response activities) (3,4). In effect, the educator’s role shifts from one of dispenser of information to facilitator of learning (5,6). Since the development of the Khan Academy in 2006, the use and efficacy of FC in nonmedical education have been well established (1). However, there is limited evidence on the utilization of this teaching format in medical education, and none so far to our knowledge in the setting of a radiology clerkship for medical students (7,8). Therefore, the purpose of this study is to determine the effectiveness of “flipping” the introductory clerkship in radiology.

Acad Radiol 2015; ■:1–8

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<http://dx.doi.org/10.1016/j.acra.2014.11.003>

MATERIALS AND METHODS

Course Description

The introductory clerkship in radiology at our institution is a subset of a larger Introduction to Medicine Clerkship.

Medical students are enrolled in this clerkship between their second and third years before clinical rotations. The current class had 101 students. The curriculum design for our clerkship was based in large part on the Alliance of Medical Student Educators in Radiology National Medical Student Curriculum in Radiology (9). For this iteration of the clerkship, we were allotted 12 hours of teaching time over 3 days. Because of time constraints, this allotment had been reduced from prior years, in which we were allotted 20 hours of teaching time. Clerkship administrators requested that we omit pediatric radiology and women's imaging from the didactic portion of the course (due to the incorporation of these subjects in subsequent third-year clinical rotations), so we decided to teach these subjects entirely via online learning modules (independent learning group).

Our initial focus in creating online modules and RadCasts involved three subject areas: musculoskeletal, abdominal, and cardiothoracic imaging. These three subjects were taught using the blended learning model, which involved student viewing of short videos online before coming to class, followed by interactive in-class activities.

The remaining subjects were taught via traditional didactic lectures that were approximately 50 minutes in length (lecture learning group): interventional radiology, general imaging modalities, radiology safety, and neuroradiology.

The first day of class began with a brief introduction to the field of radiology followed by a course overview, in which the FC model was explained to the class and student expectations were reviewed. The students were also given a study schedule for completion of the e-learning modules. This introduction was followed by a review of imaging modalities (x-ray, computed tomography, magnetic resonance imaging, and ultrasound), including basic concepts in image acquisition and appropriate use of imaging. Over the remainder of the course, the students were introduced to subspecialty topics in radiology. For the full course schedule, please refer to [Appendix 1](#).

Offloaded Content

For several months before the clerkship, faculty and residents from the Weill Cornell Department of Radiology participated in the creation of a variety of e-learning modules in the form of RadCasts, RadTutorials, RadGames, and an interactive simulator.

RadCasts

These short Microsoft PowerPoint 2010 presentations (10–15 minutes) provide review of a clinical approach to common imaging examinations with self-assessment questions at the end. These RadCasts were recorded using BSR screen recorder, version 6, and Camtasia Studio, version 8. Audio and video components of these video lectures were optimized using Adobe Cloud CS7; Xilisoft Video Converter Ultimate,

version 7; VideoPad editor 3.55; and PowerDirector 12 software. These “RadCasts” files were then converted to HyperText Markup Language (HTML/HTML5) using Articulate Storyline Update 5. They were then uploaded to our open source website (create-rad.com) using Amazon Web Services (AWS) S3 with hosting through Squarespace.com and Vimeo.com, using iframe integration.

RadTutorials

These tutorials review imaging evaluation of a specific clinical condition or specific patient population. These RadTutorials were created using Microsoft PowerPoint 2010 and converted to HTML/HTML5 using Articulate Storyline Update 5. They were then uploaded to our website using Amazon Web Services (AWS) S3, with hosting through Squarespace.com using iframe integration.

RadGames

We created an interactive learning module containing chest diagnoses called *Game of Unknowns*. This module was created using Microsoft PowerPoint 2010 and converted and uploaded in similar fashion as the RadTutorials.

Interactive Clinical Anatomy and Radiology Utilization Simulator

The Interactive Clinical Anatomy and Radiology Utilization Simulator (ICARUS) is a program currently in development by the author, which fosters problem-solving skills using a simulation platform that teaches basic radiologic anatomy, appropriateness in imaging, and basic image review. Four ICARUS modules were used during the radiology clerkship. The framework for these modules was created using Microsoft PowerPoint 2010. Modules were then converted to HTML/HTML5 using Articulate Storyline Update 5. They were then uploaded to our website using Amazon Web Services (AWS) S3 with hosting through Squarespace.com and Wistia.com using iframe integration.

In-class Student-centered Learning

Faculty members teaching the in-class component of this course were given the e-learning resources that students would use before the class and were asked to have the students apply this knowledge during the interactive class session. Lectures were taught with a case-based approach, and student participation was encouraged with open-ended questioning and use of the Turning Point audience response system. Faculty-led workshops using interactive games and radiology simulator were held in the computer lab with approximately 30–35 students per group. A final review session in *Jeopardy* format at the end of the course encouraged team-based learning.

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