# Online Learning Tools as Supplements for Basic and Clinical Science Education

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**ABSTRACT:** Undergraduate medical educators are increasingly incorporating online learning tools into basic and clinical science curricula. In this paper, we explore the diversity of online learning tools and consider the range of applications for these tools in classroom and bedside learning. Particular advantages of these tools are highlighted, such as delivering foundational knowledge as part of the "flipped classroom" pedagogy and for depicting unusual physical examination findings and advanced clinical communication skills. With accelerated use of online learning, educators and administrators need to consider pedagogic and practical challenges posed by integrating online learning into individual learning activities, courses, and curricula as a whole. We discuss strategies for faculty development and the role of school-wide resources for supporting and using online learning. Finally, we consider the role of online learning in interprofessional, integrated, and competency-based applications among other contemporary trends in medical education are considered.

**KEYWORDS:** undergraduate medical education, online learning, flipped curriculum, instructional videos, faculty development

## Introduction

The past decade has seen a remarkable proliferation in the use of online learning in many areas of education. A 2015 survey of online learning in US higher education showed that more than one in four (5.8 million) students took at least one distance or online education course.[1] Online learning in the health professions has increased dramatically as evidenced by the trend in published studies over the past decade. A PubMed© search of the combined terms *online learning* and *medical education* yielded 736 publications for the five years of 2011–2015, compared with 380 between 2006 and 2010 and 143 between 2001 and 2005. These figures certainly represent just a fraction of the online learning resources being applied in many of the health profession educational programs since only a small number of these are likely to appear in publication. Educational programs utilize online learning for many of these disciplines, including medicine, dentistry, nursing, and health technology among others. Furthermore, the health professions utilize online learning technologies to train learners at all educational levels, including undergraduate, graduate, and postgraduate trainees. In some instances, online learning stands alone as the core, primary curriculum of a program. More commonly, online learning tools are components of the curriculum, supplementing traditional face-to-face classroom and clinical educational activities.

For the purpose of this report, we define online learning as computer-based instruction that students typically access over the Internet from a desktop or mobile device, outside of the physical classroom or other traditional learning environments. There are many modalities of online learning, each with a spectrum of educational applications. Moreover, each variant requires consideration of different strategies for integration into courses and the broader curriculum. The growing availability of these enticing tools opens up new educational opportunities and leads to an expectation that educators and educational administrators will incorporate online learning into their curricula. However, the development of *best practices* for these tools is still in its infancy. Educators need guidance to help them select online learning modalities to utilize in different educational contexts and to integrate them effectively into individual courses and across the curriculum.

While online learning has many applications in health professional education, the focus of this article is on online learning as a supplement to instruction in undergraduate medical education. We will consider online learning over the full scope of undergraduate medical education, in both basic and clinical sciences, supplementing education that takes place both in the classroom and in the clinical setting. Our aim is to explore the advantages and challenges of using online learning for medical educators and educational administrators. Our primary focus will be to explore the important elements to consider for the successful and efficient application of online tools and their integration into curricula.

The next section will present an overview of online learning modalities available and selective examples of their applications. We will describe the advantages of supplemental online learning in general as well as examples of specific online learning modules to highlight opportunities afforded by integrating particular modalities into the curriculum. Following this overview of various online modalities, we will examine pedagogical and practical challenges posed by integrating online learning into individual learning activities, courses, and the overall curriculum. Though still in its infancy, faculty development in the application and production of online learning resources is important for success. We will consider approaches to faculty training as well as the challenges of online learning implementation and quality control in a school's broader curriculum. Finally, we will consider future directions for research and resource development in online learning in the context of contemporary trends in medical education.

## Diverse Modalities and their Advantages and Challenges

Online learning may take several forms in delivering and supporting curricula. At the most basic level, online learning resources may simply provide a mechanism for learners to engage asynchronously with content delivered in a lecture in either video or audio form. This form of content delivery, often referred to as a podcast, can be used to reexamine areas of a lecture that may have seemed unclear or to deliver content in lieu of a classroom presentation. Alternatively, online resources may be explicitly integrated or blended with in-class activities, as in the flipped curriculum approach where students interact with videos, audio clips, or readings prior to a classroom session to provide core knowledge and content that informs applications during the in-class session. Finally, online learning may provide the full mechanism for delivering and assessing knowledge and skills as occurs with massive open online courses (MOOCs).

There are advantages and strengths common to all types of online learning, and some particular to certain modalities. One fundamental advantage is the suitability of online learning applications to the current generation of learners. The so-called *Millennials*, with birth years from the early 1980s to early 2000s, have been termed *digital natives* having grown up and developed intellectually and socially in the context of digital technology. This generation of learners appreciate and perhaps expect the flexibility of interacting with educational material when they want, at their own pace, and according to their interests. A related advantage is the opportunity for students to engage with these tools according to their individual learning needs. With online materials, students can titrate the time that they spend mastering content to match their own learning needs and developmental milestones. In addition, educators can embed hyperlinks to additional remedial content in online learning modules to meet the educational needs of students having difficulty with foundational knowledge. On the other end of the learning spectrum,

embedded hyperlinks to more advanced content can support *Deep Dives* into areas for students seeking a greater depth of knowledge, understanding, or skill development. Of note, students will often search online education materials regardless of whether a particular course offers them. A common concern is whether these self-identified online materials meet pedagogical and content standards of the school or instructor.

Multimodal pedagogies that blend online audio and video learning tools with in-class didactic activities can be particularly effective in enhancing the learners' engagement and enrich opportunities for both the acquisition and application of knowledge and skills in both basic and clinical science learning. For example, Prober and Kahn[2] have recently advocated for the use of 8–10 minutes online videos to deliver *evergreen* content to medical students in core areas of the basic science curriculum. They define evergreen content as foundational knowledge that is accepted as factually true. This online exposure to core content and knowledge outside of the classroom prepares the learner for faculty-facilitated interactive classroom discussions focused on the application and mastery of the video-delivered content. This flipping of the classroom has seen widespread adoption and successful integration into K-12 educational curricula[3,4] and is now finding its way into the educational domain of professional schools.[5–7] This pedagogy has the advantage of allowing students to engage the basic knowledge and facts of an area or discipline in accessible and brief videos, at their own pace and over as many viewings as needed for mastery. This also enables the faculty to maximize time with the students focused on modeling and encouraging interactive discussions helping students to acquire and use paradigms and strategies for applying facts and knowledge needed in the clinic and laboratory. Thus, the emphasis in this paradigm is to shift the acquisition of knowledge and skills to time outside the classroom and to utilize in-class time for training in the application of these skills and knowledge.[8] For example, at our school, the Yale School of Medicine, prior to conducting dissections in the human anatomy course, students are encouraged to view videos to understand core terminology and see regional cadaver dissections. This familiarity with the maneuvers and terminology that they will be expected to apply in their own dissections removes some of the uncertainty with the procedures and allows faculty to focus on more advanced discussions of structure, function, and three-dimensional relationships during the actual laboratory session. Similarly, a published study of the use of online materials and a flipped classroom model in the training of graduate learners in the acquisition of cardiovascular, respiratory, and renal physiology has demonstrated the effectiveness of this blended learning approach in motivating learners and in their retention of key physiological concepts and knowledge.[5]

One of the challenges for this approach is deciding whether students are required to view the videos before a session or whether to treat the videos as a one of many resources available for mastering the preparatory content. While videos may be an effective content delivery mechanism for many learners, a

subset of students may acquire core knowledge and terminology better from other materials such as books, or nonvideo web resources. Careful thought needs to be put into how unique and necessary is the video content to what will actually occur in-class. For example, can the same goals be accomplished by providing students with multiple options for class preparation that could include a packet of written notes, a chapter in a text, or an online video? Finally, if videos are constructed in a way that their viewing is essential for participation in classroom-based activities, it may be necessary to monitor student-viewing habits to encourage compliance and to have confidence that students are adequately prepared for the application and analysis of knowledge that will occur in the classroom.

In the clinical sciences, a blended learning approach can facilitate the learning of clinical skills and provide students with greater confidence and knowledge to prepare them for when they are required to apply these skills on real or simulated patients. For example, online instruction in clinical skills with video displays of an examiner and patient allows for depictions that may not be readily feasible in the classroom, clinic, or hospital room. Using this approach, students can observe the appropriate application of physical examination skills in videos and review them as often as needed to prepare them for their own application of these skills with real or simulated patients. Video depictions of physical examination maneuvers combined with an instructional voice overlay can be used to expose students to modeled performance and the ability to rewind for closer inspection and repeat viewing. Video displays of clinical findings, such as abnormalities seen on physical examinations, are much richer than a still photograph in a book, and when aligned with voice, overlay can effectively highlight physical examination maneuvers and key learning points. In addition, this approach is especially valuable for exposing learners to uncommon physical examination findings that students may see only rarely during their time in a particular clinical setting or rotation. Using this methodology to provide exposures to important, but infrequently seen patient cases, allows for the convergence of the triad of the learner, the patient with the particular physical examination finding (video), and the most appropriate instructor.

In communication skill education, educators can utilize different modalities of online learning for basic or advanced communication skills training. For example, at our school, educators deliver brief online audiovisual lectures to teach the basic components of the medical interview to prepare students for standardized patient workshops to practice these basic skills. For more advanced communication skills, video depictions of real or simulated patient interviews can be developed to target learning of particular communication skills, which would not be feasible in real-time viewing, eg, challenging communication skills such as giving difficult news and taking a sexual history. Educators use these video demonstrations as *trigger tapes* and tools to promote analysis, reflection, and classroom discussion. Indeed, students reviewing these videos after their own

engagement with patients facilitate their reflection on areas of strength and weakness in their application of these skills.

Educators can develop online learning content to target individual learning needs by using interactive modalities that can provide some complexity around learners' thought processing. Branching logic programs built into modules promote an interactive approach to learn and practice clinical reasoning skills, while students appreciate the varying impact of sequentially acquired clinical data. For example, the CLIPP and SIMPLE computer-assisted pediatric and internal medicine cases developed by MedU[9] expose students to interactive and dynamic virtual patients that provide for realistic case-based learning and clinical reasoning. This allows students to practice these skills in a safe learning environment, at their own pace and with ample feedback to self-assess their mastery.

Educators can integrate online learning with both classroom and bedside learning in a variety of interesting ways. Online modules may follow face-to-face learning to reinforce or extend learning. Alternatively, as described earlier in the widely used *flipped curriculum* design, online learning allows students to acquire basic, foundational knowledge as preparation for face-to-face classroom or bedside learning.[2,10] This design can maximize the time spent and the quality of the educational engagement with expert educator(s) and with other students. Faculty can facilitate more dynamic, interactive learning sessions where students apply the new knowledge acquired via online materials using a variety of pedagogies such as problem-based learning, team-based learning, clinical simulation exercises, and patient encounters. This approach can be especially beneficial for learners with diverse educational or experiential backgrounds allowing them to master common terminology and basic knowledge that will facilitate greater participation in the interactive face-to-face learning activities. For example, we created a blended learning program comprising an online module followed by a live workshop to teach the interprofessional, spiritual, and cultural aspects of palliative care to medical, nursing, divinity, and social work students.[11] The online module was interactive, multimedia, and fostered accessibility and control over the content and pace of learning for these groups of highly diverse learners. The online module allowed students to gain familiarity with the subject readying them to interact meaningfully in the interprofessional simulation workshop.[11]

Among the challenges for undergraduate, medical education is the identification of foundational knowledge that all learners must acquire and deciding when to introduce certain elements in the curriculum to become most *sticky*. Tradition often dictates when, in the curriculum, elements of knowledge or skill are introduced and the limitations of curricular and faculty time often limit how often and in what depth content is delivered and revisited. For example, we often introduce the science of embryology and the impact of teratogens and growth factors during the preclinical phase of the medical curriculum, yet students will not experience the clinical manifestations of birth defects until several years later when

they are interacting with patients on their clinical rotations. Online content has the advantage of providing the basis for the initial exposure to specific foundational knowledge when students are mastering core concepts yet remains available for reinforcing these concepts at later points in training when learners are required to recall and apply these skills and knowledge in the clinical environment.

As more schools adopt curricula integrating basic and clinical sciences, strategic longitudinal deployment of online educational tools throughout the curriculum may provide reliable, accessible, and effective means for revisiting and reinforcing key concepts and skills along learning continuum. As schools and curricular leaders identify the foundational and *evergreen* areas of knowledge and skill needed by all health professional students, it raises the question of how and if online resources targeting this content should, or could, be shared across institutions. There are obvious advantages to this approach. First, it would allow health professional schools to focus more of their curricular efforts and faculty resources on higher order processes and skills related to clinical reasoning and critical thinking. Second, it could provide greater opportunities for emphasis in each schools' curricula for initiatives that are special or unique to their educational mission. However, there are many challenges to such an approach. The numerous textbooks available in medical education are testament to the lack of agreement on what is foundational in each discipline, or even the best approach to acquiring this knowledge. Furthermore, may faculty and students feel that the interpersonal interactions that occur in lectures and small groups are often where inspiration and modeling occur and movement of some of this to shared videos could reduce these opportunities.

Gathering academic and community clinical educators for faculty development in many areas of education has always been a major logistical problem. With its flexibility for individual schedules and learners' needs, online learning can help promote clinical faculty learning to disseminate standards in teaching approaches and content. Indeed, online modalities may be well suited to instruct and assist faculty to develop and skillfully incorporate online learning technologies in their own teaching activities. Our clinical skills course for preclerkship students relies on as many as 20 faculty instructors to facilitate small group sessions. The challenges of busy physician schedules often make it impossible to get all of these faculty into development sessions to coordinate instructional pedagogies and content delivery. As a result, the course leadership has developed a number of brief faculty development videos addressing areas such as the sensitive use of drapes/gowns during the physical examination, each component of the physical examination, and a series of videos in which they spell out the logistics for a particular session, ie, room setup, various skill stations, and timeline. Faculty can view these videos online prior to their sessions to ensure that all small groups are providing uniform instruction.

## Faculty Training and Curricular Considerations

One of the challenges that looms over a move toward online learning pedagogies and the use of video- and audio-based technologies is the recruitment, training, and support of faculty. Faculty tasked with educating students in the health professions increasingly find their time for educational activities limited by the accelerating pressures for time devoted to patient care and running and funding laboratories. Many of the technological skills required to develop effective online materials are not part of the typical faculty member's skill set. In addition, the faculty have often not been trained in how to structure and facilitate in-class and in-clinic activities that focus on the application of the knowledge and skills that students are exposed to in the online materials. If faculty are to be successful in using online and blended learning pedagogies, it is essential for curricular leaders to create support structures for training and faculty development that do not place unreasonable and unworkable additional pressures on faculty.

In making videos and other online materials, there is always the tension between the desire for high production and professional appearing products and the time, equipment, and expertise required to create these resources. Early decisions outlining the curricular goals for online learning are important in guiding faculty and making support decisions. For example, when thinking about the production of videos, one must consider a number of logistical and resource issues. Will faculty members make and edit their own videos? Will there be central resources such as studios and how will they be managed? How versatile or complex is the recording system, how are faculty trained, and finally, are resources available to guide faculty in creating effective and interactive videos? Each of these decisions will affect which, and how many, faculty will champion these new pedagogies, the effectiveness, and the impact of the materials they generate, and even the type and breadth of online formats they will adapt.

The versatility and complexity of the recording systems can dramatically influence engagement in several of these domains (Fig. 1). For example, greater versatility in editing, visual effects, and annotation often dramatically increases training requirements and the need for greater engagement by support personal. This may also increase the degrees of freedom available in the design and execution of video creation that can be attractive for the most innovative and committed educators but may create barriers for the typical faculty member without time to explore and learn the nuances needed to make decisions on the use of these options. Although the burden on faculty training and time using sophisticated and versatile recording systems can be somewhat offset by the availability of support personal, this can also restrict scheduling to times when support personal are available and may preclude faculty from scheduling and using the facilities based upon their own availability.

In addition to the importance of resources to support the production of online materials, equally important is faculty

**Figure 1.** Studio available for faculty within the Yale School of Medicine library. Pictured is Jaideep Talwalkar, the Director of the Yale School of Medicine Clinical Skills Program who creates videos for both student and faculty instruction and development. The simplicity of system allows faculty to generate their own videos without extensive technical help. Video production is done using PowerPoint, Keynote, or other applications running on an Apple computer with Camtasia video capture, editing, and production software. Annotation during the production of the video is done using a Wacom drawing tablet with video display. A high quality production boom mounted microphone is used to capture voice over narration.

development in effective and interactive design strategies that engage the learner. Among the principles that need to be communicated to online educators is that, as in good lecturing, a video must have a well thought out flow and organization and focus on a limited number of learning objectives. As we know from the literature,[12,13] adult learners have limited attention spans and active learning periods when sitting in the lecture hall, and we must assume that these constraints also exist for attending to online materials. Time spent watching videos, the level of engagement created by interactive video techniques, and how they complement learning in the clinic or classroom have a profound impact on the learner's willingness to view these materials and the information they take away. For example, using a flipped video approach to train PGY-2 and PGY-3 residents at Yale in electroencephalography interpretation, Moeller et al[14] reported that learners found that 6–16 minutes long videos were appropriate length and would be watched by the majority of participants. However, the longer videos might not be fully watched. Thus, educators unaware of these limitations may design online materials assuming that the learner will watch them like a movie from start to finish with equal focus and attention throughout.

As online video content assumes a greater role in guiding and preparing students for in-class discussions and problem solving, it will be important for educators and curriculum leaders to monitor the level of engagement of students with these resources prior to classroom sessions. Analytics focused on student viewing of online videos and the extent to which videos are completely or partially watched will be critical for assuring the success of classroom discussions based upon the higher order processes of applying, analyzing, and evaluating ideas and concepts[15] that will require students have a common knowledge base. These data may also be useful in guiding educators in selecting the types and format of video content and delivery that are most effective in engaging students and ensuring their preparation for classroom discussions.

This latter point also raises an important issue about our assumptions concerning how learners use these materials. While we often assume that the act of watching material in a video is consistent with learning the material, like any other form of content delivery, videos require the learner to engage actively in a way that most of us do not normally do when we watch a movie or TV show. Thus, we cannot assume that the learner will automatically engage with these resources in the ways we intend. Recent work at the K-12 level suggests that students may need training in the appropriate means of engagement with online materials to maximize their impact. To this end, Kirch[16,17] has advocated training students in active learning approaches for using video-based instruction.[14] Her Watch, Summarize, and Question paradigm makes students more effective and efficient learners when using video-based materials[14] and suggests that even our digital natives may need training to make optimal use of these emerging online pedagogies.

When faculty apply online tools and blended learning pedagogies in individual courses or instructional activities, there may be no need to require central oversight or impose standards of practice. However, if the curricular goal is to apply these pedagogies widely throughout a curriculum or as a foundational instructional method, it may be necessary to balance the educator's autonomy in their individual course with the need to ensure that the learners embrace and engage these learning tools appropriately. For example, if the level of preclassroom engagement required of the learner with online resources or the design and quality of the videos varies across courses, students may not only fail to learn what is expected of them but also judge future activities by the strengths or weaknesses of these initial exposures. If these initial experiences are not positive, they may disengage from these materials for all future courses. Therefore, it may be necessary to establish a limited number of universal standards for the use of online materials that are evidence based to maximize the effectiveness of these materials and sessions. These might include measures like restrictions on video length, standards for levels of in-video interactivity and assessment, guidelines on the balance of time spent engaging with online materials in preparation for classroom or clinic-based activities, and clear communication of the expectations on how online content informs classroom instruction and interactions. Currently, our institution does not employ such monitored standards; however, we do provide faculty producing curricular videos with a set of *Best Practice* guidelines (List 1), including some of the principles discussed earlier in this article, which faculty have found very useful.

**List 1.** Best Practices provided to Yale faculty producing curricular videos.

- Restrict video length to 8–15 minutes
- Focus on only a few concepts
- Provide learning objectives at the start of the video
- Add action using callouts, live drawing, animations, etc. to grab attention
- Use simple, slides/scenes with limited text
- Provide in-video quizzing
- Rehearse narration and annotations to limit post production editing
- Create explicit linkage between online and in-class activities for students

## Future Directions and Contemporary Educational Trends

We believe that it is no longer relevant to conduct research comparing traditional classroom with online learning supplemented instruction. The question is not whether to use supplemental online learning but what modalities to use and how to integrate them most effectively both at the individual course and curricular levels. Educators need evidence-based guidance for choosing and incorporating online learning modalities to achieve their learning goals and desired educational outcomes. Moreover, as explored in the previous section of this article, medical school educational administrators have much to consider in planning and implementing supplemental online learning over a broader curricular level. Dedicated application of scientific research and dissemination of shared resources (perhaps at a national level facilitated by the American Association of Medical Colleges) would certainly help advance these efforts.

What role can supplemental online learning play in other contemporary trends changing medical education? As mentioned earlier, online learning is likely to be an effective tool to make the connections between curricular components as schools work toward more robust vertical and horizontal curricular integration. As educators experiment with approaches to meeting the formative and evaluative needs of competency-based curricula, they may consider the specific use of online modalities for both learning and assessment. Educators now recognize the ability to work effectively on an interprofessional team as critical skill for medical education, and as shown in example above, supplemental online learning has particular advantages for preparing students for interprofessional educational activities. We also need thoughtful and creative consideration and experimentation as we begin to leverage online learning into both pedagogical content and approaches in the areas of social mission, community engagement, and health-care systems training.

We find ourselves at a time of major innovation in many areas of medical education. As perhaps with the introduction of any new technology, both the opportunities and potential pitfalls with online supplemental learning may seem larger than the reality will turn out. Nonetheless, the *cat is out of the bag*; online supplemental learning is happily here to stay, and our journey to discover how we can use it to benefit our students the best we can will be exciting and likely full of surprises.

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## Author Contributions

Wrote the first draft of the manuscript: MSE and MLS. Contributed to the writing of the manuscript: MSE and MLS. Agree with manuscript results and conclusions: MSE and MLS. Jointly developed the structure and arguments for the paper: MSE and MLS. Made critical revisions and approved final version: MSE and MLS. All authors reviewed and approved of the final manuscript.

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