Virtual Learning in Graduate Medical Education: Applying Learning Theory for Effective Educational Videos

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The COVID-19 pandemic and mitigation strategies to address it have drastically changed health care delivery, and graduate medical education (GME) has not been immune to these changes. In a short time, many papers were published describing methods to enable performing virtual physical examinations[1] and implementing virtual interviews.[2–4] However, less emphasis has been placed on facilitating the transition to virtual education. The use of educational videos has a long history in undergraduate medical education.[5–7] In this setting, educational videos have often served as a supplement or alternative to live sessions as well as a tool for a flipped classroom approach.[8] While there is limited evidence supporting the use of educational videos in GME,[9,10] articles have discussed their potential value to encourage higher learner attendance, share educational products among programs, and promote cross-national and international work.[11–15] Asynchronous videos offer both the convenience and consistency of content exposure,[16] regardless of training level, presenter ability, or clinical workload.

As virtual learning will likely continue after the pandemic ends, synchronous and asynchronous educational videos will continue to be a part of GME. Thus, it is important to discuss the development of evidence-based videos to ensure continued educational benefit from this format. While research on general educational theory application in GME is lacking, significant work has been done in undergraduate institutions and medical schools demonstrating the efficacy of these principles. Appropriate application of cognitive learning theory may support successful creation of educational videos and conversion from live to virtual formats.

Cognitive Learning Theory

Cognitive learning theory offers an evidence-based approach for educational video development and helps describe how internal and external factors influence a learner's ability to process information. Educators should design videos to manage cognitive load, maintain attention, facilitate schema construction, and promote engagement. We provide recommendations and practical examples for how to optimize educational video design using cognitive learning theory.

Cognitive Load

Cognitive load theory is a subset of ideas and principles underneath the umbrella of cognitive learning theory focusing on how information is processed through working memory.[17]

Three types of cognitive load have been studied: extraneous load, intrinsic load, and germane load.[18] *Extraneous load* describes processing that does not support the learning objective and may arise from outside distraction (ie, an uncomfortable or excessively busy learning environment or a poorly designed lecture). Minimizing extraneous load allows prioritization of intrinsic and germane loads. *Intrinsic load* describes the processing related to the inherent complexity of material. Reducing intrinsic load requires either decreasing the amount of information or simplifying it through the development of schemas, as discussed below. *Germane load* describes the processing required to organize new information into schemas for storage in long-term memory. Minimizing extraneous load and managing intrinsic load may free working memory for germane processing, allowing learners to better organize and absorb presented materials.

Recommendations for optimizing cognitive load when developing educational videos are found in the online supplementary data.[19–21]

Video Design

Structure

Videos should be brief to best maintain resident attention. While studies of attention spans during traditional lectures in chemistry and general

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undergraduate education have mixed results,[22,23] Guo et al specifically examined undergraduate video lectures, showing that length directly affected learner engagement time, with engagement defined as how long learners watched the videos and whether they attempted post-video questions. For videos shorter than 6 minutes, engagement was ~100%. Engagement was ~50% for recordings 9 to 12 minutes long, and for videos with a duration of 12 to 40 minutes, learner engagement was ~20%. Additionally, engagement improved when slides were interspersed with images of the lecturer's talking head and when a traditional "chalk talk" was used employing real-time annotation on the slides themselves, rather than PowerPoint slides alone.[21] When creating asynchronous educational videos for GME, consider breaking videos into shorter segments. The narrators of procedural videos can draw attention to aspects of setup or anatomy using annotation, and more traditional lectures (synchronous or asynchronous) can omit some text-filled slides completely and annotate on a blank slide in real time for a virtual chalk talk feel. Annotation tools are found in PowerPoint or virtual meeting hosting programs such as Zoom or WebEx. These tools also allow for participants in synchronous presentations to point out imaging abnormalities or list a differential diagnosis for a case.

Content

In addition to adjusting the main content to optimize cognitive load (as shown in online supplementary data), preparation of the video should utilize the concepts of schemas, interpolated testing, and interleaving.

In medical education, the construction of specific schemas, sometimes referred to as "illness scripts," assists in processing and remembering large blocks of information. A common schema in resident stroke education is a cranial nerve III palsy, learned as the "down and out pupil" with ptosis and mydriasis. This becomes a single concept rather than the memorization of each ocular muscle. By creating a specific schema for a condition, learners reduce the amount of working memory this information occupies, decreasing cognitive load and freeing up space in working memory to process other, more complex, information.[24] Thus, educational videos should contextualize the information based on recent patient encounters, lectures, or prior readings to facilitate the formation of a schema.

Utilizing questions during synchronous or asynchronous videos (known as interpolated testing) can promote resident attention and engagement.[25] The polling features available with some online platforms (Poll Everywhere, Zoom, Microsoft Teams, Mentimeter, DirectPoll) make questions easy to incorporate during live presentations.

Interpolated testing also allows for the use of *interleaving*, wherein the learning of different concepts or skills is mixed (interleaved) rather than learned in entirety prior to moving on to the next topic (blocked learning).[26,27] In GME, for example, interleaving is utilized when learning about management of cardiac patients while on non-cardiology services rather than only while on that rotation. Asynchronous educational videos inherently incorporate this principle, as residents and fellows can revisit topics or procedural techniques unrelated to their current rotation. Additionally, during synchronous sessions like journal clubs, grand rounds, and case presentations, review questions from prior lectures also employ interleaving. Questions can be completely unrelated to the topic at hand, or remotely related to refer to similar prior material, such as reviewing elbow conditions with similar pathophysiology during a knee injury talk.

Presentation

Narrator engagement with the lecture is paramount to promote learning. Along with the association between video length and attention, the narrator's speaking rate and enthusiasm directly correlate with learner engagement in studies of undergraduate students.[21] Videos that are more personal—with a narrator speaking quickly, conversationally, and with excitement—are preferred by students over less relatable "high fidelity studio recordings."[21]

Summarized recommendations for video design can be found in the BOX.

BOX Recommendations for Video Lecture Design

Structure

- Keep videos short and concise
- Display video of instructor along with slides
- Include "chalk talk" or annotated portions
- Use a personal atmosphere over professional studio approach

Content

- Incorporate schema formation
- Include interspersed questions
- Balance text and images on slides

Presentation

- Narrate quickly
- Speak with enthusiasm
- Use a conversational tone

Conclusions

Although a rapid transition to virtual education platforms was necessitated by the COVID-19 pandemic, virtual learning will likely be utilized even as in-person gatherings resume. GME programs are already suggesting continued educational videos for shared program didactics or national lecture series.[12,13] To maintain the same attention, engagement, and effectiveness as in-person talks, educators should apply learning theory principles when designing educational videos for GME. While this can seem daunting, adapting cognitive learning principles to virtual formats is feasible and may enhance the educational experience for trainees.

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