Effective Educational Videos in Emergency Medicine

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ABSTRACT

Video is a popular format for teaching and learning online. Emergency medicine (EM) has been a leader in online learning and EM educators may wish to use video to teach. The creation of online video content is fraught with pitfalls that may make videos less effective. We review notable theory and evidence regarding effective use of video for education in EM with international considerations.

Emergency medicine (EM) has been a pioneer in the creation and dissemination of online resources for learners.¹ Video, in various forms, is a common modality for online teaching. The nature of EM puts educators in a unique position to produce videos on a breadth of topics, which may impact patient care both inside and outside of the specialty. With globalization and the continued spread of the internet, EM educators can have a worldwide educational reach.²

While online resources proliferate, debate continues about their value.^{3–7} Guides exist for making educational videos more effective and easier to produce.^{8–10} Reviews of educational theory as it applies to video production also exist.^{11,12} We aim to offer evidence- and theory-based strategies for the EM educator who wishes to pursue effective video production.

METHODOLOGY

The writing group consisted of four EM physician educators with mutual interest in creating and using video. We set out to create a narrative review, which inherently reflects author biases, so we find it important to describe our backgrounds.¹³ Drs. Thomas and Guptill are members of the Global Emergency Medicine Academy

(GEMA), a community within the Society for Academic Emergency Medicine (SAEM) that aims to improve the global delivery of emergency care through research, education, and mentorship. Drs. Young and Mellick are EM educators interested in creating educational videos, especially those related to technical skills. Dr. Mellick has a popular YouTube channel with over 170,000 subscribers (www.youtube.com/user/lmellick).

We sought to answer the question, “How does the EM educator make effective educational videos recognizing a global audience?” We reviewed existing literature on the principles of cognitive theory as it relates to learning from video, including in cross-cultural or low-resource settings. We searched PubMed/MEDLINE, Google, and Google Scholar for appropriate sources from 1960 to July 2018, restricting language to English. Keywords/key phrases included “video,” “teaching video,” “educational video,” “instructional video,” and “video production.” We hand-searched reference lists to find additional citations to review. The authors also brought personal resources for group consideration. The resulting sources were assessed for relevance, with group consensus determining which to include in this review. We focused on information that we considered most pertinent to teaching video

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types common to EM. Using the data abstracted, we developed an overview of educational video creation in EM with specific recommendations.

CURRENT STATE OF KNOWLEDGE ON THE TOPIC

Cognitive Theories of Learning

Modern learning theory can inform EM teaching best practices using video. “Working memory,” a term coined in 1960, is fundamental to learning.¹⁴ Working memory is essentially conscious attention, which is limited in the amount of information it can process at one time. Working memory creates “schema” that are held in long-term memory to allow humans to make sense of the world. Learning is the process of creating schema.¹⁴ Cognitive Load Theory states that at any given moment in time, working memory is burdened by three types of cognitive load (Figure 1).¹⁵ Intrinsic load is inherent to the information that is being processed and is defined by its complexity. Germane load is cognitive load that effectively contributes to schema development (i.e., learning). Extraneous load is information that requires mental work to process but does not assist in schema development. With this in mind, an educator can design experiences that maximize learning by carefully considering and monitoring each type of cognitive load and by avoiding overload. Mayer and colleagues used their study of cognitive load to develop their Cognitive Theory of Multimedia Learning.^{16,17} Select principles and techniques are presented in Table 1.

Teaching Video Styles

An educator may consider popular formats currently in use when selecting a video style (Table 2). Khan Academy (www.khanacademy.org) style videos merit special

consideration. Students enrolled in online math courses engaged longer with Khan-style problem-solving tutorials and attempted a postvideo problem more often than with videos derived from PowerPoint slides.¹⁸ While they require specialized equipment to produce, the resulting videos may be attractive to EM learners because of their resemblance to medical “chalk talks.”

Video Length

Video length can impact student engagement. Studies of business and YouTube videos found steep engagement drop-offs at 2 to 6 minutes, with a steeper, faster initial drop-off for videos with longer total run times.^{19–21} Guo and colleagues found a maximum median engagement time of 6 minutes for students in online math and science courses.¹⁸ When students earned certificates, engagement still dropped off after 6 minutes, but less sharply, indicating that the incentive of a certificate may mitigate drop-off.²² It is advisable to make videos as short as possible and under 6 minutes whenever feasible.

Video Perspective

Educational videos may be three-dimensional, flat, or a mix of the two. Khan Academy-style videos, explainer videos and screencasts are typically two-dimensional. A flat image helps focus attention on a complex concept, which may reduce extraneous load. For live-action video, camera perspective, or angle of view from which to record the video, is a consideration. *First person perspective*, or point-of-view (POV) videos, are recorded from the eyes of the practitioner (Figure 2). POV is a common perspective for video games. POV may be accomplished in the emergency department or simulation center using wide-angle sports cameras such as a GoPro or the less wide Pivothead camera. One advantage of this style of video for technical skills is that it does not demand additional cognitive load to transpose action to the performer’s perspective.¹⁷ *Third-person perspective* occurs when a cameraman captures interaction between characters. The camera does not exist as a character in the scene. This may be useful for planned “in-studio” videos, when another individual is available to act as a camera operator but does not interact with the characters in the video. *Second-person perspective* is that of a character in the video other than the main character and is generally uncommon in film or video games but could be useful for teaching videos of live patient encounters. A secondary practitioner participates as a subject by recording video while interacting with the patient and the primary

Figure 1. Visual representation of cognitive load theory, adapted with permission from Moreno and Park.⁴⁸

Table 1
Principles of Cognitive Theory of Multimedia Learning^{12,16,17,23}

Desired Effect*	Principle/ Technique	Description	Example
Reduce extraneous cognitive load	Image	Adding a speaker's image to the screen does not enhance learning.	Removing a "talking head" from the corner of a syncope screencast video frees the learner to focus the visual channel on the content.
	Weeding	Reducing extraneous material decreases nonessential processing.	Removing unnecessary background music from a resuscitation video frees the learner to concentrate on the content.
	Signaling	Learning is facilitated by cues that highlight important components.	A narrator may use an arrow to call attention to a point of interest on a procedure video or gray out the region outside of the area of interest.
	Perspective	The first-person camera perspective is better for the demonstration of a technical skill than second or third person, because the learner does not need to take the additional cognitive step of transposing the action to his or her point of view.	A pediatric endotracheal intubation is demonstrated in a first-person video, allowing the learner to see where her hand should be positioned on the laryngoscope handle from her own perspective.
	Redundancy	On-screen text deters from learning when it repeats narration.	A narrator reading on-screen text listing the steps of umbilical line placement does not contribute to learning.
Optimize germane cognitive load	Modality	On-screen text should be spoken rather than printed, offloading information from the visual channel to the underused verbal channel.	The umbilical line steps in the above example should be spoken, not printed.
	Dual channels	Visual and auditory information are processed in separate channels.	A complementary description of central line placement with a visual representation facilitates learning.
	Pretraining	Knowing key terms and concepts prior to a lesson facilitates learning.	A pretest in which the learner must identify the equipment needed for a thoracotomy will provide a framework for learning the procedure from a video.
	Active processing	Learning occurs when new information is mentally organized and processed in context of prior learning.	Interposed questions in a pediatric weight estimation techniques video require active participation and help establish connections between material.
	Limited capacity	Learners have limited ability to process elements in each channel at any one time.	A description of shoulder dystocia appearing as on-screen text alongside an illustration overloads the visual channel.
	Multimedia	Audio and video are more effective than audio alone.	A screencast about congestive heart failure is more engaging than a podcast covering the same content.
	Personalization	A conversational-style narrative is more conducive to learning than a formal style.	Using terms like "you" and "your" instead of "the" personalizes the content.
	Voice	A friendly voice is better than a monotone, robotic voice.	A human voice narrating a joint aspiration is better than automated text-to-voice.
Manage intrinsic cognitive load	Segmenting	User-paced segments facilitate learning better than one continuous unit.	Breaking a 30-minute toxicology presentation into four individual toxidrome segments makes it more effective.

*Principles/techniques may impact multiple cognitive load types but are presented in a single category for simplicity.

practitioner. Second-person perspective also exists when a narrator talks directly to the camera, and the audience is treated as the second character.

Narration Style

Narration can be used in two ways: a spontaneous, unscripted performance or a scripted, planned one. Live patient encounters are necessarily unscripted. Spontaneous videos are advantageous because they

promote information transfer using a conversational tone ("you" instead of "the") and relatively fast, enthusiastic speech, which triggers engagement and a sense of social interaction.^{18,23} The disadvantage to a spontaneous approach is that the presenter may not optimally organize thoughts and miss important content. Scripting may be used in place of this approach, especially for more highly planned videos such as screencasts. While this approach helps to prepare the topic

Table 2
Teaching Video Styles

Style	Description	Advantages	Disadvantages	Example
Screencast	Two-dimensional ("flat") recording of slides with narration	Preparation may already be partially complete in the form of a preexisting lecture	Special software must be obtained and/or learned	https://vimeo.com/115529933
Explainer	Scripted whiteboard or other animation	Visually impressive and memorable Succinct	More time-consuming Requires more planning	https://youtu.be/NhDvWXJIAOU
Demonstration	Live patient encounter (exam findings and procedures) Simulated procedures	Less time and preparation required More likely conversational	Navigation of patient consent and privacy issues	https://www.youtube.com/watch?v=aN7zDxyHy8
Recorded presentation/lecture	Live or "in-studio," may use green screen	Leverages time already invested in a talk Archives quality teaching	Traditional lectures may be ineffectively long	https://www.youtube.com/watch?v=9Y2i-v2zanU&t
Expert interview	Live recording with or without an audience	Recorded in one take Little editing	More difficult to control content	https://www.youtube.com/watch?v=7U6YHOuvxu0
Khan Academy-style ("chalk talk")	Two-dimensional recording of real-time illustration of concept (usually hand-drawn) with narration	Viewed as more personal Available apps make production easier May be made directly with a tablet	Required software/hardware with associated learning curve	https://www.youtube.com/watch?v=1jzZe3ORdd8

Figure 2. A first-person perspective technical skills training video employing the signaling principle.

and can assure more efficient and complete treatment of a topic, it can seem sterile and emotionless. When scripting text, one might take advantage of the personalization principle by attempting to make the tone as conversational as possible (Table 1). This requires reengagement with the material while performing the narration, much like an actor delivering lines, and is a compromise between the two extreme approaches.²⁴ When text is displayed on screen, Mayer's dual-channel theory proposes that it should not be simultaneously presented verbally, as this overloads the auditory and visual channels.^{12,23}

Animation

Animation is not universally beneficial. It risks increasing extraneous cognitive load if it does not serve a specific purpose. The benefit derived from animation is dependent upon how the animation is designed; it is best used to illustrate movement or changes with time.²⁵

Active Learning

Following Mayer's active processing principle, learning can be enhanced by techniques that require learners to participate actively with content. Unlike a lecture, video does not allow for most live audience engagement

techniques. Testing, however, is feasible with video and has a powerful effect on learning and retention.^{26,27} Pre- and postlearning quizzes are commonly used, but integrating midstream questions into teaching videos also improved EM residents' test performance.²⁸

IMPLICATIONS FOR EDUCATION AND TRAINING IN EM

Cognitive Load Management

The EM educator can take an active, intentional role in managing cognitive load to increase video impact. Considering cognitive load types, extraneous cognitive load is undesirable and should be *reduced*, germane cognitive load is contributory to learning and should be *optimized*, and intrinsic cognitive load, which is inherent to the content itself, can only be *managed* (Figure 1).

Interactivity

Actively building schema is more effective than passively experiencing content. It is possible to incorporate interactivity by packaging video with questions. Hapyak (<https://corp.hapyak.com/>) and EDpuzzle (<https://edpuzzle.com/>) are examples of services that add interactive questions to existing video, including YouTube. Opting for multiple short videos takes advantage of the segmenting principle, giving learners control over which sections they access. A low-stakes preassessment may activate prior knowledge and reduce the intrinsic load of the forthcoming video.⁹ YouTube incorporates iterations of interactivity, including cards, allowing interposed poll questions at any point in a video, and end screens, which point viewers to further recommended content.²⁹

Production Considerations

Academicians need to balance output with production. Production needs may be higher for higher intrinsic load content. For example, a video demonstrating a new technique for nasal atomization of medications might require little planning and no scripting to be effective, while a video explanation of ventilator modes might require more preparation to produce a structured product. An educator might consider *storyboarding* a video with such a high intrinsic load. A storyboard is a sequence of images or illustrations created to help visualize an end product. A more scripted approach may be useful in this scenario if the educator has the ability to perform a narration

without sounding stale. Animations, if desired, can be more easily and efficiently created in presentation applications like Keynote and PowerPoint and turned into videos using built in functionality or screencast software. Attention to production may be beneficial for highly complex topics, but counterintuitively, learners in online courses engaged more with low-production videos, which may reflect that learners respond to the familiarity of lower production.¹⁸ While acknowledging that poor-quality production can distract from the message, this suggests that an EM educator should not obsess about high production value. While the video quality of smartphones has improved dramatically in recent years, techniques that improve audio often depend on equipment placement, such as the use of external microphones. Practically, developing skills in audio manipulation allows narration to be recorded in one take, with errors or empty space edited out later. Marking recording audio errors or blank space with a device such as a dog clicker can make them easier to locate and correct in postproduction.³⁰ Production should match both the content complexity and the stability.⁸ Production quality can be lower when content is likely to change and need updating.

Peer Review

Emergency medicine is a leader in instituting peer review for online resources.^{31,32} The role of peer review in online content such as videos is not clear. The peer review process is known to delay knowledge translation,³³ which could counteract the benefit of immediate availability that online learning provides. Peer review may help ensure product quality, monitor for content sensitivity, and prevent inadvertent compliance mishaps. The unique format of online video may lend itself to new forms of peer review, such as post-publication peer review, in which changes are made and documented after publication.³²

Privacy and Legal Concerns

Emergency medicine educators must obtain consent to film and disseminate live patient encounters. The advent of social media and reality television may be responsible for the willingness of many patients to participate. Aside from legal concerns, clinicians must consider their societal duty to maintain confidentiality and trust. For example, smartphones should be password protected and attention paid to external or auto backup services making videos vulnerable to hacking.

Consent may be obtained by several routes, including on camera or in writing. As the consent process will be institution-specific, vetting with legal, compliance, and human resources departments is required. Educators can avoid potential pitfalls associated with consent by creating content in a simulation center using mannequins and/or simulated tissue. However, the benefits of video production with real patients or procedures may outweigh the inherent risks.

Global Health Considerations

There is significant potential to provide EM-specific, open-access online educational resources in places where formal EM training is limited or currently developing. Multiple online video platforms make educational videos available to learners in developing countries.³⁴ There is a paucity of research regarding the effectiveness of educational videos created in high-income countries and their use in low- to middle-income countries (LMICs); however, we do know that online EM resources are used worldwide.²

The Western perspective has dominated the media for many years.³⁵ Media deemed appropriate in one setting may not be appropriate in another, as cultural differences are still formidable obstacles to effective communication.³⁶ Cross-cultural communication has been influenced by the concept of high- versus low-context cultural dimensions.³⁷ Video education modalities might be most appropriate in high-context cultures where indirect communication relies on gestures and tonal signals. In low-context cultures, communication is structured, specific, and reliant on facts and statistics for teaching, with audio and video both

being good choices. These dimensions can be important for audience-targeting and learning facilitation.³⁸

As the majority of free, open-access medical education (FOAM) is targeted at high-resource settings, consideration must be given to the technology required to translate learning into practice.³⁹ For example, creating an ultrasound procedure trainer with ballistics gel may not be feasible in many countries, but tofu or gelatin may work as a substitute.^{40–42} A lack of attention to resources is the main barrier to FOAM use in LMICs.⁴³ Consider lower-resolution/small-size videos to promote downloading ease in countries with unreliable Internet, slower bandwidth, and higher data costs.³⁹ Some countries ban video-hosting sites. YouTube is blocked by governments in multiple countries (including high- and low-middle income countries).⁴⁴ Also, English is not always the primary language. Consider closed captioning of educational videos in the same language as the speaker. Closed captioning aids with listening comprehension.⁴⁵

Humor is ubiquitously used in medical education and can have an important role; however, it may not always translate appropriately.^{43,46,47} A cross-cultural humor guide, such as the one available online at https://speakerhub.com/sites/default/files/ebook_v.1.8.pdf, can provide guidance.

Practical Example

We offer the following case as a practical example. An EM educator designs a 20-minute video about Wolf-Parkinson-White (WPW) syndrome, explaining orthodromic and antidromic variations, the pitfalls associated with atrial fibrillation in the setting of

Figure 3. Cognitive load diagram of a hypothetical WPW educational video intervention. Overall cognitive load is decreased by manipulating extraneous load. Germane load is increased, leading to better learning. Intrinsic load is inherent to the material and does not change but is managed by breaking up the video into two parts. Adapted with permission from Moreno and Park.⁴⁸

WPW, recognition of WPW, and an approach to treatment. She adds music because she thinks that the content is “dense.” She makes the text fly in to the screen and records a picture-in-picture webcam of herself talking. She records the narrative “off the cuff.” The cognitive load for this video might be mapped (Figure 3). She monitors video usage with analytics and notes that views and completions are lower than expected. She removes the music and animated text to improve the video. She prepares a script to organize her thoughts but does not stick to it rigidly to maintain a conversational tone. She re-records the video. She speaks with a faster, enthusiastic pace to shorten the video. She excludes the picture-in-picture webcam video. She breaks the 20-minute video into two 6-minute segments, one with background information and the other related to recognition and treatment. Germane load is increased, extraneous load is decreased, and intrinsic load is managed.

Explainer Video

We created a video to summarize and demonstrate some of the principles discussed above and uploaded it to YouTube (youtu.be/NhDvWXJIA0U).

CONCLUSION

Emergency medicine educators can facilitate the transfer of knowledge and skills to learners by taking note of how we create content. Attention to cognitive load principles positions instructional videos to be more impactful, and consideration of the resources of a global audience increases their reach.

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