Developing Video Content to Engage Students in STEM

Justin Gonzalez, Nikki Kanakis, Sylvia Long, Renee Souvenir; Dr. Hannah Hiester
College of Arts and Sciences

Abstract

In the growing digital age, videos are a useful source of accessible learning material. However, it is important to design and use videos effectively to maximize benefit to the learner and to avoid misusing technology. The purpose of this study is to create guidelines for instructors to use in the creation of multimedia video lessons, specifically focusing on STEM subjects. These guidelines direct instructors to design videos that support effective learning through consideration of essential and generative processing, motivation, and elimination of extraneous elements. The guidelines were constructed through a comprehensive literature review of multimedia video learning and video design, examining the effects of video structure, modes of instruction, emotion and motivation, and other aspects of video learning. In addition, this study included designing and creating sample videos that adhere to the guidelines. Overall, the guidelines are a useful tool for STEM education, providing a baseline for the creation of impactful videos.

Introduction

•Aim: Identify and evaluate the most effective design principles for multimedia learning in relation to STEM video instruction, and in turn, create guidelines for STEM video instruction

•The field of multimedia learning aims to find if educational material brought by new technology is fostering learning by researching what is most beneficial for learners, rather than outright advocating for the use of new technology

•Multimedia learning is the process of learning through words and pictures (Mayer, 2009)
- Its overarching goal is to make the process of attaining new information and integrating it into working memory seamless for the learner

•The effectiveness of multimedia learning is rooted in three assumptions (Mayer, 2009):
- Channels are distinct processing units for the brain, with the brain containing one audio channel and one visual channel
  - Multimedia learning fits this channel model well since information in this format is presented through auditory narration and visual models
- Each channel has a processing limit
  - Since multimedia learning uses the audio and visual channels equally, which prevents any one channel from experiencing cognitive overload, this assumption is also satisfied
- Learners should actively engage with the material to understand it
  - Multimedia learning is rooted in the idea that students learn by constructing mental connections between concepts, rather than learning through a stream of information

•If proper design principles are utilized, multimedia learning can encourage (Mayer, 2009):
- Greater essential processing (the mental processing necessary for a basic understanding of a lesson)
- Greater generative processing (the mental processing necessary for connecting with new material and integrating it into established knowledge)
- Less extraneous processing (the excessive processing due to poor design elements)

•These references are relevant to the topic because they help guide toward the qualities which make STEM instructional videos engaging and beneficial for constructing knowledge

Methods

This project was accomplished by engaging in extensive reading and analyzing of research regarding multimedia learning principles. During this search, Richard E. Mayer's *Multimedia Learning* (2009) was used as a frame, giving a theoretical basis of multimedia learning and its guiding principles. Through this research, a set of guidelines was developed and summarized in a checklist that comprises design principles necessary for an effective multimedia STEM video. The purpose of the checklist is two-fold, to summarize the most vital elements for an effective STEM video, and to support further creation of videos of that nature. Using the checklist as a guide, two sample videos were created, adhering to the design elements researched in this study.

Results

Below is the checklist of design elements essential for effective STEM video production. Screenshots of the application of these elements in the two videos produced, one on plate tectonics and one on food webs, are shown in Figs. 1-4.

Multimedia Learning Video Checklist

Section 1: Dual-channel Theory
- ❑ Simultaneously engage the auditory and visual channels of learners.

Section 2: Extraneous Processing
- ❑ Remove decorative details (See Figs. 1 & 3).
- ❑ Remove redundant design elements.
- ❑ Place related narration and images simultaneously (See Fig. 4).
- ❑ Place related text and narration simultaneously.
- ❑ If an animation is used, place visual cues.

Section 3: Essential Processing
- ❑ Use signaling (See Figs 2 & 3).
- ❑ Segment videos.
- ❑ Overview essential concepts at the beginning of the lesson (pre-training).

Section 4: Generative Processing
- ❑ Consider prior knowledge of students when using problem-solving examples.
- ❑ If using an on-screen agent as a guide, have the on-screen agent provide complex feedback to questions (explaining why), rather than simple feedback (yes/no).
- ❑ Use personalization for the voice of the narrator and/or on-screen agent.
- ❑ If using vicarious learning, use a model student that is the same age and experience level as the target audience.

Section 5: Motivation
- ❑ Use round shapes.
- ❑ Anthropomorphize shapes.
- ❑ Use warm colors in video design but avoid red (See Figs 1 & 4).
- ❑ Use humor if the tone of the learning video calls for it (but don't use it excessively).
- ❑ Utilize vicarious learning, especially as a tool of challenging learners' knowledge.

Section 6: Accessibility
- ❑ Make sure all accessibility features are applicable to all aspects of the project at hand.
- ❑ Provide choice for accessibility methods.
- ❑ Eliminate unnecessary complexities to accommodate a wider range of literacy and language skills.
- ❑ Arrange information with emphasis on the importance of a subject.
- ❑ Maximizing "legibility" of information.
- ❑ Compatibility with different devices used by people of different abilities.
- ❑ Differentiate elements in ways that can be described

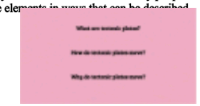

Fig 1. Screenshot from video on plate tectonics: Use of warm colors for intrinsic design (Section 5) and removing decorative details (Section 2)

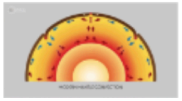

Fig 2. Screenshot from video on plate tectonics: Signaling through arrows to show motion (Section 3)

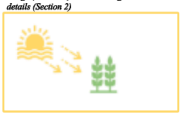

Fig 3. Screenshot from video on food webs: Removing decorative details (Section 2) and signaling through arrows to show energy transfer (Section 3)

Fig 4. Screenshot from video on food webs: Placing narration and images simultaneously (Section 2) and use of warm colors for intrinsic design (Section 3)

Discussion

Technological innovations will continue to expand the tools we have to teach, especially regarding learning videos. Our research is necessary for bridging the gap between academic findings and real-world use by offering instructors a concise pathway of implementing multimedia learning theory, maximizing generative and essential processing, and minimizing extraneous possessing, into learning videos.

One of the biggest challenges when using the checklist to make a video is balancing points from the extraneous processing section (specifically removing decorative details) and the motivation section (anthropomorphized shapes and using humor). However, implementing points, such as using a personalized voice and segmenting the video, can be done with ease.

Overall, the checklist successfully encapsulates key design elements of a multimedia learning video.

Research Limitations
- The impact of recent technological advances such as TikTok was not explored.
- This study focused on single stand-alone videos rather than videos that might be used interactively with other educational materials.
- The writers of the literature review have no prior background in the field of education or educational psychology.

Future Directions

Future research should consider the learning environment of the learners. For example, looking into the difference in learning gains when showing a learning video through a smartboard in a classroom setting versus having students watch a learning video on their device or on their own time. The research in this study also highlights the importance of further research on whether static images or animations are more beneficial for learning, the impact of vicarious learning on low prior knowledge compared to high prior knowledge learners, and the role that humor plays in learning outcomes. Another potential avenue to pursue is field-testing the videos developed using the checklist in the classroom to determine their effectiveness and further test the validity and usefulness of the checklist.

Acknowledgements

We would like to thank Dr. Hannah Hiester for guiding us through our research and inspiring us with her love of teaching. We would also like to thank Barbara Shoplock for continuing in Dr. Hiester's place as our mentor for the remainder of our research.

References

SCAN ME