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Research Article

Use of personal storytelling in educational videos promotes student engagement and science identity in undergraduate biology courses

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ABSTRACT In this era of information abundance and digital connectivity, educational videos are a transformative and widely used resource in STEM higher education. Much of what is known about the effective use of educational videos comes from analyzing videos used for content delivery and the impacts on knowledge gains or behavioral engagement with videos. Less is known about how videos may impact students' affective learning experiences, feelings, and attitudes or how to effectively use videos in science education beyond just as a content-delivery tool. This study explored the impact of three distinct video styles: a whiteboard animation, a recorded discovery lecture by one of the discoverers, and a documentary short film featuring both discoverers in conversation on student outcomes in a large-enrollment undergraduate biology class. Students were randomized to watch one of these three formats, all covering the same scientific content (i.e., the Meselson and Stahl experiment), followed by a post-video survey. The documentary film, "The Most Beautiful Experiment," which integrated interpersonal storytelling and informal dialog, had the most significant impact on outcomes related to affective learning, including science identity, attitudes about biology, speaker relatability, and emotional engagement. No significant differences in knowledge gains were observed across video styles. This study highlights the potential of personalized and embodied video formats to enrich STEM education and warrants further research into their broader applications.

KEYWORDS STEM education, genetics, educational videos, multimedia learning, affective learning

Educational videos have been a transformative tool in higher education, serving as one of the most widely used digital resources to support learning since the COVID-19 pandemic (1). They provide a different learning modality—one that students are quite familiar with—that complements and reinforces what students learn in class. Use of videos outside the classroom can enhance accessibility since learners can engage with the video content in conditions that are more ideal for their learning, such as replaying content, adjusting vocal speed, and reading captions (1). Videos also have the potential to incorporate diverse representations of scientists and their research (2). Furthermore, they can be an effective cognitive support for students engaged in aligned and meaningful activities—activities that shift away from a passive instructor-centered approach to an interactive student-centered approach (3, 4). For example, an educator can have students watch a video outside of class to seed an active learning activity in the classroom or lab, as in a flipped classroom approach (5). Considering these reasons, it is not surprising that undergraduate students value videos as learning tools over traditional lecture or textbook readings (6, 7).

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Much of the research on the effective use of educational videos in higher education has focused on measures of the cognitive domain of learning—particularly their use as content-delivery tools to promote knowledge gains (3, 6, 8–17) and, to a lesser degree, behavioral engagement (9, 18). However, learning is a multidimensional construct that also includes other domains, such as affective (19). The affective domain of learning considers the emotional engagement, feelings, motivations, and attitudes that occur during the process of constructing knowledge. Less is known about how videos can impact the affective domains of learning. Yet, measures related to attitudes and beliefs, such as students' science identities or relatability to scientists, can impact a sense of belonging and persistence in STEM education, specifically for historically marginalized groups (20–23). Therefore, analyzing what video elements positively impact measures of affective learning is important for understanding the use of educational videos to promote diverse, broad participation and persistence in science education (14, 24–26).

The term "educational video" encompasses a wide variety of production styles, tones, and pedagogical intentions. Yet most empirical work has focused on traditional lecture-style presentation or tutorial videos—formats optimized for information delivery (9, 17, 18, 26, 27). In contrast, narrative-driven formats, animated explainers, and cinematic documentary-style videos remain underexplored despite their growing availability. These diverse styles differ not only in visual and audio design but also in how they humanize scientific discovery or connect learners to the people behind the science. Critically, they also vary in the degree to which they implement design principles known to foster meaningful learning and engagement.

In this study, we investigated the impact of three distinct video styles: (i) a whiteboard animation, representative of typical online explainer videos (ii); a lecture video delivered by one of the original discoverers, which blends formal instruction with some personal reflection in a lecture-style presentation format; and (iii) a cinematic short film featuring both discoverers in a casual conversational setting, using storytelling, archival footage, and interpersonal dynamics. These three videos were all produced by the same filmmakers—the nonprofit Science Communication lab (formerly iBiology)—which provided a unique opportunity to investigate comparisons across videos produced by the same content creator, as opposed to comparing videos produced by different creators. While all three videos present the same scientific content about the Meselson and Stahl experiment, they are stylistically distinct from one another, differing in their use of personal narrative, tone, and audiovisual structure.

We focus on five research questions around the use of different video styles as supplemental learning resources: RQ1) Which video style best promotes knowledge gains?; RQ2) Which video style best promotes student identification with scientists/the scientific community?; RQ3) Which video style best promotes speaker relatability and knowledgeability?; RQ4) What are the effects of video style on science attitudes?; and RQ5) Which video style do students find the most emotionally engaging? For RQ5, emotional engagement can be broadly defined as spontaneous positive or negative reactions that occur without deliberate cognitive effort. These reactions can be related to (i) arousal states, such as anxiety or boredom, or (ii) emotional states, such as happiness or sadness (28–30). To answer these research questions, an out-of-class homework assignment and survey were used to collect data from students who were randomly assigned one of three videos.

METHODS

Course overview

This study was performed in a large-enrollment (496 students) upper-division undergraduate majors genetics course at a large, R1 land-grant university in the Western United States that serves over 30,000 undergraduate students. The course, which has four lower-division course prerequisites, is part of the core upper-division biology curriculum for 21 biology and biology-related majors. This four-unit course covers content in transmission genetics and molecular genetics and meets for 110 minutes in-person twice per week over a 10-week quarter. In addition to the main four-unit course, there is an additional optional discussion section that students can elect to enroll in. Students who enroll in the discussion section earn 1 unit of course credit graded as Pass/No Pass for attending one weekly 50 minute discussion (30–40 students per section) led by a Graduate Student Instructor who reviews content and problems covered in the main course. Earning a Pass in the discussion section requires students to attend a minimum of seven weekly discussions over the 10 week quarter, complete seven out of nine total discussion homework problem sets, and complete two video assignments.

Study design

The focus of videos used in this study was the Meselson-Stahl Experiments that provided evidence for the mechanism of DNA replication (31). This topic was covered in a 110 minute class session in Week 5 of the course that included a traditional lecture paired with a series of five in-class questions where students made predictions and analyzed results from the experiment. To supplement the content covered in the lecture, a video assignment was administered within Week 5 only to students enrolled in the optional discussion sections. We embedded an online survey within the assignment that students completed immediately after watching the video (32). In the survey, we used a between-subjects factorial experiment design that meant that each student was randomly assigned one of the three video types to watch, followed by the survey questions (33). The video assignment settings prevented students from fast-forwarding through the videos, and the survey link was only provided once a student reached the end of the video. Summative assessment of content knowledge was collected in a multiple-choice exam administered in Week 8. The full video assignment, survey questions, and summative assessment questions are provided in the supplemental material.

Study participants

Of the 496 students enrolled in the main class section, 302 students self-enrolled in the discussion sections, providing a convenience sample that was randomized into one of three treatment groups for the video assignment. Given the potential role of self-selection among students who enroll in the optional discussion, only participants who enrolled in the discussion sections were included in the study. No comparisons were made between students who self-selected into discussion sections with those who did not. Of the 302 who did participate in the experiment as part of the video assignment, 34 did not consent to having their data used in a research study and thus were removed from the sample. The final treatment sample resulted in 268 participants ($N = 268$).

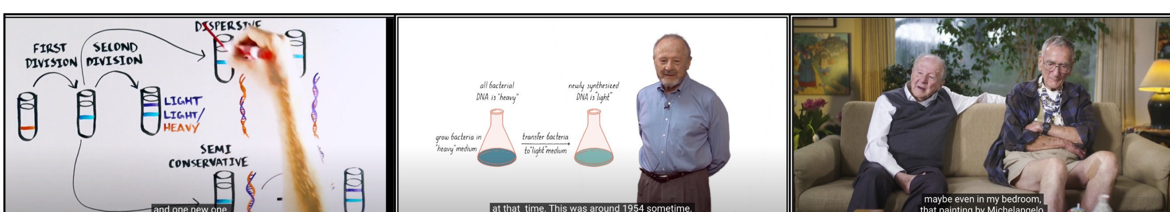
Students completed a course evaluation survey in Week 10 asking questions about their experience with the course, content delivery, and demographic information. Of the 268 student participants, 16 people did not provide demographic data. Of the 252 who did, 74.6% identified as women [$n = 188$], 22.6% as men [$n = 57$], 1.6% as non-binary [$n = 4$], and 1.2% who declined to say [$n = 3$]. Ethnically, 44% of students identified as Asian [$n = 111$], 20.9% as Caucasian [$n = 56$], 20.5% as Hispanic or Latino [$n = 55$], 5.6% as mixed race [$n = 14$], 2.6% as African American [$n = 6$], and the remaining 10 people identifying as Pacific Island, "other," or preferring not to answer. Most students (73.4%) were in the third year of their degree programs [$n = 185$], with 15.1% reporting being in their fourth year [$n = 38$], and the remaining 11.5% in other years. Additionally, 45.2% of students identified as "first generation" college students, which means the first person in their immediate family to attend college, and 32.5% identified as transfer students (from other universities and community colleges).

Video stimuli conditions

Students who self-enrolled in the discussion sections provided a convenience sample that was randomized into one of three treatment groups for the video assignment, with each treatment group assigned a different video format covering the experimental evidence generated by Dr. Matthew Meselson and Dr. Frank Stahl that revealed the semi-conservative nature of DNA replication. Each video covers the same quality and quantity of scientific information, but differs in length, video style, and use of audio and visual channels (Fig. 1). The first condition was a whiteboard animation ("The Semi-Conservative Replication of DNA"; 7:31 min), which describes those experiments and resulting outcomes using dynamic and colorful whiteboard drawings with voice-over narration from an unidentified female. The second was a recorded lecture ("Matthew Meselson: The Semi-Conservative Replication of DNA"; 13:08 min) featuring Dr. Meselson standing in front of the camera, describing those experiments and outcomes and sharing some personal anecdotes in more of a traditional lecture style with slides projected behind him. The third was a cinematic short film ("The Most Beautiful Experiment: Meselson and Stahl"; 22:07 min), which features both Dr. Meselson and Dr. Stahl interviewed together, sharing their personal stories, along with descriptions and outcomes of the experiments with music, dynamic graphics/animations, and archival and supplemental footage. Of the final total sample of 268 students (*N* = 268), 95 were randomly assigned the animation video (ANI), 79 were assigned the lecture video (LEC), and 94 were assigned the short film narrative video (FIL). The video assignments were administered using the Canvas learning management system with an embedded post-stimuli survey that students completed immediately after watching the video.

CTML framework video evaluation

To help make sense of differences that emerged between the video styles in our analyses late in the study, we characterized the videos through the lens of the Cognitive Theory of Multimedia Learning (CTML) to better understand features present in each video and how those might correspond to the video style (i.e., the variable of focus in this study), as well as provide further insights for future educational research and practice to build with. CTML, first proposed by Mayer in 2005, is a leading theoretical framework guiding improvement of educational multimedia to foster learner engagement (16, 29). CTML asserts that learning is optimized when multimedia incorporates visual and verbal channels that lead to deeper cognitive engagement and processing (17, 30, 31). Research



Abbr.	ANI	LEC	FIL
Video Style	Whiteboard animation	Recorded lecture	Short documentary film
Video Title	*"The Semi-Conservative Replication of DNA"*	*"Matthew Meselson: The Semi-Conservative Replication of DNA"*	*"The Most Beautiful Experiment: Meselson and Stahl"*
URL	https://www.youtube.com/watch?v=8jPK3S9S8rg	https://www.youtube.com/watch?v=V2evjmkur7k	https://www.youtube.com/watch?app=desktop&v=7-tnuAqEp9g&t=254s
Length	7:31 mins	13:08 mins	22:07 mins

FIG 1 Summary of the three different video stimuli. The summary includes still screens of each video visual format and description of the video lengths and format.

in CTML has resulted in principles of multimedia design to foster engagement and generative processing with social cues that prime learners to connect and make sense of the material (2, 17, 30, 32). Three major principles for fostering generative processing, the *personalization principle*, the *voice principle*, and *the embodiment principle,* highlight the importance of creating an environment of social proximity and social presence between the learner and educator for motivating learners to engage meaningfully and actively participate in multimedia learning (12, 17, 19, 29, 31, 33). The *personalization principle* identifies that use of conversational style rather than formal style of language establishes a multimedia environment of social proximity and presence between the learner and educator (32). According to the *voice principle*, narration in multimedia spoken from a natural human voice rather than a machine voice contributes to social proximity and presence, specifically when the quality, tone, pitch, and pauses of the human voice convey a friendly and polite demeanor. The *embodiment principle* highlights that social cues by the on-screen instructor that convey genuine human connectedness (i.e., movement, eye contact, facial expression, and physical gestures) are critical in establishing social presence.

Using the lens of CTML, we evaluated the extent to which the *personalization*, *voice,* and *embodiment principles* are met in the video stimuli used in this study (Table 1). The whiteboard animation, the shortest of the three videos, has an easy-to-follow storyline that is narrated with a human voice that is conversational but scripted. However, the animation completely lacks personal narratives about or by the scientists, and no humans are ever viewed on screen, except for a disembodied hand that renders the drawings. The animation has social cues that align with the personalization and voice principle but does not achieve the embodiment principle. The recorded lecture (LEC), on the other hand, features the scientist, Dr. Meselson, telling the sequence of events about his experiments with static slides as a visual aid, and he includes little vignettes or personal details in his explanations, but the end result is a formal lecture—a format that does not embed social cues in ways that maximally achieve any of the three principles. The cinematic short film (FIL), which is significantly longer than the other two videos, seems to maximize characteristics of each principle, with the Meselson and Stahl relationship as a narrative device for the telling of events and outcomes. It uses pacing techniques and segmentation to allow for viewers to absorb information in a way that reduces cognitive load. The cinematic short film embeds social cues that convey genuine human connectedness around scientific content. Table 1 provides a visual summary of how example features of CTML personalization, voice, and embodiment principles appear in three video stimuli. This summary was developed through iterative evaluation and discussion among the authors in reviewing and rating each video for each feature. The assessments in Table 1 are based on consensus-building conversations among the authors.

Measures

A one-way between-group analysis of variance (ANOVA) statistical tests was used to assess if there were statistically significant differences between the different treatment groups for each of the measures (outcome variables) described below, which include the

TABLE 1 Comparison of the outcomes from each video across variables measured in this study[a]

	ANI	LEC	FILM
Knowledge	n.s.	n.s.	n.s.
Science identity	+++		+++
Knowledgeability		+++	+++
Relatability	+++		+++
Attitudes		+++	+++
Emotional engagement			+++

[a]n.s. indicates no significant differences among the three videos. +++ in bold and grey indicates that the video had a significantly larger effect than at least one of the other videos.

following: knowledge gains, science identity, speaker knowledgeability and relatability, attitudes of science, and engagement. All measure items that come from previous studies are described. This study did not carry out further analysis of the validity or reliability of the items.

Knowledge gain—Survey Quiz

Following exposure to the video stimuli, participants were immediately asked to answer four multiple-choice quiz questions assessing learning outcomes related to the topical content of DNA replication. These four questions were graded and scored as either correct (1) or incorrect (0) (M = 3.72, SD = 0.637). The four multiple choice questions used in the Survey Quiz are provided in the supplemental material.

Knowledge gain—Exam

Separate from the video assignment and survey, all students enrolled in the course, including the 268 students who participated in the video assignment and the 194 students who did not complete the video assignment, were asked four questions related to the topic of DNA replication as part of their course summative midterm exam. These questions were scored as either correct (1) or incorrect (0). Of the four questions specifically asked about DNA, the average number of questions answered correctly was 2.97 (SD = 0.84). The four multiple-choice questions used on the exam are provided in the supplemental material.

Identification with science

A three-item scale, adapted from previous work, was used to measure students' identification with science (34, 35). Students responded on a scale from (1) strongly disagree to (5) strongly agree to: **See Myself**: "*After watching the video, I could see myself doing research to answer questions like the ones that were described in the video*" (M = 3.5, SD = 1.037), **Being a Scientist:** "*After watching the video, I think I would enjoy being a scientist more than before*" (M = 3.59, SD = 0.894), and **Valuable Time:** "*After watching the video, I think it is a valuable use of my time to study the fundamental experiments behind biological ideas*" (M = 3.95, SD = 0.760). The Cronbach's alpha for these items was 0.675 and was indexed into a variable called "Identification with Science" (M = 3.68, SD = 0.70).

Knowledgeability and relatability of video speaker(s)

To measure students' perceptions of the speakers in the video stimuli, students were asked to respond using a 5-point Likert scale from (1) strongly disagree to (5) strongly agree, to **Knowledgeability**: "*I think that the speaker(s) in the video were knowledgeable about DNA*" (M = 4.53, SD = 0.644) and **Relatability**: "*I think that the speaker(s) in the video were people I could relate to*" (M = 3.38, SD = 0.934). These items were not significantly correlated, so each individual item was used as a single-factor dependent variable.

Attitudes of science

To measure how the stimuli impacted students' perceptions about how conceptual science knowledge is generated, a question was adapted from the Colorado Learning Attitudes about Science Survey for Biology (CLASS-Bio) (36). Participants responded using a 5-point Likert scale from (1) strongly disagree to (5) strongly agree to the statement: "*This video changed my ideas about how scientific research is done*" (M = 3.36, SD = 0.951).

Engagement

The emotional engagement measure was a 2-item scale that measured students' state of arousal by the narrative and personally connecting to the content. The scale requires participants to rate how engrossed students were while watching the video by responding to a scale from (1) strongly disagree to (7) strongly agree to the statements: "*I found myself wanting to know what would happen next*" (M = 5.42, SD = 1.311) and "*The video affected me personally*" (M = 3.66, SD = 1.54). These items were not adapted from previous studies or subjected to thorough analysis of validity or reliability. They significantly, positively correlated r(267) = 0.263, *P* = 0.000 and were averaged into a two-item variable called "**Engagement**" (M = 4.5, SD = 1.13).

RESULTS

Knowledge gains (RQ1)

Educational videos have been primarily used as cognitive support resources to improve learning in the context of a content delivery tool (9, 17, 18, 26, 27). To understand if supplemental educational videos with varying styles impact knowledge gains in a given topic (RQ1), student scores on the survey quiz, which were given directly after viewing the video stimuli, and scores on summative exam questions related to the topic were analyzed with an independent two-sample *t*-test. There was no significant difference in how students performed in the survey quiz compared across the three different videos (M = 3.72, SD = 0.637, *P* = 0.757). When analyzing student performance across four questions on the summative exam directly assessing the video topic, there was no significant difference between video groups (M = 2.97, SD = 0.84, *P* = 0.171).

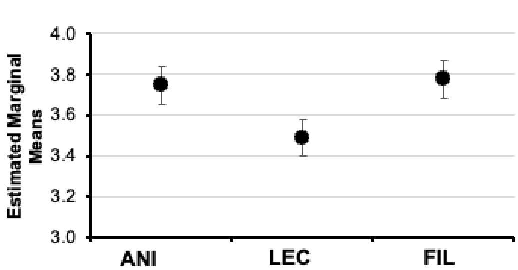
Science identification (RQ2)

Science identity, that is students seeing themselves as a scientist, is a relevant and representative measure of attitudes and beliefs inherent to the affective domain of learning (24, 37, 38). Increased science identity is an established predictor of motivation and persistence in science education (24, 34, 35, 39–42). To evaluate whether video style impacts science identity, we compared the three video stimuli for impact on feelings of whether one would enjoy being a scientist [F (1, 2) = 3.344 p = 0.037] and if one could see themselves doing research like performed in the video [F (1, 2) = 5.772 *P*= 0.004]. Students who viewed the short film (FIL) or ANI reported significantly higher levels of positive science identity as compared to the lecture (LEC) (Fig. 2).

Speaker knowledgeability and relatability (RQ3)

Scientists are historically perceived as intelligent but not relatable or kind (43–45). Enhancing the relatability of scientists can lead to an increased sense of belonging and interest in STEM, especially for groups historically excluded from science (2, 23, 46–48). To understand whether video style impacts perceptions of intelligence and relatability of the scientists portrayed, students were asked if they found the speaker(s) in the video knowledgeable and relatable. Students who watched the short film and lecture

A.



B.

Dependent Variable: Identification with Science

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	4.176[a]	2	2.088	4.331	0.014
Intercept	3586.196	1	3586.196	7438.24	<.001
videostyle	4.176	2	2.088	4.331	0.014
Error	127.764	265	0.482		
Total	3764.444	268			
Corrected Total	131.94	267			

a. R Squared = .032 (Adjusted R Squared = .024)

FIG 2 Impact of video style on science identity. (A) Comparison of estimated marginal means of science identity combined from responses to three items from students who watched the animation (ANI), recorded lecture (LEC), or short-film narrative (FIL) video. Error bars represent standard error. (B) ANOVA results measuring science identity across video styles.

found the speaker significantly more knowledgeable compared to the animation [F (1, 2) =4.552 *P*<0.000, Fig. 3]. With respect to speaker relatability, students who viewed the lecture reported finding the speaker significantly less relatable compared to what students reported after watching the short film or animation [F (1, 2) =7.249 *P*=0.001, Fig. 4].

Attitudes of science (RQ4)

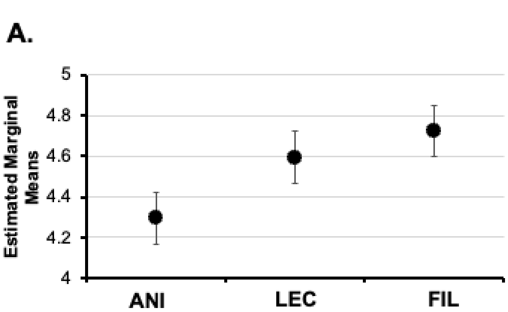
In science education, there is a positive relationship between students' attitudes toward biology and their achievement and persistence in learning biology (36, 49). The method and modality of how information is delivered can significantly influence student attitudes toward the course and course content (41, 50–53). To explore how video style might impact student attitudes about biology, student responses to a question adapted from the Colorado Learning Attitudes about Science Survey for Biology (CLASS-Bio) measuring how the video impacted student ideas about scientific research were compared across the three video stimuli (36). Students who watched the short film and the recorded lecture were more likely to report the greatest positive changes in their attitudes about science compared to students who watched the animation [F (1, 2) =4.077 *P*=0.018, Fig. 5].

Engagement (RQ5)

Storytelling has been widely used in the field of science communication and K-12 science education, as well as many other fields, to convey information and promote engagement (54–58). Emotional engagement influences the story's potential to affect subsequent story-related attitudes and beliefs (59). A two-item scale was used to measure which video style students found more emotionally engaging (RQ5). Video style had a significant impact on engagement (Fig. 6). Students who viewed the short film reported significantly higher levels of engagement compared to students who viewed the other two videos [F (1, 2) =8.990 *P*<0.000].

DISCUSSION

In this study, video style did not influence students' ability to recall conceptual knowledge from the Meselson-Stahl experiment (RQ1). However, there were significant differences between video styles when comparing student responses for measures of science identification (RQ2), speaker knowledgeability and relatability (RQ3), attitudes of science (RQ4), and emotional engagement (RQ4), with the documentary short film having the largest overall positive impact on these affective outcomes. Table 1 provides a visual summary of the comparative results for the three videos across the five research question measures. To interpret how the video styles led to differences in student outcomes, the CTML framework provides a lens for comparing how principles that foster generative processing appear in each video (Table 2). In interpreting the findings of



B.

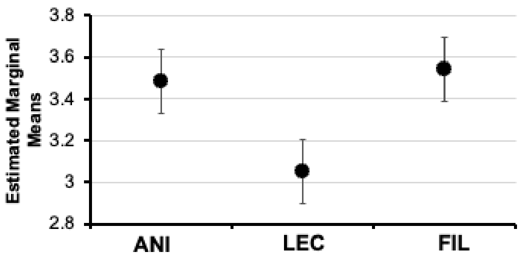
Dependent Variable: Speaker Knowledgeable

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	9.104[a]	2	4.552	11.873	<.001
Intercept	5479.016	1	5479.016	14291.605	<.001
videostyle	9.104	2	4.552	11.873	<.001
Error	101.594	265	0.383		
Total	5619	268			
Corrected Total	110.698	267			

a. R Squared = .082 (Adjusted R Squared = .075)

FIG 3 Impact of video style on perception of the speaker as knowledgeable. (A) Comparison of estimated marginal means of speaker knowledgeability from responses to one item from students who watched the animation (ANI), recorded lecture (LEC), or short-film narrative (FIL) video. Error bars represent standard error. (B) ANOVA results measuring the perception of the speaker as knowledgeable across video styles.

A.



B.

Dependent Variable: Speaker Relatability

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	12.083[a]	2	6.041	7.249	<.001
Intercept	3002.525	1	3002.525	3602.7	<.001
videostyle	12.083	2	6.041	7.249	<.001
Error	220.854	265	0.833		
Total	3289	268			
Corrected Total	232.937	267			

a. R Squared = .052 (Adjusted R Squared = .045)

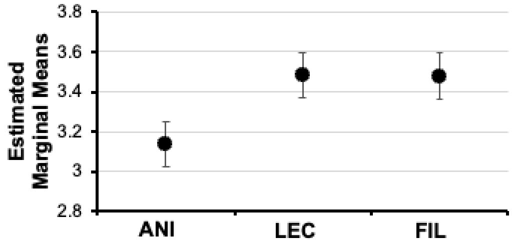
FIG 4 Impact of video style on speaker relatability. (A) Comparison of estimated marginal means of speaker relatability from responses to one item from students who watched the animation (ANI), recorded lecture (LEC), or short-film narrative (FIL) video. Error bars represent standard error. (B) ANOVA results measuring speaker relatability across video styles.

this study, it is important to note that students received conceptual information on the Meselson-Stahl experiment from in-class lectures and discussions, making the video a supplement to the content that was covered in class.

Power of personal storytelling in science education

Overall, however, the results suggest that knowledge gain need not come at the cost of more personalized and affective features of a science film, they also point to the potential additional benefits that such features might provide. A distinguishing feature of the documentary short film that differs from the more common format of educational videos, as well as the other video stimuli in this study, is the extensive use of personal storytelling in a casual and social setting among two scientists. This unique feature aligns well with the CTML personalization and embodiment principles for promoting generative processing. One might be concerned with whether the inclusion of personal storytelling would interfere with learning by creating cognitive load or extraneous processing, but this was not observed in this study. In other settings, storytelling in science education positively impacts learning (58, 60). In order to understand a story's ability to influence audiences, scholars in the field of science communication have focused on the narrative experience itself (61–64). Narrative transportation, the extent to which one becomes engaged, transported, or immersed in a narrative, influences the narrative's potential to affect subsequent story-related attitudes and beliefs (56, 59). Personal storytelling not only humanizes the instructional message, including in ways that align with the principles of CTML, but also humanizes the process of science and the social and cultural aspects of doing science. Additionally, conveying real stories and emotions in diverse portrayals of science is an avenue for alleviating alienation of people traditionally excluded from science (65, 66). While the value of personal storytelling in science communication is well-documented as an effective approach to communicate

A.



B.

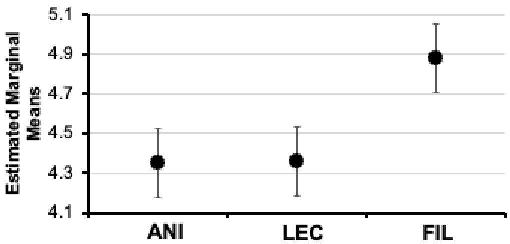
Dependent Variable: Attitudes of Science

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	7.212[a]	2	3.606	4.077	0.018
Intercept	3013.966	1	3013.966	3407.427	<.001
Video style	7.212	2	3.606	4.077	0.018
Error	234.400	265	.885		
Total	3264.00	268			
Corrected Total	241.612	267			

a. R Squared = .030 (Adjusted R Squared = .023)

FIG 5 Impact of video style on attitudes of science (A) Comparison of estimated marginal means of attitudes of science from responses to one item from students who watched the animation (ANI), recorded lecture (LEC), or short-film narrative (FIL) video. Error bars represent standard error. (B) ANOVA results measuring attitudes of science across video styles.

A.



B.

Dependent Variable: Engagement

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	16.59[a]	2	8.295	6.697	0.001
Intercept	5461.299	1	5461.299	4408.993	<.001
videostyle	16.59	2	8.295	6.697	0.001
Error	328.248	265	1.239		
Total	5866.75	268			
Corrected Total	344.839	267			

a. R Squared = .048 (Adjusted R Squared = .041)

FIG 6 Impact of video style on emotional engagement. (A) Comparison of estimated marginal means of emotional engagement combined from responses to two items from students who watched the animation (ANI), recorded lecture (LEC), or short-film narrative (FIL) video. Error bars represent standard error. (B) ANOVA results measuring emotional engagement across video styles.

complex information in an engaging and accessible manner, this approach is not widely adopted in STEM higher education, which often favors lecture-based formats with a focus on content delivery (56, 58, 67).

Recently, there has been growing evidence of the advantages of storytelling in science education, specifically in primary and secondary STEM classrooms. Biology instruction has a long history of incorporating a historical context to promote an appreciation of the nature of scientific inquiry (57). However, specific exploration of the implementation and impact of storytelling as a pedagogical approach in higher education is limited (68). Humanizing scientists in written educational materials (Project Biodiversify, https://projectbiodiversify.org/), especially groups historically excluded from science and representation in science education, increases student engagement (69). Scientist Spotlight homework assignments, which use storytelling to convey narratives of diverse scientists and their research, have been shown to significantly impact cognitive and affective learning outcomes in college science courses, including students' science identity and self-efficacy (2, 23, 47, 48, 70–72). Additionally, recent studies in chemistry education identify the potential of storytelling in educational videos as a tool to inspire and expand representation (73). Together, there is growing support for the untapped potential of storytelling as a pedagogical approach to positively impact affective learning outcomes and contribute to improving participation, belonging, persistence, and retention in STEM higher education.

TABLE 2 Example features of how CTML generative processing *personalization, voice,* and *embodiment principles* appear in three video stimuli[a]

	ANI	LEC	FIL
Personalization			
Storytelling	**Moderate**	**Moderate**	**High**
Style of Narrative	**Conversational**	*Formal*	**Conversational**
Research Narrative	*Low*	**High**	**High**
Personal Histories	*Low*	**Moderate**	**High**
Voice			
Human	**Human**	**Human**	**Human**
Tone	**Scripted upbeat female**	**Formal lecture voice**	**Conversational**
Politeness/Emotion	**Pleasant**	**Neutral**	**Pleasant, joyful, funny**
Embodiment			
Human presence	*Low*	**High**	**High**
Movement	*Low*	*Low*	**High**
Eye contact	*Low*	**High**	**High**
Facial expressions	*Low*	**Moderate**	**High**
Physical gestures	*Low*	**Moderate**	**High**

[a]Italic text indicates low-level feature incorporation, bold text alone indicates mid-level feature incorporation, and bold text and grey shading indicate high-level feature incorporation.

Videos in STEM higher education have been prominently used and studied as tools for content delivery, with a focus on expository or lecture-style videos and evaluating metrics of knowledge gains. The results of this study highlight the opportunity to explore the versatile pedagogical functions educational videos can have on both cognitive and affective learning outcomes, as well as how diverse video production styles may affect the different domains of learning. Educational videos offer an engaging and rich format for storytelling in STEM education to enable humanizing scientists and the process of science while also elevating diverse representation of scientists in education. Given the growing production and use of educational videos in higher education, it is a critical time to innovate the pedagogical uses of educational videos to extend beyond tools for content delivery and harness their potential as tools for engagement and affective learning in STEM.

Limitations and future directions

This study is exploratory and includes several limitations important to interpreting the results. The sample is a convenience sample of students who self-selected into the discussion section of a large introductory course, who may be more engaged with the course content and more likely to gain knowledge and feel positive affective outcomes from films (e.g., which could mean we see higher overall knowledge gain, regardless of the film, and possible higher levels of engagement with the films than might be the case with a different sample) (74). That we see differences in how students relate to each film is valuable for seeing how different styles and their associated features shape students' experiences, and it would be worth replicating in other classes and student samples. Furthermore, the robustness of the findings is limited by the measures used, which include single-item measures or multiple-items adapted from previous studies, and responses were not evaluated for validity and reliability, beyond inter-item correlations, in the context of this study. Future studies that carry out more robust and rigorous evaluations using multiple-item validated measures are needed to generate more generalizable insights about the impact of video style on student outcomes.

It is important to acknowledge that the lecture and film videos are not typical educational resources—they represent rare cases in which the original scientists narrate their own discovery (17, 75). This uniqueness may limit the generalizability but also provides a valuable lens to explore how personalized, relational, and embodied storytelling can influence students' affective experiences with science. It would be valuable to incorporate more films of these styles, to start to parse out what are effects of a particular film and its idiosyncrasies, and which might be effects of a style and that style's associated features. We incorporated CTML as a framework late in the analysis of this study and sketched out how the films of focus here might be understood under that framework. We used CTML to interpret the findings observed but do not present a comprehensive analysis. There are many variables relevant to video production and viewer experience that are not considered here but could be valuable measures for future comparisons (76, 77). For example, the videos each differ in length and, therefore, time-on-task, a variable that was not measured in this study. Future work could systematically test how CTML features—or features posited by other theoretical frameworks—appear in films and connect their appearance and other metrics of each video to viewer outcomes.

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DATA AVAILABILITY

All data collected and analyzed for this study are available upon request to the authors.

ETHICS APPROVAL

All research protocols were approved by the University of California Davis Institutional Review Board (1851786-1) and carried out in compliance with institutional and federal policies.

ADDITIONAL FILES

The following material is available online.

Supplemental Material

Supplemental material (jmbe00084-25-s0001.docx). Video assignment instructions, survey, and assessment questions.

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