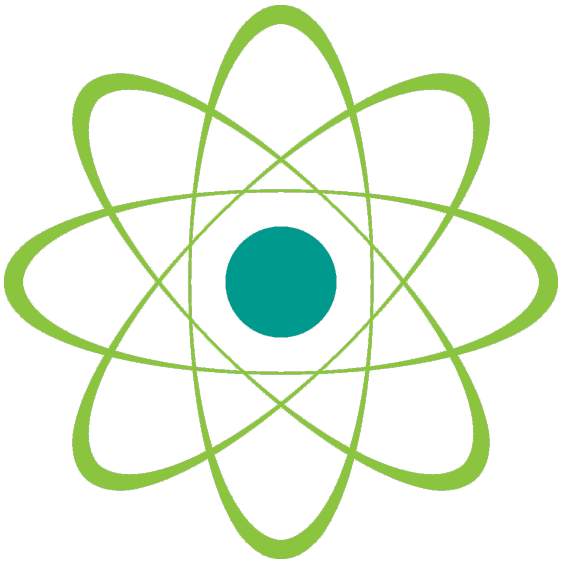

Enhancing Transmedia Capacity for STEM Journalism:

An Evaluation for the National Science Foundation

September 2019

Report Number M1901

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About:

See Change is a research institute devoted to studying and shaping behavior change programs for the greater good. Backed by theory, tested with data, and designed with care, we develop, implement, and evaluate efforts to solve issues that matter to us the most.

Knology is a collective of scientists, writers, and educators dedicated to untangling complex social issues and developing practical approaches to thorny problems.

PBS NewsHour is a wholly owned subsidiary non-profit of WETA. It is a public evening news broadcast known for it's in-depth, accurate reporting of current issues and events.

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Executive Summary

This report summarizes four years of collaborative research between public media journalists and behavioral science researchers. The National Science Foundation (NSF) funded this effort in order to better understand Early Career Adults' (ECAs; 18-35 years) media consumption habits and assess how media organizations can use *new media* and *transmedia* techniques (which use disruptive technologies and multiple media formats/platforms to construct stories) to reach, educate, and engage this audience with Science, Technology, Engineering, and Match (STEM) content. Through four years of experimenting, the partners of this grant - Knology [formerly New Knowledge Organization Ltd.] and PBS NewsHour - explored various methods to produce/distribute STEM-related content and provided valuable insight about the benefits of collaboration between journalists and researchers in an iterative production process.

The outcomes of this grant were significant—most notably, capacity building, increased production, research insights, and dissemination opportunities. The collaborative work between Knology and NewsHour created substantial capacity building opportunities for content creators within and beyond the PBS system. NewsHour staff experimented with new methods for producing and distributing STEM media content, building internal capacity, and disseminated insights gained throughout the process in order to educate colleagues and peers. Through this process, the team hopes that content creators and journalists across the mediasphere are better educated about how to better engage younger audiences with STEM-related content.

Throughout the grant, NewsHour and Knology's research yielded a variety of contributions for both knowledge advancement and the provision of advances in informal STEM learning for society writ large. In addition to increased volume of non-traditional STEM content produced through this work, the research proposes a variety of production strategies that may be more effective than current strategies at fostering audience engagement—particularly among ECAs. Additionally, the research process itself exemplifies a real-time collaboration between researchers and practitioners and the outcomes demonstrate the compelling media that this sort of collaboration can yield.

Building upon the promise of this work, we have identified three recommendations to help maximize the impacts of the insights gained through this research:

1. Media organizations should consistently try new production and distribution strategies in order to improve engagement among their audiences
2. Researchers and journalists should partner in order to evaluate production/distribution strategies and create more engaging content
3. Researchers/journalists should share their findings with others within and across disciplines.

Overall, the outcomes of this project served to both support a greater understanding of STEM engagement through journalism and provide a case study of how this work can be done in practice. We hope to see more work like this in the future media landscape.

Introduction

Project overview

Experiments in Transmedia was a National Science Foundation (NSF) Advancing Informal STEM Learning (AISL) grant co-led by PBS NewsHour ("NewsHour") and Knology (formerly New Knowledge Organization Ltd.). This grant focused on how early-career adults (ECAs; ages 18-35 years) engage with on-air and online science content produced by NewsHour, and worked to assess what methods are most effective in improving STEM literacy among young adults. This grant had an overarching goal of exploring the capacity for real-time collaboration between a research organization and a newsroom and therefore relied on an iterative process of production and evaluation.

See Change Institute ("See Change") served as the external evaluator for this research to assess the outcomes and potential impacts of the project. As the evaluator, See Change conducted two sets of interviews with members from the Knology and NewsHour teams (during Years 1 and 4 of the grant), conducted an experimental test examining ECAs' and non-ECAs' preferences for story content and platforms, and completed a content analysis of NewsHour's Year 2 and Year 3 STEM content. Where relevant, the results from these research activities are incorporated into the evaluation.

Goals

Experiments in Transmedia intended to facilitate **learning** and **capacity building** at NewsHour (and beyond) through research into ECAs and experimentation with different types of media and distribution strategies. Per the grant proposal, this is expressed through two primary goals:

1. Understand how ECAs engage with STEM media.
    a. This includes determining what type of information presentation works best to improve science literacy among this cohort through studies of ECAs' behaviors--particularly, ECAs that have historically been excluded from STEM. Including this traditionally excluded subpopulation required determining how to frame science content in a way that is culturally relevant and more readily contextualized to this group. Additionally, the research sought to distinguish any significant differences in content consumption by age or social network within this cohort.
2. Explore how informal science education media projects can use different media-based tools (ie. broadcast news, social media, and websites) to create transmedia and other content that improves information communication and increases STEM engagement.
    a. This includes experimenting with various mediums, platforms, story structures and methods of distribution. This relied on strategies unfamiliar and new to PBS Newshour and therefore building internal capacity to successfully execute on these new strategies was nurtured throughout the research and learning process.

Literature review

STEM job markets and wages have grown faster than any other field over the past decade (Fayer, Lacey, & Watson, 2017). With threats of climate change, antibiotic resistance, cyber-attacks, and other STEM-related crises looming, it is more important than ever that society is STEM-educated and prepared for the future.

Decisions about how to address current and forthcoming global issues will fall into ECAs hands and it is essential that they are equipped to handle them. Finding ways to communicate STEM knowledge and news to ECAs in an engaging and effective way should be a top priority, which is why this grant focused on developing new media strategies to reach this audience.

The term **new media** refers to types of media that rely on/are created specifically for dissemination via digital technologies and the Internet (Manovich, 2001). Rather than accessing news through traditional **media** (i.e., physical devices used to access content), such as television or newspaper, an ever-increasing number of people (especially young people) are using social media and other online **platforms** (i.e., the institutions that distribute/host content and may or may not be responsible for creating it) as their main sources for news (Fraser et al., 2018; Matsa & Shearer, 2018). This trend is exemplified by NewsHour's aging broadcast audience, who are 60-69 years old on average. In fact, prior to this grant, even NewsHour's online audience primarily consisted of adults older than 40 years (Fraser et al., 2018).

This generational gap in NewsHour's audience (and television news audiences in general, Matsa, 2018) called for the investigation and development of production strategies that appeal to ECAs. In order to actively engage ECAs with STEM topics, it is important to meet them where they are (i.e., online) with content that is relevant to them. However, engaging this audience requires more than simply disseminating the same content across different platforms (i.e. **cross-media**). A broadcast video posted on Twitter, for example, is likely not enough to both increase and sustain engagement among ECAs. New production strategies need to adopt a multifaceted approach that takes into consideration the interactions between distribution platform, **channel** (i.e., the particular stream of content being shared on a platform), story **format**, and audience expectations and preferences.

Transmedia storytelling is a production and distribution strategy that uses several types of media and platforms to tell many different stories within a single **topical universe** (i.e., the shared issue, concern, or series of events in which a story is embedded). In transmedia storytelling, content is produced to take specific advantage of the affordances of different media platforms. Rather than telling the same story using multiple different formats (i.e., **multimedia**), each piece of content created for a transmedia story has a unique contribution to the narrative. As Moloney (2014) states, the purpose of transmedia is "to lengthen engagement with a story by not repeating itself."

Moreover, transmedia storytelling offers multiple points of entry into a topical universe. It attempts to not only meet the audience where they are at a given moment but to meet them in multiple places at multiple moments throughout their daily lives. Transmedia storytelling creates

a pervasive experience by presenting pieces of the story on various platforms and in a variety of formats, but it also relies on techniques unique to these platforms to interrupt and permeate the audience's daily lives (Gambarato and Tárcia, 2017).

In theory, this kind of consistent exposure to novel stories within a single topical universe makes that topic more cognitively accessible (Zillman, 2002). This accessibility can not only impact the perceived relevance of an issue, but it can also prime what people notice in day to day lives and influence the conversations people have with other people (Eden et al., 2014). Transmedia storytelling is capable of engaging audiences both directly and indirectly to increase society's overall understanding of an issue. Although transmedia storytelling has primarily been used to promote a brand or a piece of fictional literature (e.g., *Harry Potter*), journalists can also adopt this strategy to spark civil discourse about STEM-related news and topics.

Transmedia strategies used in STEM journalism creates opportunities to reach audiences that might otherwise remain uninvolved. This includes people who have traditionally been excluded from STEM fields, such as women and African-American and Latinx people (Landivar, 2013). A model for transmedia journalism can ultimately increase societal engagement with STEM content and help create a more science-literate society.

This research, built upon the lessons uncovered through the literature review, initiated a body of work that began to define and explore the transmedia journalism paradigm. This paradigm is the capacity required of a newsroom to effectively produce and distribute content that educates and engages a specific audience in a specific thematic realm of content. It is important to understand how audiences engage with different types of media platforms and channels—specifically as it relates to the targeted themes. The paradigm evolves as an understanding of the audiences and platforms expands. The newsroom is then able to translate this understanding into the creation of quality content, customized to leverage the uniqueness of each individual distribution method.

The number of resources necessary to develop transmedia stories is higher than the resources required for a single story, even if that single story is multimedia. This research examined a case study of a transmedia series, as well as several partial transmedia and multimedia pieces that were produced during the course of the grant period. This research examined the different production needs and the required resource-intensive production capacity. However, the bulk of the research revolved around developing an understanding of how ECAs engage with media in order to inform the creation of transmedia content in the future.

Partners

The complementary expertise of the two main partners in this project— PBS NewsHour (journalism) and Knology as (research) — lends itself well to the goals of the grant. The following section outlines each of these organizations' qualifications and value to this project.

PBS NewsHour

PBS NewsHour has a long-standing reputation and extensive experience in producing in-depth, accurate news. It is a wholly owned subsidiary non-profit of WETA. Americans have consistently rated PBS as the most-trusted news institution in the country (PBS, 2019). NewsHour continues to air daily on over 350 public broadcasting member stations in the United States, and daily/almost daily on stations in at least five other countries/regions around the world. NewsHour produces hundreds of hours of in-depth news coverage about politics, culture, health, technology, etc. each year. Their experience in in-depth journalism and their international reputation make them an ideal partner for this research.

PBS NewsHour has been involved with several previous NSF grants. This previous experience with NSF grants highlights NewsHour's ongoing efforts to incorporate accessible STEM content into their programming.

Knology

Knology describes itself as an "interdisciplinary social science think tank" that collaborates with "change-makers" to understand attitudes and behavior related to the environment, health and wellness, media, and culture.

Members of the Knology team are trained in mixed-methods media research and have extensive knowledge of media studies literature (both research and theory). The co-Principal Investigator for this project, Dr. John Fraser (Knology, CEO & President) was an adjunct professor at Indiana University Center for Urban Public Health and the Editor-in-Chief of *Curator: The Museum Journal* and has worked on many NSF grants related to science education in the past.

Other members of the Knology team include lead researcher, Jena Barchas-Lichtenstein, a linguistic anthropologist experienced with mixed-methods communications and education research. The Knology team's previous experience researching informal STEM learning, past partnerships with media organizations, and familiarity with both qualitative and quantitative research methods make Knology a highly qualified partner for this research.

Approach

News consumption and news production need to be studied together, rather than in isolation, to fully understand both practices (Barchas-Lichtenstein et al., 2019). The lack of adequate feedback about what production strategies did or didn't work and why is a key challenge in developing effective strategies for communicating STEM information to mass audiences. Bringing together a news organization with a research organization to develop and **evaluate** their production strategies, this unique partnership between journalists and researchers can help overcome this challenge.

In this project, the development of new media strategies was paired with empirical research conducted by the Knology team. This research created a feedback mechanism wherein NewsHour would experiment with new strategies, Knology would assess the impact and share their findings with the production team, then the production team would use that feedback to inform future content production. This systematic approach followed an underlying principle of critical theory: the idea that "ongoing critique" of any and all theories is a necessary component in the pursuit of knowledge and truth (Giroux, 1983). In other words, one cannot understand reality without critically assessing causality (Freire, 1974).

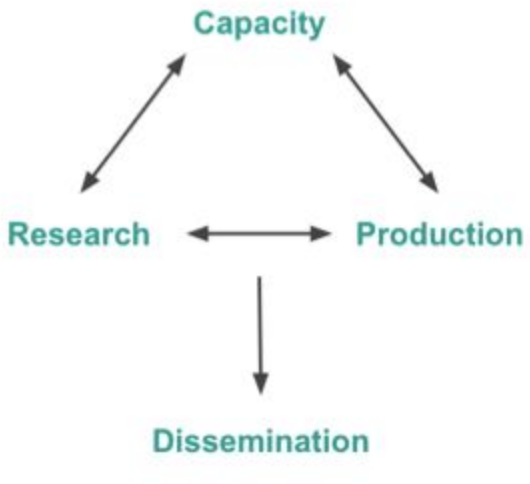
As part of this iterative process of production and evaluation, the Knology research team and NewsHour production team met quarterly to share ideas and findings and reflect on the content production process. These meetings offered opportunities for both NewsHour and Knology to think critically about their STEM communication strategies and work together to improve them. This process was key to the critical pedagogical approach that this project took. **Critical pedagogy** focuses on developing one's **critical consciousness** (i.e., one's ability to accurately perceive reality, and thus intervene in effective ways, Freire, 1974), to help learners question, challenge, and even undermine a prevailing paradigm. Giroux (1983) argues that, by examining existing hegemonic systems, we can understand that these systems are not based on objective facts, but rather "historically contingent contexts" (p. 8).

In this case, the "prevailing paradigm" refers to traditional journalistic production techniques. For example, traditional broadcast pieces use an expert and secondary person to *speak* for the audience and therefore "position their audiences as overhearers rather than interlocutors" (Barchas-Lichtenstein et al., 2019). However, there is little research that assesses whether this is actually the most effective way to reach people, especially given the dramatic shift in media consumption habits over the last decade (Mitchell, 2016). NewsHour recognized this lack of empirical research and partnered with Knology to improve their objective understanding of reality and "intervene" in ways that actually increase audience engagement.

Not only did this research intend to improve understanding of media engagement, but it also intended to establish a new model for research on mass media and communication that fosters these valuable relationships between researchers and journalists. These symbiotic relationships provide the foundation for the critical thinking that will ultimately reshape the media landscape and improve STEM and Media literacy throughout society.

Accomplishments

The activities in which NewsHour and Knology engaged as a result of this grant led to four key accomplishments: Capacity building, production, research, and dissemination. As seen in the Figure (*right*), capacity building, research, and production all reinforced each other as part of this project's iterative process. For example, building capacity increased the amount and variety of STEM content produced. These production changes then aided Knology's research activities, which, in turn, increased NewsHour's capacity and informed production strategies. This process allowed for rich learning experiences among both the NewsHour and Knology teams and provided opportunities to disseminate research findings to both academic and journalist audiences. The following sections go into more depth about what each of these accomplishments entailed and how the grant facilitated them.



Capacity building

One of the key goals of the grant was to build NewsHour's capacity to produce STEM content geared toward ECAs. To do so, NewsHour and Knology engaged in several capacity-building activities, including hiring new staff and participating in training and professional development opportunities.

Training and professional development

As a result of this grant, NewsHour added a second science producer, continued to support the existing position and hired two STEM-focused news assistants. Over the course of the grant, NewsHour employed a total of eight STEM news assistants, each serving six-month or full-year terms (depending on when they were employed during the grant period). News assistants served a unique role, as members of both the production and the target audience (i.e., 18-35 year-olds). In addition to building capacity in terms of sheer numbers, the news assistants also provided invaluable insight into how they and their peers engage with social media, giving the production team ideas for new strategies.

Funding from the grant also allowed NewsHour to hire freelance producers to help create additional kinds of STEM content; especially field tape pieces. The ability to hire freelance producers was integral to the creation of NewsHour's *Leading Edge* segment, a weekly science broadcast series that airs every Wednesday.

NewsHour supported professional growth for existing staff with training in different techniques

and skills, such as video editing, field production, and live streaming. With more team members possessing the necessary technical skills to produce STEM content, NewsHour was able to produce and adapt more content for multiple platforms in less time.

Moreover, the production team's participatory action research meetings with the Knology team convened four times a year. These research activities also served as professional development opportunities. The production team was able to articulate and reflect on their approach to STEM content production and describe the new strategies they tried, which helped them develop a more intentional process for future content production. Knology was able to gather qualitative data about NewsHour's learning and capacity building progress. Finally, Knology was able to share their research findings with the production team, so that the team could use the findings to inform content creation. These quarterly production meetings were a key activity for building capacity. The emphasis on reflection, intentionality, critical thinking and feedback as essential components of the production process fostered learning and growth in an organic and sustainable way.

The past news assistants' current positions, served as a key piece of evidence that highlighted the increased capacity to create STEM content for ECAs, both within NewsHour and the STEM mediasphere as a whole. Of the eight news assistants, one remains a news assistant at NewsHour, two continued onto other positions at NewsHour, and five others went on to accept jobs related to communications, video production, and STEM writing with other organizations (see Table 1).

Table 1. STEM news assistants: Where are they now? (as of May 23, 2019)

Name	Current position
Lora Strum	Audience Engagement Specialist, *PBS NewsHour*
Leigh Anne Tiffany	Communications Specialist, *Defenders of Wildlife*
Kristin Hugo	Freelancer, *National Geographic*, *Ripleys*, *Newsweek*
Andrew Wagner	Writer/Video producer, *AAAS/Science Magazine*; Web editor, *WJLA*
Teresa Carey	Science writer, *National Human Genome Research Institute*
Rashmi Shivni	Technical writer/Business analyst, *FDA*
Jamie Leventhal	Video producer, *PBS NewsHour*
Vicky Stein	Current news assistant, *PBS NewsHour*

Expansion of available STEM content

This section discusses the impact of the grant on the production of publicly available STEM content to advance public literacies, NewsHour's experimentation with transmedia storytelling, and the insights and techniques used to produce new kinds of content.

STEM stories

During Years 2 and 3 of the grant, NewsHour produced at least 522 STEM-related stories; 234 (44.8%) in Year 2 and 288 (55.2%) in Year 3.[1] Not only did the number of STEM stories significantly increase between Years 2 and 3 ($p < .05$), but the proportion of STEM stories originating from "non-traditional" media platforms (i.e., social media) also appears to have significantly increased from Year 2 (7.7%) to Year 3 (16.7%; $p < .001$). Table 2 shows the observed and expected counts for STEM stories by a platform each year. The expected counts (in parentheses) reflect the number of stories one would expect to observe in each category if there had not been a significant increase from Year 2 to Year 3.

Table 2. Observed and expected counts of Years 2 and 3 STEM content by platform

Media Platform	Year 2	Year 3
NewsHour Broadcast	55 (72)	105 (88)
NewsHour Website	161 (133)	135 (163)
Non-Traditional Media	18 (30)	48 (36)

In addition to increased production of diverse and interdisciplinary STEM-content, this grant also facilitated the development of multiple new science segments, such as the *Leading Edge* and *ScienceScope* segments.

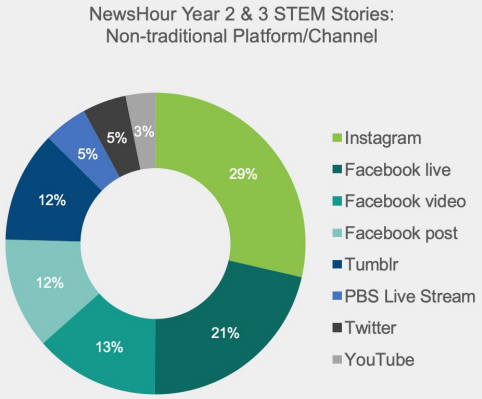
Prior to the grant, NewsHour produced a weekly science piece for Science Wednesday on their website (previously Science Thursday). The majority of these pieces were text-based articles that were not necessarily incorporated into NewsHour's broadcast or social media. The *Leading Edge* segment replaced Science Wednesday as a weekly *on-air* segment featuring veteran journalist Miles O'Brien. The *Leading Edge* offers "in-depth reporting on relevant and timely science and technology every week on the national nightly news broadcast." The series is also distributed across NewsHour's social media platforms (PBS NewsHour, 2016). Barchas-Lichtenstein et al. (2019) describe this segment as "serious but not academic," intended for a general audience in order to emphasize science as an "everyday occurrence." These stories are typically 6-10 minutes long.

[1] This data came from See Change Institute's content analysis. Note that these are conservative estimates, as these numbers do not necessarily account for all of the STEM-related content produced *outside* of NewsHour's science team.

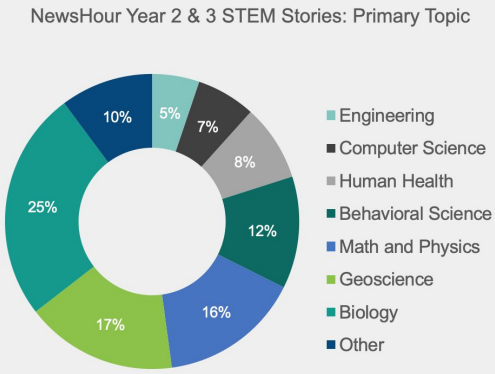
NewsHour STEM content: A closer look

See Change Institute conducted a content analysis of NewsHour's STEM story production during the second and third year of the grant. Here is a closer look at the STEM content distribution that emerged from that analysis.

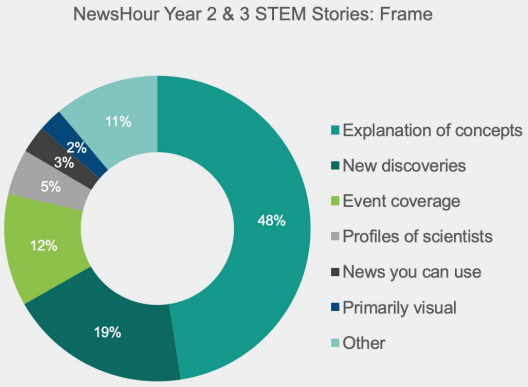
Non-traditional platforms. Of the non-traditional platforms that NewsHour used, Facebook was the most common (47% of non-traditional content), followed by Instagram (29%). Within Facebook, NewsHour used Facebook live most frequently, followed by Facebook video, and Facebook posts. NewsHour also used social media to promote upcoming content on other platforms. While the See Change Institute did not include promotional content in their content analysis, it is still important to recognize NewsHour's use of social media for this purpose.



Topic. The See Change Institute coded stories for the primary and secondary topic(s) based on the STEM content areas defined by the NSF. NewsHour's STEM stories addressed a wide variety of primary topics, including biology, geoscience, and math and physics. Most stories also discussed at least one to two more secondary topics (on average, each story addressed two to three topics total) (Fraser et al., 2018; Roberts et al., 2017), highlighting the interdisciplinary nature of STEM research and reporting.



Story Frame. The See Change Institute coded the frame of each story from Years 2 and 3 of the grant. Framing codes were adapted from the Pew Research Center's 2018 assessment of science content on Facebook (Hitlin & Olmstead, 2018). This Pew report defined the primary frame as the "main goal or focus" of a story. The majority of NewsHour's STEM stories were framed as *explanations of concepts* (nearly half), followed by *new discoveries*, and *event coverage*.



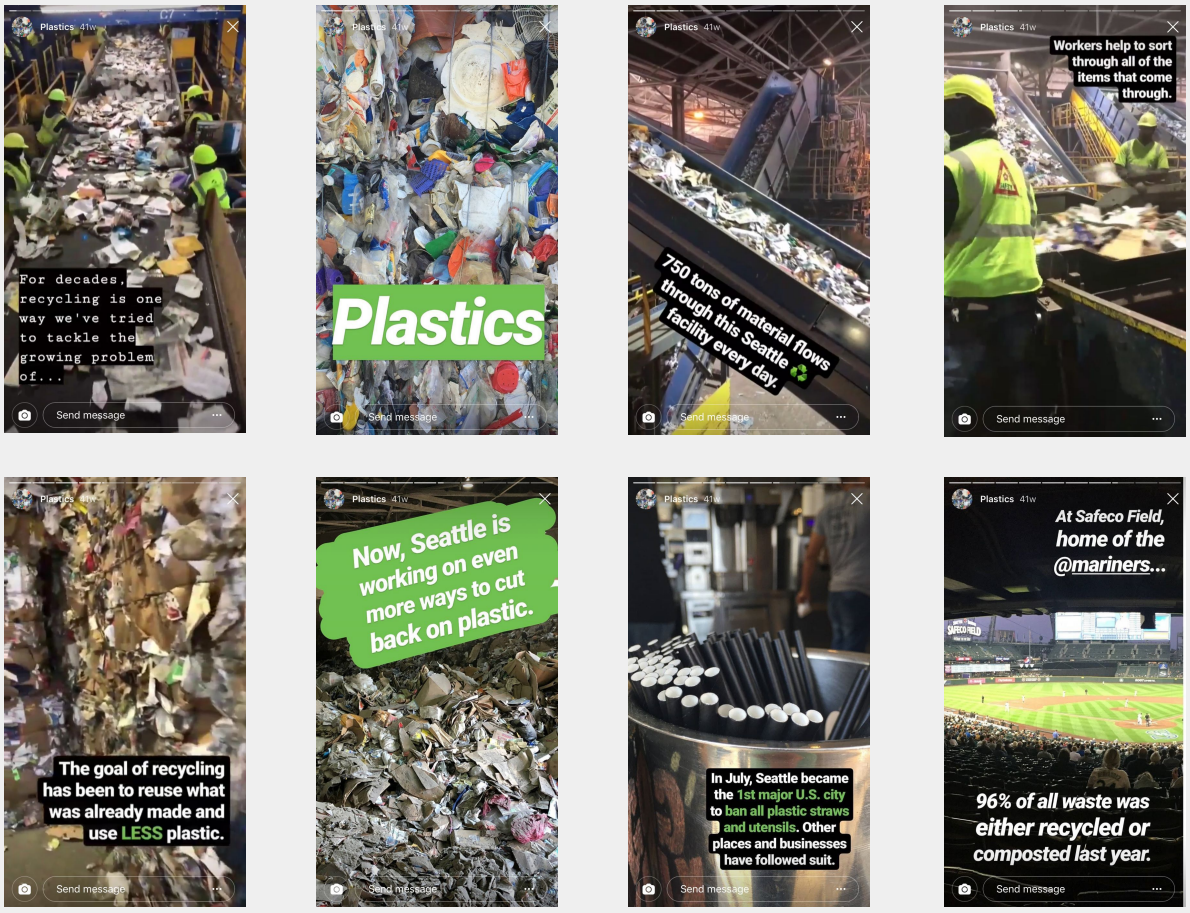
The *ScienceScope* segment, on the other hand, was originally developed as a social media series, but eventually moved to NewsHour broadcasts and website articles. These pieces go into detail about a specific scientific research project or discovery. The videos use a straightforward, explanatory, and relatively informal approach and are characterized by high information density, early college-level vocabulary, and bits of humor. *ScienceScope* videos tend to speak directly to the audience, rather than placing them as overhearers. These pieces are intended for audiences with a moderate degree of science literacy and tend to use more graphics/animation than a typical broadcast piece (Barchas-Lichtenstein, 2019).

Traditional broadcast	ScienceScope
 *Host as a conversation facilitator; positions audience as overhearers*	 *Host as a presenter; speaks directly to the audience*

While the *ScienceScope* segment moves away from the traditional model for STEM reporting, it is still usually embedded within more traditional platforms. As NewsHour experimented with social-first content, they also began developing content in formats that were native to specific social media sites. For example, NewsHour used Facebook Live to cover several topics. This content is longer than broadcast content (> 15 minutes) and usually features a live conversational interview between the news correspondents and an expert in a given field of research. Viewers are able to ask questions in the comments as they watch and the expert will answer a selection of them as part of the conversation. NewsHour has also started using Instagram stories as a way to either recap or provide background information on STEM news stories (see below). The ability to create this type of content highlights the increased capacity of the NewsHour team to reach audiences in non-traditional ways (in theory, ECA audiences), which is essential for engaging viewers and creating transmedia content.

Non-traditional format case study: *Plastics* Instagram story

Instagram stories have an especially unique format, as they consist of a series of 5-10 second clips/photos with a vertical aspect ratio. In order to tell a story with these limitations, these stories tend to be text, graphics, and animation heavy. The following screen captures show the first eight parts of a 10-part Instagram story about plastic pollution.



Transmedia stories

As the production team gained more skills with emerging technologies, they were able to increase their production of transmedia STEM content, in addition to individual STEM stories. To reiterate the distinction between transmedia storytelling and other production strategies, "[a] transmedia story unfolds across multiple media platforms, with each new text making a distinctive and valuable contribution to the whole. In the ideal form of transmedia storytelling, each medium does what it does best" (Jenkins, 2006, p. 95). While NewsHour experimented with transmedia storytelling for a variety of topics, the most notable case of transmedia storytelling was a week-and-a-half long series on the opioid epidemic called *America Addicted* (see below).

Transmedia case study: *America Addicted*

America Addicted consisted of 11 broadcast pieces, three on-air segments, eight web pieces, two Twitter chats, two Facebook Live sessions, one livestream of a Senate hearing, and one interactive poll. In addition to originating from a variety of different platforms, the majority of this content was also shared/promoted across platforms, including Facebook, Twitter, YouTube, and Periscope.

The broadcast pieces alone totaled to nearly 2 hours of content. Each piece had a different focus. The series opened in Huntington, WV, the "epicenter of America's opioid epidemic," showing the overwhelming impacts of opioid addiction on everyone, including opioid users, first responders, business owners, and newborns. This was followed by pieces about the science of opioid addiction, the socio-political context of the crisis, the impact of opioid addiction on the workforce, and responses to the crisis. The 3 other on-air pieces were a series introduction, which explained the history and magnitude of the crisis, a #BriefButSpectacular segment talking about addiction and recovery, and a first-person narrative about a mother's experience with her teenage son's addiction.

Other non-video web articles focused on topics, such as how to have a conversation with your kids about opioids, disagreements about using drugs (i.e., Subutex) to treat opioid addiction, and safe pain medication disposal, among other things. Facebook Live videos included a live discussion and Q&A about the opioid crisis in general and a live conversation about how schools can educate students on the dangers of opioid addiction. NewsHour also hosted multiple "NewsHour chats" on Twitter, where they posed a series of questions related to the opioid epidemic to facilitate discussions about each topic in the responses.

America Addicted acts as an exemplar of transmedia journalism. Each piece of content approached the topic with a different perspective, adding unique value to the story of the opioid epidemic. The use of Facebook, Twitter, Periscope, YouTube, and Broadcast television provided multiple entry points for NewsHour's audience, which is an essential aspect of transmedia storytelling. Finally, the use of interactive storytelling strategies, such as Twitter chats, polls, and live Q&A sessions may have drawn in audience members who otherwise would not have gotten involved with the series.

Although *America Addicted* was the most extensive transmedia piece that NewsHour produced over the course of the grant, they frequently utilized cross-media, multimedia, and transmedia techniques to tell important STEM news and **evergreen** (i.e., not inherently relevant to current events) stories about other topics. Table 3 presents a series of stories that NewsHour covered using some type of cross-media, multimedia, or transmedia technique. All of these stories included some traditional and some social media content, including traditional content that was adapted for social media in order to meet audience expectations for a given platform.

Table 3. Transmedia, multimedia, and cross-media case studies

Year	Topic	Description
1	Fireworks	4th of July story that included a web article on the science behind fireworks and Facebook Live video that expanded on their history.
1	Tree Frog Acrobatics	Facebook video, broadcast piece, article, and Instagram video of a slow-motion tree frog jumping and landing; format varied by platform.
1	Dolphin Sanctuary	Broadcast piece, Facebook, and Twitter video about a dolphin sanctuary, with second Facebook video and article about dolphin communication. Promoted on Twitter and Tumblr.
2	Lionfish Invasion	Broadcast piece 1 (additionally on YouTube) and 2, article, Tumblr and PBS infographics, about the threat of Lionfish in Atlantic reefs and potential solutions.
2	Vampire Bats	Instagram story, article (embedded Youtube video), and broadcast piece about vampire bats. Promoted on Twitter for Halloween.
2	Thirty Meter Telescope	Broadcast piece, Tumblr post (GIFs and quotes), and Facebook video about a controversial telescope that scientists want to build atop a sacred indigenous mountain in Hawaii.
2	TRAPPIST	Broadcast piece, article, Facebook Live video, and Tweets (1, 2, 3, 4, 5) covering the discovery of several potentially habitable exoplanets.
3	Elephant Seals	Article, Tumblr post, and Facebook video about elephant seals' ability to recognize other seals by their rhythmic calls.
3	Total Eclipse	Broadcast pieces (1, 2), articles (1, 2, 3), Facebook videos (1, 2), Facebook Live video, YouTube video, and Tumblr post related to the Total Solar Eclipse.
3	Hurricanes Harvey & Irma	Broadcast pieces (1, 2), articles (1, 2, 3, 4), Facebook videos (1, 2) and Facebook Live video of extreme natural weather events.
3	Toxic Butterflies	Article, interactive Tumblr post and Instagram video about non-poisonous butterflies that evolved to appear poisonous.
3	Kilauea	Broadcast piece, articles (1, 2, 3, 4, 5), Facebook videos (1, 2, 3), Facebook Live video, and Instagram photoset about the eruption of Kilauea, a volcano in Hawaii.
4	Hurricane Florence	Broadcast piece, articles (1, 2, 3, 4), Twitter updates (1, 2), and Instagram video/InstagramTV about meteorology and the Hurricane.
4	Plastic Pollution	5 broadcast pieces and 4 articles (series page), InstagramTV videos (1, 2, 3), and Facebook videos (1, 2) about the global plastic pollution.

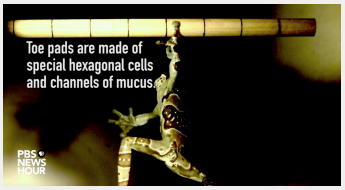
During Year 1 and Year 2, most of the case studies primarily utilized cross-media and multimedia strategies. In contrast, the stories from later in Year 3 and Year 4 are more representative of transmedia storytelling. This improvement in the quality of transmedia content exemplifies NewsHour's growing capacity to produce these in-depth series on STEM topics to engage broader audiences.

New media production techniques

As part of the process of creating content for non-traditional platforms, it was essential for NewsHour to develop production techniques that take advantage of the affordances of these platforms and recognize the audience's expectations for content on that platform. With input from the news assistants, the production team began experimenting with new story formats.

In particular, NewsHour focused on developing *social-first* videos, which are videos that are created, first and foremost, for social media (but are otherwise platform-agnostic; Barchas-Lichtenstein et al., 2019). In general, these are information-dense 2-4 minute long videos intended for a general audience. They are often humorous, lighthearted, and less formal than traditional broadcasts. If these videos have a host, the host usually plays a "presenter" role, speaking directly to the audience. NewsHour tends to use these videos to break down and explain a topic in detail or to share a breaking story prior to the nightly broadcast (Barchas-Lichtenstein, 2019). The science production team manipulated several other parts of the stories to increase engagement, within and outside this overarching category of social-first videos. Table 4 lists and describes some of these techniques.

Table 4. New media production techniques

Technique	Description and rationale
Digital explainer video	• Intended to explain or clarify complex concepts • Reduces barriers to entry by explaining concepts in a way that's easy to understand. • Often accompanied by a written piece for audience members interested in learning more. (Barchas-Lichtenstein, 2019).
Captioned videos	• 85% of all Facebook videos are viewed without sound (Patel, 2016) • Non-live social media videos have open captions • Videos rely only on images and explanatory captions to convey information (see screenshot) • Content is more accessible to people with hearing impairment and auditory processing difficulties • Allows viewers to fully engage with the content silently 
Aesthetic story	• Perceived relevance is key for audience engagement (Fraser et al., 2018) • Attract audiences because they are "gross, cute, funny, or just plain weird" (news assistant quoted in Barchas-Lichtenstein et al., 2019). • Attempt to "engage people who are visually oriented and interested in the '*color and texture*' of a story" (Fraser et al., 2018), but to whom the STEM focus of the story may be irrelevant.
No intro/outro	• Expect content to be short and get to the point quickly (Barchas-Lichtenstein et al., 2019) • Traditional broadcast pieces have an intro and/or an outro • Lengthy introductions create a behavioral barrier to engagement • NewsHour's social media content rarely contains a traditional intro/outro, even when adapted from a broadcast
"Non-science" lead-ins	• ECAs need to sense the relevance of a story immediately (Fraser et al., 2018) • Using a non-science lead-in, headline, caption, or intro to establish the broader relevance can increase reach by immediately capturing the audience's attention (especially non-STEM audience members)
Podcasts	• Increased popularity over the last several years; 40% of young adults ages 12-24 have listened to a podcast in the last month (up 10% from 2018; Peiser, 2019) • Since May 30, 2019, NewsHour produced a total of 25 science episodes (Apple Podcasts), ranging from 2-13 minutes each (7 minutes on average) • Discuss similar topics as other STEM content for that week in an audio-only format

Research

Knology and NewsHour engaged in a variety of research efforts that were essential for promoting a better understanding of media consumption habits among ECAs and non-ECAs. Below, the See Change Institute reviewed of these research efforts, including the participatory action lab, audience surveys, focus groups, and experimental evaluation of the opioid series.

Participatory action research

Based on the idea that one cannot study news production and news consumption in isolation of each other, Knology took a **participatory action** approach to assess how NewsHour is adapting its STEM content to address the realities of today's media consumption. Whyte, Greenwood, and Lazes (1989) describe participatory action research as research in which the people being studied actively engage with the researcher throughout the whole research process. Accordingly, this research relied heavily on qualitative input from the news assistants, who were uniquely positioned as members of both the target audience and the production team.

While participatory action methods are less common in journalism research (Barchas-Lichtenstein et al., 2019), scholars suggest that they provide useful insights into understanding journalism practices in the new media landscape (Niblock, 2012). The direct collaboration between journalists and researchers through this grant makes these methods both feasible and mutually beneficial. Researchers gain insights into the production process, while journalists learn and build capacity as they incorporate feedback from the research into their production strategies. The various qualitative methods used to conduct this research are summarized in Table 5.

Table 5. Participatory action research methods

Method	Description
News assistant journal entries	• Bi-weekly/monthly entries on suggested topics: Daily activities, critiques of the STEM mediasphere for ECAs, other experiences relevant to the research (Fraser et al., 2018)
Annual news assistant interviews	• Individual 30-minute exit interviews • Goals: discuss their experiences, follow up on specific questions, and solicit feedback (Fraser et al., 2018).
News assistant roundtables	• 6 news assistants and other non-science team members • Based on news assistant journal entries (Fraser et al., 2018)
Production meetings	• Quarterly meetings to "Engage in deep reflection on media production, results, and theoretical explorations about cause and effect." (Barchas-Lichtenstein et al., 2019, p. 7)

The overarching finding of this research identified that people prefer stories that are "exemplars of their **genre,**" which refers to the "formal features and structures" that, together, offer information about the type of content or "communicative event" in which the audience is about to engage (Barchas-Lichtenstein et al., 2019, p.12-14). People hold different expectations for content on different platforms, and in order to engage audiences, the content on these platforms needs to match expectations.

> *"[T]he same content is allowed to take different shapes depending on the platform… a broadcast segment about flu season would have the anchor and an expert sit for a discussion, while the same topic would be addressed on Facebook as a Q-and-A, and on Twitter as a Twitter Chat."*
>
> *-Year 3 New Assistant*

Barchas-Lichtenstein et al. (2019) note that there are systematic differences in content expectations between broadcast and individual social media platforms (e.g., differences in privacy settings, ability to share and add commentary, and limits on text length). While the news assistants and production team understood that these systematic differences existed prior to this research, the participatory action research allowed the team to articulate exactly what these differences are and create content accordingly. The news assistants noted that the expectations and participation structures for content on various platforms are dynamic, thus changing as the affordances of each platform evolve and the production team's capacity to produce social media content increases. The researchers and the production team worked together to identify some of the key underlying differences between platforms in order to consistently create engaging content for each. Table 6 outlines the key differences between expectations for social media and broadcast content.

Table 6. Audience expectations for broadcast and social media content

Broadcast	Social media
• More serious tone • Longer length (5-10 minutes) • Audience as an overhearer; high levels of mediation between the audience and expert/subject • High production value, less spontaneity • Greater psychological distance between audience and host • More reflection and in-depth coverage	• More humorous or informal tone • Shorter length (2-4 minutes) • Audience as an interlocutor; host or expert speaks directly to the audience with minimal mediation • Less scripted, polished, and produced • Host comes across as more relatable • Immediate and ephemeral; expectations for more vulnerability and authenticity

In addition to platform expectations, Barchas-Lichtenstein et al. (2019) discuss the role of *style* and *medium* in setting audience expectations for content. For example, the role of verb tense in informing the viewer about whether the content is a news story or a feature/evergreen story. Barchas-Lichtenstein et al. (2019) note that news stories tend to use the *past tense*, while feature stories nearly always speak in the *present tense*. This signals to the viewer what they

are about to watch and sets expectations for that content. The medium also affects audience engagement with a piece, as it can completely change the participation structure. Barchas-Lichtenstein et al. (2019) discuss the differences between the identical article posted online versus printed in a newspaper. Online, the audience can directly engage with the author/editors and other audience members through the comments section, allowing for immediate feedback and discourse. In print, the process of contacting the author/editors not only takes longer but is also less public and affords fewer opportunities for discussion among audience members. When creating content, it is therefore important to consider how one wants their audience to engage in the content, as this can greatly affect the production strategy one ultimately chooses to use.

Participatory action research: Key findings
• People prefer content that meets their expectations for the genre • There are systematic differences in audience expectations within and between traditional and non-traditional platforms; producers should carefully consider audience expectations for a given platform when deciding how to present a story

Audience surveys

While the participatory action research offered useful insights about audience expectations for different types of content, Knology conducted audience feedback surveys to complement it. These surveys were intended to assess baseline media consumption habits and story impressions/preferences among the target audience.

Beginning in Year 1 of the grant, Knology employed Amazon Mechanical Turk to recruit a panel of 18-35 year olds who lived in the U.S. and were not currently in school to participate in the baseline and audience feedback surveys conducted in Years 2 and 3. They elected to work with this platform based on an investigative report NewsHour undertook and a fair-wage principle for remuneration. This panel ultimately consisted of about 1,270 members. The methods for these surveys are in Table 7.

Table 7. Audience feedback survey methods

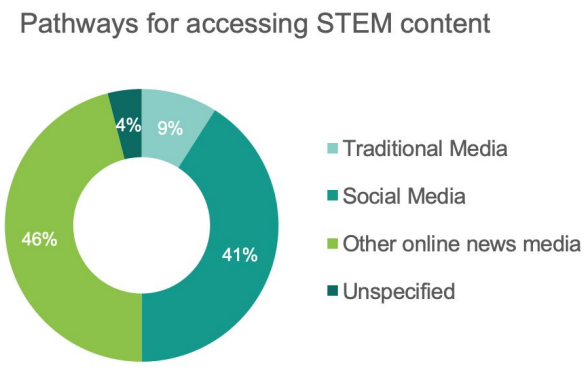
Survey		Methodology
Baseline Survey	Part 1	• Assess overall social media use and news consumption, interests, and sharing patterns (Roberts et al., 2017) • Questions about how closely participants follow different types of news (defined by scale and topic) and social media sites
	Part 2	• Discover how ECAs access and use STEM news • Participants: those who indicated that they follow "science and technology" news at least once per week in Part 1 • Asked how often respondents see, view, and share STEM / non-STEM stories
	General	• All answered demographic questions (gender, educational attainment, and race/ethnicity)
Audience Feedback Surveys	Year 2	• Tested different formats for six story topics (see Table 8)
	Year 3	• First Story: Repeated design from Year 2 (different formats) • Second Story: Manipulated video based on hypothesized factors that impact personal relevance (see Table 8) • Answered an open-ended question about story relevance
	General	• Randomly assigned to view/read one of the story variations • Answered questions about impressions, information sharing and seeking likelihood, and science identity • Answered demographic questions about their gender, educational attainment, and race/ethnicity

Baseline survey. Overall, 595 people participated and in Part 1 and 90 people participated in Part 2 of the baseline survey. Of the 595 people who participated in Part 1, about half reported they were male and half reported they were female. Participants reported being mostly white (78%) and holding relatively high levels of educational attainment (85% had at least some college education).

In Part 1 of the survey, Knology found that ECAs consume local and national news more often than international news (a few times per week vs. once per week), and most frequently consumed news about government and politics.[2] Science and technology news was the second most frequently consumed, at about once per week. Participants indicated that they share news relatively infrequently, but when they do, it is usually on Facebook.

[2] Note: This survey launched in close time proximity to the 2016 general election, therefore, this finding may not reflect ECAs' engagement outside of an election season.

In Part 2 of the survey, Knology found that the majority of respondents (72%) accessed STEM news through social media or other online news media outlets, with only 4% getting STEM news from traditional media, see Figure (*right*). The most frequent platforms used were Facebook, Reddit, and YouTube, respectively. These findings support NewsHour's decision to direct their efforts toward expanded online STEM media content, as the internet is the primary place where the target audience is accessing their news.



Knology also inquired about the reasons people choose to engage with STEM news. 73% of respondents said that their interest about the subject matter was a primary motivator, while 22% indicated personal relevance as a primary motivator. Finally, like respondents in Part 1, Part 2 respondents were also unlikely to share the content on their social media pages.

Audience feedback surveys. In Years 2 and 3, Knology conducted audience feedback surveys with participants from the MTurk panel to determine the target audience's preferences for different story formats (e.g., varying length, depth, use of visuals and captioning). Table 7 outlines the methods for these surveys; Table 8 lists the story topics and formats tested.

Table 8. Story topics and formats for Years 2 and 3 audience feedback surveys

Story topic	Formats tested
Year 2	
Ocean Trash (*n* = 193)	Broadcast, short social video
Lionfish (*n* = 100)	Broadcast, infographic
Holograms (*n* = 100)	Article, short social video
TRAPPIST 1 (*n* = 150)	Article, broadcast, short social video
Ice Shelf (*n* = 100)	Broadcast, short social video
Tornadoes (*n* = 99)	Article, short social video
Year 3	
Lyme Disease (*n* = 303)	Article, broadcast, Facebook Live video
Dolphin Graveyard (*n* = 301)	Version 1 (original broadcast), Version 2 (reordered to begin with discussion of ongoing harm to marine life), Version 3 (Version 2 + opening sentence to increase empathy related to animal suffering)

Knology's analysis of Year 2 survey responses revealed that participants considered the article format to be less interesting than infographics ($p < .01$) and broadcasts (marginal, $p < .1$) and more difficult to follow than all other formats ($p < .01$). Participants were also the most likely to rate the article as too long compared to the other formats ($p < .0001$). Format did not have any significant impact on reliability, significance, or visual appeal ratings, nor did it impact information sharing/seeking intentions. This analysis also found that people with higher science identities had higher interest ratings, higher perceived accessibility ratings, and more positive length judgments than those with lower science identities ($p < .01$).

The Year 2 analysis focused primarily on respondents' impressions of the story, while Year 3 data analysis focused heavily on the role of personal relevance in story engagement. Knology's findings are based on the systematic coding of open-ended responses about the story's relevance. Intentions to share any of the stories on social media or via email were low, while intentions to share the story with others *in person* were higher. In-person sharing intentions were also highly correlated with information-seeking intentions. For all three types of sharing, personal relevance and science identity significantly increased sharing intentions (for one or both story topics). Knology did not find significant differences in any of these variables based on story format.

Regarding impressions for the Lyme disease story,[3] Knology again found that participants perceived the article to be less interesting than other formats. While there were some other differences between formats, Knology reasoned that these were likely a result of confounding factors (i.e., story frame[4]). For the Dolphin Graveyard story, participants considered Version 2 (discusses harm to marine life first, no opening sentence) to be less interesting and sadder than the other versions, suggesting that an empathy-eliciting lead-in may improve viewers' impressions of a story.

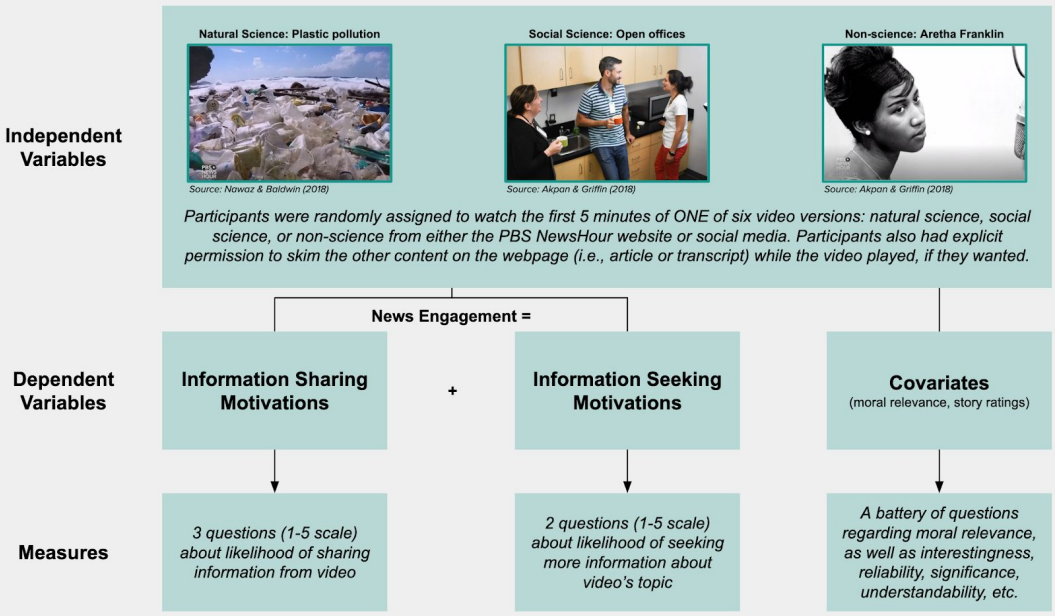
Audience feedback surveys: Key findings

- Participants primarily access STEM news through non-traditional platforms; interest in, curiosity about, and relevance of the story topic are key motivators for engagement
- Articles were often considered too long and less accessible and interesting than other formats
- Personal relevance and science identity were associated with more positive story impressions and increased information sharing and seeking intentions

[3] Note: Year 3 story impressions came from the open-ended responses, rather than the 7-point ratings of semantic differentials, as described in the results for Year 2.
[4] The broadcast piece focused on experimental procedures and vaccines for Lyme disease, while the other two videos focused on prevention and detection.

Supplemental audience feedback research

See Change Institute conducted an experimental test similar to Knology's audience feedback surveys in order to compare ECAs' and non-ECAs' engagement with and impressions of various story topics and platforms. The goals of this study were threefold: (1) validate and update Knology's findings, (2) evaluate differences in STEM engagement and impressions of STEM content between younger and older generations, and (3) examine the role of moral relevance and science identity/curiosity in people's receptivity to STEM content. This experimental testing included 6 conditions (2 variations of three videos) with a survey adapted from Knology's audience feedback survey (added closed-ended questions about moral relevance and science curiosity; see diagram). See Change collected a total of 2,020 valid survey responses (1,193 ECAs; 827 non-ECAs).



The statistical analysis revealed no significant effects of age or platform on any of the dependent variables. However, there were statistically significant differences in information sharing and seeking motivations based on the story topic. Participants who watched a video about plastic pollution indicated greater motivation to share the story or seek more information about the topic than those who watched a video about Aretha Franklin or Open offices ($p < .001$). While it is unclear whether the significant effect of topic was general (e.g., people are more interested in natural science) or specific (e.g., people find pollution more interesting than open offices or Aretha Franklin), one key takeaway from this research is that, in order to engage people with STEM content, media organizations *must* identify and create content on topics that viewers find relevant and interesting.

See Change also assessed the relationship between moral relevance, story impressions, science identity/curiosity, and engagement. All of these variables were positively correlated with information sharing and seeking motivations ($p < .05$). The more relevant the story was, the more positive the viewer's ratings, and the higher the viewer's science identity and/or curiosity, the higher the viewer's engagement. This finding validates Knology's previous findings that story relevance (qualitative) and science identity (quantitative) play significant roles in audience engagement.

Audience focus groups

During Years 2 and 3, Knology conducted audience focus groups to gain insight into how ECAs engage with the media to build STEM knowledge and determine which media formats work best for communicating STEM content to ECAs. During the first part, a Knology facilitator guided a discussion about media consumption habits related to STEM and non-STEM news. During the second part, participants watched a series of NewsHour STEM videos and provided their feedback about the videos. The questions that guided the discussion for each focus group are in Table 9. The specific methods and results for each set of focus groups are in their respective sections below.

Table 9. Guiding questions for Year 2 and Year 3 focus groups

Questions/Prompts
News consumption ● Show of hands: [Y3] ○ Who has a television at home? ○ Who has cable? ○ Who watches broadcast television on alternate platforms? ○ Who receives a physical newspaper? ○ Who watchest news at regular time on television? ● How often do you consume news? [Y2, Y3] ● How do you find your news (e.g., news websites, social media)? [Y2, Y3] ● Do you prefer to read articles, watch videos, or listen to news? Why? [Y2, Y3] ● What news topics are you most interested in? Why? [Y2, Y3]
STEM news consumption ● Can someone define STEM? What constitutes a STEM news story? [Y2, Y3] ● Can you give me an example of a STEM story you remember from the last few weeks? [Y2, Y3] ○ Why was it memorable? [Y2, Y3] ○ Did you share the story with anyone? Why or why not? [Y2, Y3] ○ Did you seek out more information about the topic? [Y2] ● How often do you consume STEM news stories? [Y2, Y3] ● How do you find your STEM news? [Y2, Y3] ● What STEM topics are you most interested in? Why? [Y2, Y3] ● Is it important that a STEM story have a human interest or moral component to pique interest? [Y2, Y3; **Note**: this was asked *after* viewing the clips in Year 3]

Table 9 (continued).

Video feedback

- What did you learn about this topic? [Y3]
- Which videos [segments] did you like most/least? Why? [Y2, Y3]
- What elements are/are not appealing to you (e.g. images, music)? Why? [Y2]
- Do you think different platforms appeal to different audiences? Why? [Y2]
- What elements are/are not appealing to 18-35 year olds? Why? [Y2]
- What were the biggest difference between the segments? [Y3]
- Which of the video segments did you find most relevant to you? Why? [Y3]
- Who do you think is the audience for each? Why? [Y3]
- Which format is best for STEM news? Why? [Y3]
- How likely would you be to click on a link to these videos on your own? [Y2, Y3]
- How likely would you be to share these videos with family or friends? [Y2, Y3]
- Is there anything else you would like to share about STEM news? [Y2, Y3]

Year 2 focus groups. In Year 2, Knology conducted focus groups of 18-35 year olds in Indiana, Montana, New Mexico, and New York. Participants came from a variety of socioeconomic backgrounds and occupations, including some in the media field. After answering questions about their STEM and non-STEM news consumption, participants watched four or five NewsHour STEM videos (each on a different topic, using a different format) and provided feedback according to the guiding questions in Table 9. See Table 10 for the description and feedback of each video. Knology gained the following insights regarding news consumption habits and effective STEM communication for this audience:

- **News consumption habits.** There were three types of news consumers in this age cohort: (1) those who continuously consume news, (2) those who check the news several times throughout the day, and (3) those who engage with the news sporadically. Although participants indicated that they engage with a variety of news formats, they primarily consume online audiovisual content. Several participants cited Facebook as the main source for news but mentioned that they are careful to only consume news that is recommended to them by a friend/family member or comes from well-cited and reputable sources. In general, participants noted that the reliability of the source was a key factor in their decisions to engage with content. When it came to STEM news, respondents indicated an interest in health and technology-related news, as well as news about local environmental issues. Participants asserted that perceived relevance was key for drawing them into both STEM and non-STEM related content (Roberts et al., 2017).

- **Effective STEM communication.** Participants emphasized that stories need to draw them in *immediately*. To do so, stories should start with some sort of "hook" and then immediately communicate the relevance of the story. Participants also indicated a preference for fast-paced, short content that followed some sort of narrative arc and had "tightly integrated storytelling elements," such as music, images, and infographics. Moreover, to prevent news avoidance, focus group participants recommended including

some sort of solution or call to action in upsetting stories so the viewer doesn't only dwell on the negative facts. Finally, participants recommended including links for follow up information with each story to make it easier for interested viewers to learn more about the topic. (Roberts et al., 2017)

Table 10. Content feedback from Year 2 focus groups

Topic	Platform/ Format	Description	Participant feedback
Brainwaves	Traditional broadcast	About a new technology that uses brainwaves to allow quadriplegics to type sentences by thinking (Length: 6:26)	Felt the style of this video was dated and there was a low level of overall appeal
Ice Shelf	Facebook video	About a growing rift in an Antarctic ice shelf and the global consequences it will have when it breaks off (Length: 1:00)	Did not find this video inspiring or appealing; did like the use of metaphors to explain it in an accessible way
Gecko	Instagram video	Animation about a newly described gecko species that sheds its scales to escape predators (Length: 0:10)	Found this video visually pleasing, but felt the content was more of a fun fact than news. Recommended a link for info.
Lionfish	ScienceScope broadcast	About a robot that hunts Lionfish in order to mitigate the devastating impact of this invasive species in Atlantic reefs (Length: 4:55)	Some preferred this to traditional broadcast or social media piece due to the humor and accessibility. Some felt the tone was directed towards a younger audience and did not explain the relevance of the problem.
Body Parts	Facebook video	About keeping and preserving body parts (teeth, limbs, organs) after they've been removed from one's body (Length: 1:14)	Favorable opinions; felt the subject was relatable and wanted to learn more about her. Thought this would be a good video to share on social media.

Year 3 focus groups. In Year 3, Knology conducted paired focus groups of 18-35 year olds and 36+ year old adults in Denver, CO, Milwaukee, WI, and Atlanta, GA (six focus groups total). Knology used a similar semi-structured protocol as described above for each focus group. Unlike in Year 2, participants answered a short questionnaire about their engagement with legacy news outlets (including major news outlets in that city) before each focus group session began. After an initial discussion about news consumption habits, each group watched two videos about the *same* topic, presented in different formats (i.e., traditional broadcast vs. ScienceScope broadcast). The facilitator asked a series of questions about participants' impressions after each video (See Table 9). Responses from the older age group helped Knology determine where 18-35 year olds differed most from non-ECAs. Knology gained the

following insights about ECAs' news consumption habits and format preferences from these paired focus groups:

- **News consumption habits.** ECAs are more likely to use their phones and less likely to use a computer, television, radio, or print newspaper to access news than non-ECAs. ECA news consumption is characterized by fragmented reading/watching patterns, as they tend to jump around in an article or video to determine whether it's relevant before engaging further. Both age groups consume news from legacy outlets, with local newspapers being the most popular.

  > *"The news finds me"*
  >
  > *-Year 3 ECA focus group participant*

  Both age groups reported a mix of active and passive news consumption, but ECAs typically sought out content less frequently than the older age group. Non-ECAs tend to consider the source/news outlet to be a key concern, while ECAs are more interested in finding information about specific topics, leaving the news outlet as a secondary concern. Many ECAs reported using a news aggregator but recognized that the algorithms governing these sources do not offer a full picture of the mediasphere. When asked specifically about STEM news, some ECAs said that STEM topics are not particularly common within the larger media landscape, while others said that they come across a lot of headlines, but tend not to click on them. ECAs identified advancements in technology, ocean science, astronomy, "gross" science, and women in STEM as some STEM-related topics that interest them, especially when formatted as explainer videos.

  Finally, when asked about their sharing behavior and the likelihood of sharing the videos they had viewed in the focus group, ECAs said they typically only share stories that are personally relevant to them, and participants in each age group mentioned sharing content that they felt were related to some sort of moral injustice. When asked if they would share the videos they saw as part of the focus group, some participants indicated that they prefer to share content they feel they have discovered on their own and others are not aware of. In general, focus group participants are hesitant to share news stories due to concerns about the accuracy of the information and the reliability of the source.

- **Effective STEM communication.** Echoing the findings from the Year 2 focus groups and audience feedback surveys, the relevance of a story was a key motivating factor for news consumption. ECAs also implied a preference for shorter content, stating that the traditional broadcast video was too long and they would have skipped ahead had they been given the option. Some ECAs felt the ScienceScope piece was directed towards a much younger audience, but participants from both age groups still preferred this video due to its effort to involve the audience. The most notable finding, however, was that audiences are particularly interested in content that is "different or outside the norm of what one usually encounters," which includes "diverse gender and racial representation in STEM" (Fraser et al., 2018, p. 22).

Audience focus groups: Key findings
● Immediate communication of story relevance is essential for engaging ECAs ● ECAs prefer content that is short and fast-paced ● Participants in both age groups care about the reliability of sources ● Participants in both age groups like stories that connect to broader social issues, address novel topics and feature underrepresented people ● ECAs want calls to action and links for additional information to accompany stories

Opioid case study

As discussed above in the transmedia case study, NewsHour produced an extensive week-and-a-half long series on the American Opioid epidemic and administered controlled pre-/post-intervention audience surveys to determine the impact of this content on viewers' attitudes and knowledge about the Opioid crisis.

Pre-intervention survey. Knology administered a pre-intervention survey to assess ECAs' baseline knowledge and attitudes related to the opioid crisis. A panel of 796 U.S. adults ages 24-33 completed the pre-intervention survey. This survey asked respondents a series of questions related to common myths and misconceptions about opioids, personal connections to the topic, news consumption related to the crisis, health literacy, and health-related attitudes.

Post-intervention survey. A subset of 200 participants who took the pre-intervention survey also completed the post-intervention survey. First, participants were asked to watch a video or read an article about the Opioid epidemic (four conditions total; see Table 11). Then, participants answered questions about myths/misconceptions, the relevance of the story, their learning and reactions to the story, their news consumption habits, and their science identity.

Table 11. Opioid survey conditions.

Format	Description
Article	A relatively long text-based article about the controversy surrounding the use of Suboxone to treat opioid addiction. After introducing the controversy, the article discusses how different treatment centers in Florida have approached opioid addiction treatment and why.
Twitter chat (link not available)	An online Twitter conversation about opioid use and substance abuse with the Baltimore City Health Commissioner (Dr. Leana Wen) and the medical director of the Substance Use Disorder Initiative and Addiction Consult Team at Massachusetts General Hospital (Dr. Sarah Wakeman).
Broadcast	A traditional broadcast piece about New Mexico's response to the opioid crisis, including harm reduction programs, therapy for Medicaid patients, naloxone access and training, and opioid education. The second half of the video explains why opioid addiction is so prevalent in New Mexico (it is a key location for drug trafficking). (Length: 11:11)
Explainer	This is an explainer style video that uses images, animations, and interviews to explain the neuropharmacology of opioids and how it creates a pathway towards addiction. This video was accompanied by a text-based article. (Length: 5:04)

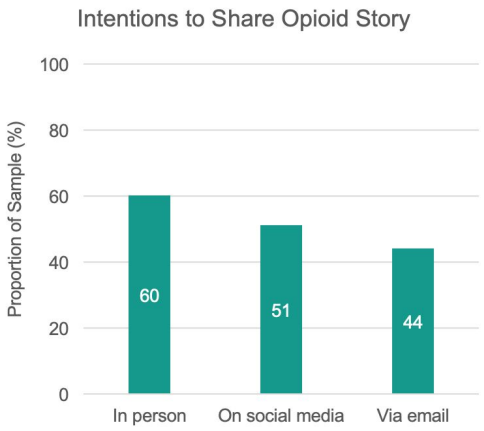
Results. This experiment was designed to examine changes as a result of viewing/reading NewsHour stories about the opioid epidemic. This section reports the effects of story format on each variable and describes the effects of relevance and science identity.

- **General relevance.** Half of the respondents found the story relevant. Of respondents who found the story relevant, general relevance was most common (17%), followed by an interest in the topic (13%), and personal connections/experience with addiction (11%). People who indicated that the story was irrelevant to them often used moralizing language (e.g., "I don't associate myself with addicts") to explain their reasoning. Knology did not report any significant impacts of story format on relevance. However, relevance was a strong predictor for several other variables (described below).

- **Story impressions.** Participants reported finding all four story formats to be interesting, informative, and clear. Participants had mixed responses to the twitter chat; some found it confusing, but overall responses described it as scientific and accessible. Participants who viewed the broadcast clip had generally positive reactions; they appreciated the personal narratives used to tell the story. Some felt this piece was too long; one participant mentioned that the piece was too long for online content, but a good length for a story on television, reiterating one finding from the participatory action research. Participants who saw the explainer video described it as scientific and informative, noting that they were pleased with the production value of the piece.

For the closed-ended responses (ratings of reliability, interest, significance, visual appeal, accessibility, and length), format only significantly impacted length judgments.[5] Relevance, on the other hand, had significant impacts on all six items, with large effects on interest and significance ratings and moderate effects on reliability ratings. Participants who found the story relevant had more positive ratings across the board. Higher science identity was also associated with more positive ratings of interest (moderate effect), significance (small effect), and visual appeal (large effect).

- **Information sharing and seeking intentions.** On the post-intervention survey, a large proportion of respondents indicated that they were interested in learning more about the topic (71%), but fewer said that they were actually planning to learn more (56%). Additionally, participants were most likely to agree that they would share the story with someone else in person, followed by social media, then email (see Figure, *right*). Participants who found the story relevant were more likely to be interested in learning more and to be planning to learn more than those who did not (large effect). Likewise, relevance increased in-person, social media, and email sharing intentions (large effects). A high science identity was also associated with increased information sharing and seeking intentions (very large effects). For participants with a low science identity, the effect of relevance on sharing/seeking intentions was particularly significant. Knology did not find any significant impacts of format on information sharing and seeking intentions.



- **Knowledge and learning.** In the pre-intervention survey, about a quarter of respondents indicated that they are not knowledgeable about the opioid crisis, compared to 58% who said they were.[6] After viewing the opioid story, 72% of respondents reported learning something new, however, there was no relationship between self-reported knowledge (from the pre-intervention survey) and learning something new. Self-reported knowledge *did* significantly predict relevance; the higher a participant's self-reported knowledge, the greater the likelihood they found the story relevant (very large effect). Relevance also had a significant, but small effect on new learning; 80% of participants who found the story relevant reported learning something new, compared to 64% of those who did not find the story relevant. Knology did not report any significant effects of format on learning.

[5] Because there were actual differences in length, Knology did not run post-hoc analyses.
[6] There were some regional differences in self-reported knowledge about the opioid epidemic. Respondents in urban areas reported higher levels of knowledge than those in rural areas.

- **Myths and misconceptions.** In the pre-intervention survey, participants responded to nine items testing their knowledge/beliefs about opioids and the epidemic. Of these items, participants were most likely to respond correctly to the statements: “Pain is complex, with physical and psychological components” (82%) and “If you flush medicine down a toilet or throw it away, it can end up in drinking water” (59%). Participants answered the statement “Most doctors agree that prescription painkillers are the best option for chronic pain” incorrectly the most frequently (48%).[7]

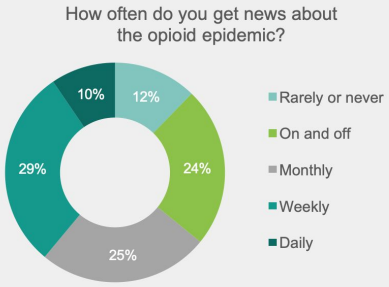
  In the post-intervention survey, participants responded to seven of the nine items from the pre-intervention survey.[8] Respondents answered two items correct significantly more frequently on the post-intervention survey than the pre-intervention survey: “Pain is complex, with physical and psychological components” and “If you flush medicine down a toilet or throw it away, it can end up in drinking water.” Note that these are the same two items that respondents answered correctly most often in the pre-intervention survey. Knology did not report any significant effect of format on participants’ responses to these items.

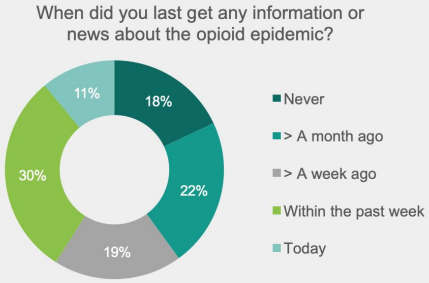
- **Personal connections.** Of the participants who reported personal connections to opioids in the pre-intervention survey (see figure, *above*)[9], 62% found the story relevant, compared to 34% without personal connections. This significant relationship between personal connections and relevance applied overall and for each of the three sub-questions.

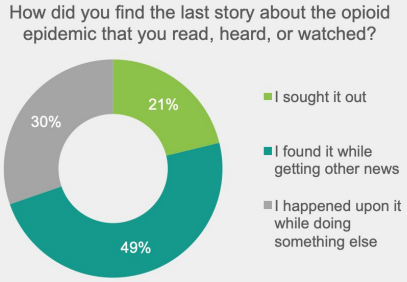
[7] There were significant regional differences in responses to these questions. Despite higher levels of self-reported knowledge, rural respondents answered these items correctly significantly more often than urban respondents for four of the five measures that had significant differences. Suburban respondents were the most likely to indicate that they did not know the answer.
[8] Knology dropped items about insurance coverage because the NewsHour stories did not address this topic.
[9] There were significant regional differences in responses to these questions. Although the exact significant differences were not reported, it appears that suburban respondents were the least likely to have personal connections to the opioid epidemic.

News consumption habits

In the pre-intervention survey, participants answered three questions about their news consumption related to the opioid epidemic. These pie charts represent the participants' responses to each of these questions. Participants were also asked where they would be most likely to look first if they wanted information about opioids. Most respondents said a reportorial or curated news sources (e.g., Google), rather than a medical or social source.







On the post-intervention survey, participants were asked additional open- and closed-ended questions about their general news seeking behavior. Sixty-seven percent of respondents considered themselves active news consumers and 69% said that following the news was important to them. Participants who indicated that they were more active news consumers were also more likely to have indicated that the story was relevant to them (large effect). In the open-ended responses, a large proportion of respondents said they felt a moral obligation to be informed about the news.

Based on this research, Knology developed some hypotheses about the mechanisms through which relevance influences engagement. They identified two different types of relevance: broad and narrow. People who have a broader perspective tend to find any story with a human interest element relevant to them, whereas people with a narrower perspective tend to only find stories with an immediate personal connection relevant to them. To engage people with narrower perceptions of relevance, it is important to appeal to issues that have an immediate impact on them, such as specific topics that are relevant to different regions of the country. Since respondents indicated they feel a moral obligation to be informed about what's going on in the world, Knology also hypothesized that using a moral frame may increase perceived relevance. More research is required to determine whether this is an effective strategy. Additional ideas for research include testing the impact of "future-facing hooks" and explicit connections to social, economic, and environmental justice issues on perceived story relevance.

Opioid case study: Key findings
• Higher self-reported knowledge strongly associated with perceived relevance • Science identity and perceived relevance improved some or all story impressions (respectively) and increased information sharing and seeking intentions • Effects of relevance were particularly strong for participants with low science identities

Dissemination

This section presents the opportunities that Knology, NewsHour, and See Change have had to share the research findings from this grant with journalists and science communicators. This includes presentations (including posters, videos, and webinars) and publications.

Presentations

Learnings from this grant were disseminated through 12 presentations, conference posters, videos, and webinars between NewsHour, Knology, and See Change Institute. Table 12 lists and describes each of these dissemination opportunities.

Table 12. Presentations, posters, videos, and webinars related to this research

Presentation	Description
February 2017: The Online Scientist: Social Media and Public Engagement	• NewsHour team (Nsikan) • American Association for the Advancement of Science annual meeting: Communicating Science Seminar; audience of scientists and science communicators • Discussed how scientists and science communicators can incorporate social media to increase public engagement with science
May 2017: Reaching early career adults with science information	• NewsHour team (Julia, Nsikan); Knology (John, Su-Jen) • NSF 2017 STEM For All Video Showcase; open to a public audience • Video presentation provided an overview of Year 2 findings
May 2018: SC2: Science Communications & the Science of Communications	• NewsHour team (Nsikan) • Media Impact Funders Forum; audience of media funders, media makers, and nonprofits • Discussed science in the media and enhancing public understanding of science
June 2018: Helping health and science experts understand the role of the media	• NewsHour team (Julia) • The MAYDAY Fund: Pain & Society fellowship workshop; public engagement and leadership training for experts on pain • Discussed how medical experts can communicate work to journalists to spread information

Table 12 (continued).

August 2018: Communicating Science to a Broad Audience	● NewsHour team (Nsikan) ● NSF Science & Technology Centers Directors Meeting ● Discussed what content producers can do to make a good science story
November 2018: Cracking the Code Kick-off	● NewsHour team (Julia) ● KQED (Bay area based PBS member station); audience of staff/advisors for public media ● Session to launch project; shared production methods and testing ideas based on the most recent findings from this project
November 2018: What do we mean by Silence?	● Knology team (Jena) ● Presentation at the American Anthropological Association annual meeting; academic audience ● Described the use of captioning in social media content for reasons other than accessibility, including silent viewing
February 2019: Engaging millennials with STEM Journalism: An experimental investigation of what works	● See Change team (Ari) ● Poster session at the SPSP Psychology of Media and Technology Preconference; academic audience of psychologists ● Discussed predictors of engagement with NewsHour STEM content
April 2019: 4 ways to make your social media journalism more effective, proven by science	● NewsHour team (Julia, Nsikan and Travis) ● Presentation at the PBS Technology conference; audience of people in public media who work in technology ● Discussed how relevance, morality, poetics, and platform can affect audience engagement among science and non-science people
April 2019: Lessons from Scalable Approaches	● NewsHour team (Nsikan) ● Arthur M. Sackler Colloquia of the National Academy of Sciences; audience of researchers, practitioners, content experts, and philanthropists ● Communications practices that can be applied on a large scale to increase cultural and institutional capacity to address misinformation
April 2019: Webinar: 4 ways to make your social media journalism more effective, thanks to science	● NewsHour team (Travis, Julia) ● NewsHour webinar; open to a public audience, but intended for media organizations ● 6 part webinar series discussed digital strategies for public media, as well as tips, techniques, and best practices for making social media most effective and serving digital audiences
May 2019: How to optimize STEM news consumption by ECAs	● NewsHour team (Julia, Nsikan); Knology (John, Jena) ● NSF 2019 STEM For All Video Showcase; open to a public audience ● Video presentation provided an overview of year 4 findings

Publications

As of August 22, 2019 Knology and NewsHour have collaborated on two published papers as part of this grant. The first paper was published in January 2019 as part of the USC Annenberg Norman Lear Center Media Impact project. This is a white paper that consists of an overview of the research findings from this project and a discussion of its impacts on the media studies, communications, and STEM journalism fields. The second paper, "Negotiating Genre and New Media for STEM News," was published in *Journalism Practice* in June 2019. This paper, which is cited several times throughout this evaluation, focuses on how journalists are adapting to changes in the mediasphere with an emphasis on the genre. It includes a literature review on media production and consumption, as well as the methods and results for Knology's participatory action research.

In addition to these two publications, the NewsHour and Knology teams are in the process of preparing four additional papers to submit for publication after the grant. These include:

- ***A Lexicon for transmedia journalism*:** This paper defines key media terminology and describes the application of transmedia storytelling to journalism.
- ***What do we mean by silence?*:** A draft of this paper was presented at the Annual Meeting of the *American Anthropological Association*. It discusses the increasing use of captioning in social media videos as a response to increasing access on mobile devices in public places.
- ***Morality and relevance in STEM media*:** This paper presents a morality coding scheme for open-ended 'relevance responses' across multiple surveys (e.g., STEM, Health) to determine whether theories of morality help explain perceived relevance.
- ***Finding relevance in the news*:** This paper (1) examines the linguistic features of open-ended 'relevance responses' across multiple surveys (e.g., STEM, health) to determine whether there are different ways of talking about relevance and (2) makes a methodological argument in favor of a language-centered approach to open-ended survey data.

Impacts

Throughout the four-year grant process, NewsHour and Knology's research program yielded a variety of contributions for both knowledge advancement and the provision of advances in informal STEM learning for society writ large. Through behavioral research on the target population (ECAs), NewsHour and Knology gained valuable insight about how to frame science content in a way that is culturally relevant and more readily contextualized to this group. Further, the experimentation with different media tools, platforms, timing and distribution methods allowed them to effectively implement the strategies derived from their research. Below, the See Change Institute reviews these accomplishments with regard to intellectual merit and broader impacts.

Intellectual merit

One of the chief intellectual merits of this grant is the extension of transmedia production techniques into the realm of STEM communication, evaluation of the potential impacts, and development of new insights for dissemination in a variety of academic literature.

As noted in the literature review, the transmedia storytelling technique was primarily developed in the context of examining fictional story content. For instance, the techniques and successes of media franchises such as the Marvel Universe or DC comics (Jenkins, 2006). The majority of the existing literature on transmedia storytelling exists outside of traditional peer-reviewed scholarship. Current insights only offer limited guidance to scholars and practitioners seeking to study and utilize these techniques in areas such as news production and STEM communication, where rigorous, evidence-based practices are needed. These observations present a clear gap in scholarship on transmedia in pertinent fields such as journalism and science communication. To the See Change Institute's knowledge, this grant provides some of the first attempts to extend the concept of transmedia storytelling into STEM communication in a rigorous, research-infused fashion.

The extension of transmedia scholarship into the sphere of STEM communication necessitates critical theorizing and discussion of effective approaches. Through the development, deployment, and evaluation of content production, the research team identified barriers to advancing scholarship and generated insights fruitful for future academic theorizing and hypothesis testing. For instance, the research process made it clear that the investigation of transmedia storytelling still suffers from a lack of a consistent set of operational definitions of key constructs (e.g., the differentiation between 'medium,' 'platform,' and 'channel'). To address these insights, Knology is currently drafting an academic paper for peer-review which will introduce these discussions into the scholarly literature.

Research conducted on the *America Addicted* opioid series found that the perceived personal relevance was one of the key motivators for interest and engagement with the content among ECA's and non-ECA's, and that higher degrees of personal science identity influenced audience perceptions of the series in positive ways. Knology's series of audience feedback surveys also found that alongside perceived relevance and science identity, *curiosity* about the topics and

stories was a key motivator for ECA's positive impressions of the STEM content. This research suggests that one potential way of increasing engagement is to spark interest and curiosity in readers throughout unique transmedia storytelling techniques (see the "Research" section for additional insights).

Broadly, such findings contribute to the emerging 'science of science communication' research domain in which scholars are seeking to increase the rigor and real-world applicability of science communication research by exploring principles of effective communication both in the laboratory and in the real world (Jamieson, Kahan, & Scheufele, 2017). More specifically, these findings lend novel support to ongoing scholarship on science identity (Fraser, Shane-Simpson & Asbell-Clarke, 2014) and the emerging literature on science curiosity (Kahan, Landrum, Carpenter, Helft, & Jamieson, 2017). The findings additionally offer a unique contribution to scholarship on the role of narrative storytelling in promoting public understanding and engagement with science (Dahlstrom, 2014), including specific dilemmas such as climate change (Flottum & Gjerstad, 2016). The grant team's efforts to disseminate these findings both through academic publications and presentations (see the "Dissemination" section of this report) is helping bring these findings into the conversation in fields ranging from journalism to psychology to science communication.

Finally, a key piece of the intellectual merit of this project is the unique collaborative approach between Knology and NewsHour throughout this grant. Their collaboration was one in which teams of journalists and researchers worked together to iteratively investigate issues pertaining to the production and dissemination of STEM media content. In doing so, they adopted a critical pedagogical approach to examine current practices, identified techniques to improve practice, and critically evaluated the insights generated from trying out new approaches for producing and disseminating content.

In a more "traditional" approach to such research, scholars and practitioners work mostly independently; practitioners employ their best professional judgment in the production and dissemination of content, and researchers make suggestions of what 'works' and what doesn't based on a form of empirical evaluation or reliance on an existing body of research. Such traditional approaches often fail to fully maximize the potential for knowledge acquisition and for broader impacts by not facilitating effective collaboration among the different stakeholders. The journalistic practice is ever-evolving and must adapt to different content, contexts, and audiences in a rapid manner. For scholars to gain a full appreciation of this and develop meaningful theories of audience engagement and media production, it is necessary that these different groups work together to further develop their knowledge of effective science communication.

For example, the participatory action research was instrumental in building NewsHour's capacity to produce engaging content for non-traditional platforms. Not only did the findings from the research improve NewsHour's STEM content on various social media platforms, but the process of the research itself served as a valuable learning experience for the production team. The quarterly production meetings, in particular, helped the production team "learn how to learn,"

which ideally indicates that the impacts of this collaborative approach will extend long past the end of the grant. Through such actions, these two teams were able to work together to share insights and opportunities, with both sides learning valuable lessons about the production and evaluation of media content. Members of the production team learned more about the scientific research process and how to construct research questions, while the research team garnered important insights into the production process and how to most effectively evaluate such processes. This shared learning enabled the teams to iteratively evaluate, modify, and implement new production practices for STEM content at NewsHour.

Thus, one of the chief intellectual contributions of this grant is the demonstration of the possibility for real-time collaboration between researchers and practitioners (in this case, content producers) through such a critical pedagogical approach. Such findings lend credence to the importance of real-time collaboration and offer support to existing calls for more collaborative field research in the science communication domain (Kahan & Carpenter, 2017). Adoption of this approach in other contexts is likely to lead to intellectual contributions not just for journalism and communications, but also for fields such as organizational behavior, which may seek to investigate the most optimal settings to facilitate successful collaborative research of this kind.

Broader impacts

NewsHour and Knology's collaborative efforts yielded broader societal impacts for journalistic practice and the communication of STEM content across a variety of media platforms. Increased staff capacity for content production, the provision of advanced training in new production techniques and practices, increases in non-traditional media productions, and dissemination of research and production insights across media institutions and the broader scientific community all contribute to the broader impacts of this project.

As noted, eight news assistants were hired during the period of the grant. The hiring and training of these assistants helped contribute insights for NewsHour regarding how to best construct content for ECA's, while also aiding in the actual production of more non-traditional content. NewsHour's enhanced capacity and production of STEM content appeals to diverse audiences across multiple platforms, and contributes to the likelihood of greater STEM engagement among key audiences, including those audiences not typically exposed to STEM content. Indeed, See Change Institute's independent content analysis verified that there was a small but statistically meaningful increase in the number of non-traditional media content produced by NewsHour during the course of the grant. Such increases came mostly in the form of added content on platforms such as Instagram and Facebook (e.g., Facebook Live), thus further amplifying the potential of reaching ECA's who may not seek out NewsHour content otherwise. While it is not feasible to directly evaluate whether such changes in content production produced societal-level increases in ECA STEM engagement, we are confident that the provision of more STEM content on platforms which are frequented by ECAs, combined with the creative, new production techniques, increases chances of ECA engagement.

Furthermore, the majority of the news assistants hired and trained by NewsHour during this grant have moved on to new STEM journalism positions with other outlets, such as *National Geographic* and *Science Magazine*. These news assistants undoubtedly have carried on the insights they've gained during their work with NewsHour, which may influence the production efforts at these other media institutions seeking to communicate STEM content. Additionally, several of the assistants have continued on in positions at NewsHour (e.g., Lora Strum, audience engagement specialist), putting NewsHour in an even better position to extend the impacts of this project well-beyond the grant period.

More broadly, our evaluation covers NewsHour and Knology's efforts to produce a variety of STEM content using transmedia storytelling strategies. In addition to the likely benefits of the increased volume of non-traditional STEM content, transmedia storytelling may be more effective than many current strategies for promoting audience engagement. Survey data collected during the course of this grant suggests that deriving a sense of personal relevance from STEM content is vital for promoting engagement with such content among ECA's. One means of accomplishing this may be through the use of transmedia storytelling. Such techniques are explicitly intended to engage audiences with a topical universe in which multiple perspectives and stories all contribute to a broader narrative. By populating this topical universe with relatable characters, compelling stories, and high-quality production value, transmedia storytelling may enhance the perceived personal relevance of STEM content and increase ECA's audience interest and engagement with such content. These increases in interest and engagement, theoretically, should have an array of impacts on broader society. Such impacts might include greater dissemination of STEM content through social media, increased awareness and education about STEM issues, and ultimately a more informed and engaged citizenry. However, while transmedia storytelling is promising, future research is needed to fully understand how to apply the insights from this grant in ways that maximize their potential.

NewsHour and Knology made considerable effort to ensure the broader impacts of their work through the dissemination of findings pertaining to the grant with relevant audiences. For example, a member of the NewsHour team met with KQED Science to discuss how the insights from this grant might help inform ongoing efforts at their own desk. NewsHour also hosted a six-part webinar series for media organizations in which insights were shared on best practices and techniques for digital media production and dissemination. Coupling these presentations with the others highlighted in the "Dissemination" section suggests that the NewsHour and Knology teams sought to maximize the broader impacts of their work by sharing insights with audiences who could benefit from them.

Through a combination of transmedia storytelling, increased production of non-traditional STEM content, training of news assistants, and dissemination of insights, the NewsHour and Knology teams worked to maximize the potential for broader impacts in their work. Ideally, such efforts will contribute to a broader media landscape transformation that is capable of maximizing audiences in ways that motivate informed public action on pressing societal issues ranging from the opioid crisis to climate change.

Conclusion

Experiments in Transmedia successfully facilitated learning and capacity building at NewsHour (and beyond) through research into ECAs and experimentation with different types of media and distribution strategies. Moreover, this project provides a tangible and successful example of real-time collaboration between researchers and media practitioners (in this case, content producers) through a critical pedagogical approach. In addition to the empirical research and knowledge of ECAs codified through this research, evidence of the successful collaboration can be seen through enhanced communication streams and relationships between and among research organizations, media outlets and their former and current staff. As such, the positive impact of this research on both NewsHour and Knology offers this project as a case study of an effective, mutually beneficial partnership between researchers and journalists.

In building upon the promise of transmedia storytelling, See Change has identified three recommendations to assist in maximizing the potential insights gained through this research. For organizations who are interested in exploring the type of collaboration implemented by News Hour and Knology, we recommend the following:

Media organizations should consistently try new production approaches, strategies, story formats, distribution channels, etc. and track results. Experimentation is a necessary part of a *learning* process to *improve* communication. Organizations must try new things in order to determine what works and what doesn't (in general and for specific audiences). This can have the added benefit of extending the reach of media content to new audiences.

Journalists should partner with researchers to help them assess strategies for producing media content. Trying new production approaches is not enough. The results of these experiments need to be tracked and analyzed if the experiments are to be useful in informing future content production. Experiments in Transmedia can be effectively used both as a case study and a model/ approach. As described in this report, this experiment was successful because of the collaborative and iterative nature of production and experimentation. In order for content production models to improve levels of engagement, there needs to be a consistent feedback loop (what worked, what didn't work) that then informs future content production.

Researchers/Journalists should share their findings with others. Lessons learned by a single media outlet can help the adoption of STEM related concepts across audiences and various media outlets. Other organizations can adopt effective strategies to increase media engagement (across several different fields of journalism). Sharing findings creates a collective knowledge foundation that allows journalists/researchers to work together to improve communication and make media content more accessible.

This learning and experience with new production strategies can help NewsHour and other media outlets produce STEM content that appeals to ECAs—especially those who do not find STEM topics inherently relevant. Ultimately, increasing STEM engagement among this cohort should foster a more science and media literate generation of young adults who are prepared to face the global problems of today and the future.

Glossary

This section will include a glossary of key terms that were used throughout this report, including:

Capacity building. The process of obtaining and developing skills, tools, knowledge, equipment, personnel, and other resources in order to improve an organization's ability to effectively do their jobs and meet their goals (Potter & Brough, 2004)

Channel. A particular stream of content being shared on a platform (e.g., PBS, IFLScience [FB])

Critical pedagogy. A teaching philosophy that focuses on developing learners' critical consciousness to help them question, challenge, and even undermine prevailing paradigms

> **Critical consciousness.** One's ability to accurately perceive reality, and thus intervene in effective ways (Freire, 1974)

Cross media. The same content distributed on several different platforms to increase reach (rather than content created according to the specific affordances of a platform) (Moloney, 2014)

Evergreen content. Content that is always relevant, as it is not inherently tied to current events

Format. The modality used to communicate information, such as text, audio, or video.

Genre. The format, content, style, and medium of a report that, together, offer information about the type of content or "communicative event" in which the audience is about to engage (Barchas-Lichtenstein et al., 2019)

Media/Medium. The physical device used to access the content (e.g., television, newspaper, smartphone)

> **Broadcast media.** A type of media that is used to facilitate one-way communication (usually audio or video) to a mass audience (e.g., television, radio)
>
> **Social media.** A type of media that is web-based and affords peer-to-peer and/or multi-directional communication.

Multimedia. One platform and channel used to share different media formats (e.g., a text article with an embedded video) (Moloney, 2014)

New media. Types of media and mass communication that rely on or are specifically created for dissemination via digital technologies, namely the Internet (Beal, n.d.)

Participatory action research. Research in which the people being studied actively engage with the researcher throughout the whole research process (Whyte et al., 1989)

Platform. The institution that distributes or hosts the content (e.g., Cable, Facebook), that may or may not be responsible for creating it.

STEM. An acronym used to refer to anything related to Science, Technology, Engineering, and/or Mathematics

Story. An underlying narrative or social condition that can be explored from various viewpoints

Topic. The shared issue, concern, or series of events in which a *nonfiction* story is embedded

Transmedia. The systematic, deliberate, and integrated communication of a story across multiple media platforms/channels, making use of the unique contribution that each can make to the narrative.

> **Transmedia journalism.** Many reports, many forms, many channels, one topical universe, one voice, all within some loosely bounded period of time
>
> **Transmedia promotion.** One story told through many formats and platforms. There is *one* anchor piece to which other content is secondary. Secondary content is not intended to stand alone; instead, its goal is to increase engagement with the anchor piece.

Voice. The representation of institutional authority, delimited largely by the governing editorial culture, rules, and norms of communication of an institutional principal or executive producer of (nonfictional) reports.

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