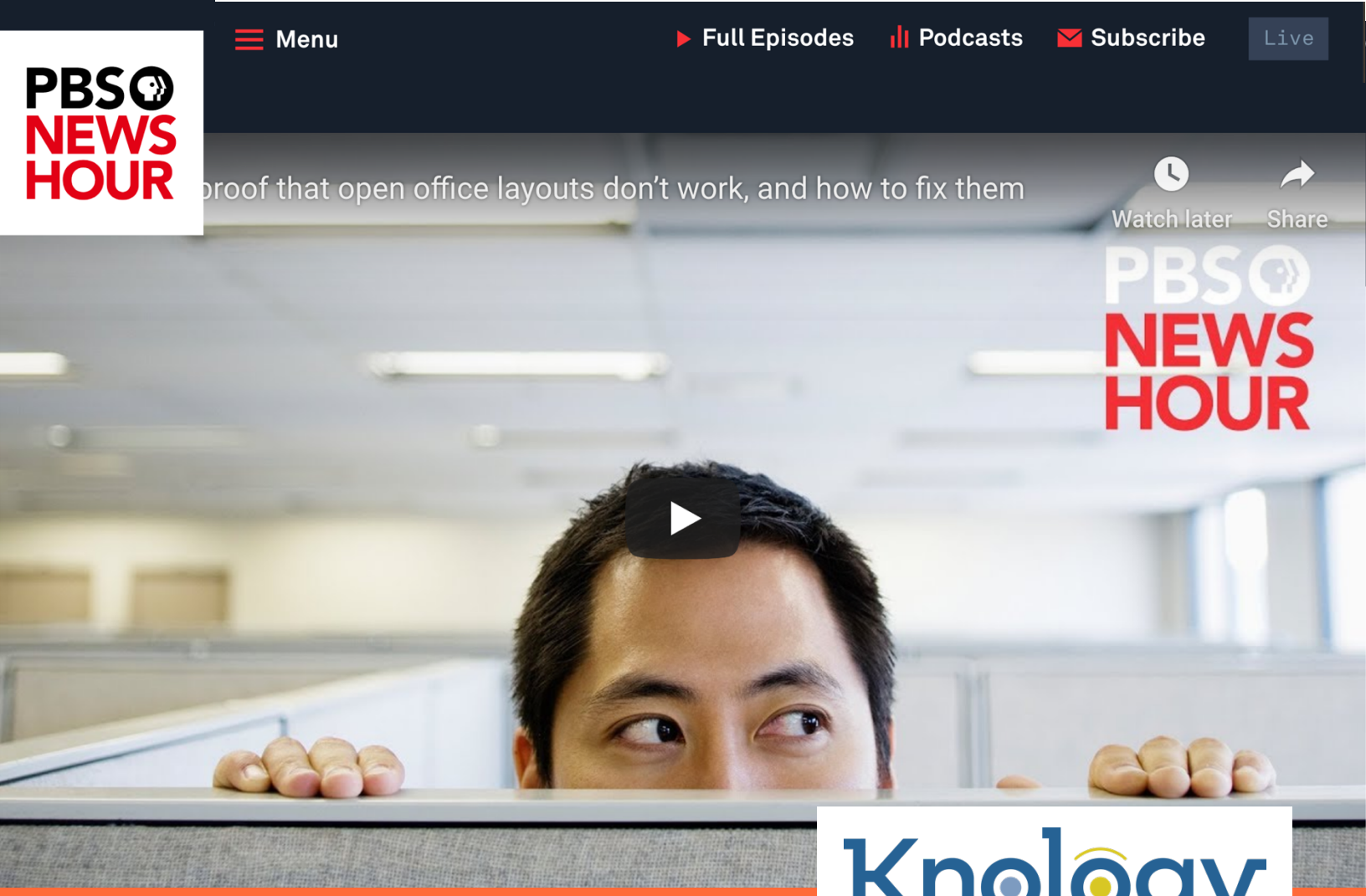

Knology

Experiments in Transmedia:
Studying Techniques for Increasing STEM Content Acquisition by Young Adults

Understanding Early-Career Science News Consumers

November 7, 2019

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How Changing Media Practices Are Shaping the Future of STEM Journalism

An executive summary of the Experiments in Transmedia research project

In 2017, PBS NewsHour produced one of their most complex transmedia series to date. #AmericaAddicted, which focused on the opioid crisis facing communities around the U.S., included 14 broadcast reports, 10 articles on the NewsHour site, four livestreams, three Twitter chats, and more than 200 associated videos and posts on over half a dozen platforms. The different reports take a wide range of perspectives and focus on different aspects of this crisis. Each report is embedded in dense networks of content, with a variety of entry points for audience members, that tell a single overarching story: an epidemic of opioid abuse is overwhelming the United States.

For the Experiments in Transmedia study, this series provided the perfect testbed for exploring how a transmedia approach to news contributes to STEM literacies across the country. Launched in 2015 as a collaboration between WETA/PBS NewsHour and Knology, Experiments in Transmedia sought to understand how people who finished formal education fairly recently use science content from news media. In addition to the current report, Knology and NewsHour have published a number of reports and a peer-reviewed paper that describe the findings in greater depth.

Over the course of this four-year project, which was funded by the National Science Foundation, NewsHour produced STEM news reports, including the aforementioned #AmericaAddicted series. These reports covered trends across all fields of science and were distributed both on weekly broadcasts and through multiple digital platforms like Twitter, Facebook, Instagram, and YouTube. Knology researchers worked with the NewsHour team to collect and analyze data from target audiences to understand how they use these stories to continue increasing their STEM literacies, competencies, and skills.

The proliferation of these platforms in recent years offers a slew of opportunities for media organizations to communicate and interact with audiences. Audiences can talk back to journalists in real-time on social media, and they have their pick of news and related content in different formats and on multiple devices. These experiments set out to test Jenkins' (2007) theory of transmedia storytelling in a journalism context. In particular, Jenkins contends that transmedia storytelling creates "different points of entry for different audience segments," thereby expanding the potential audience. Together, Knology and NewsHour explored how news organizations can use multiple media platforms to tell STEM stories that engage different types of viewers.

Early-career people in particular are skilled at navigating new platforms and are very selective about what they choose to engage with. In thinking about how this group uses science content from news media, Experiments in Transmedia tried to understand how early-career adults interact with the different formats that news content currently takes and gain insights into how best to serve their needs. It also provided STEM learning experiences for early-career journalists with an eye towards increasing their interest in STEM communication careers.

Despite the wealth of research on formal school learning, little is known about how this cohort engages with STEM media content after they leave school. Experiments in Transmedia revealed diverse entry points into and motivations for accessing STEM news content. For those who identify as "science people," the way forward for news organizations is clear: keep producing good STEM news content that isn't dumbed down, and this group will continue to seek it out. The challenge then is in encouraging individuals who don't have prior science interest to engage with STEM content.

Some stories appeal to much larger audiences and include people who do not identify as "science people." These individuals' interests are rooted in more humanistic motivations that govern their story choices. Specifically, some people are interested in stories because they find them to be morally relevant on some personal level. For example, people who knew someone connected to opioids were more likely to find content from the #AmericaAddicted series relevant. Other people are drawn to stories because they have broader societal relevance. Still others are drawn to stories for aesthetic or poetic reasons – something about the stories' form appeals to particular sensibilities these individuals have.

This study also offers an alternative explanation for why young people sift quickly through content. What it suggests is that younger audiences are masters at managing their news and media feeds. When they navigate from one story – or platform – to another, they are making quick decisions about the relevance of content and moving on if stories don't immediately present them with what they want to know. This group prefers stories that eschew long introductions, equivocations, and clickbait. The quicker stories get to the point, the more likely millennial audiences are to stick with them.

So, what do these findings mean for people who produce news? This study provides the tools needed to create robust STEM learning opportunities for early-career adults and offers insights into the different motivations early-career adults approach STEM content with. The implication for news producers is that they need to ensure they provide both (a) high-level content that targets the science-literate to maintain their base audience, and (b) content that relies on personal and general moral relevance as well as aesthetic motivations, to draw other audiences in. These strategies need not be mutually exclusive. In all cases, structuring stories so that the lede contains humanistic framing will keep early-career adult audiences reading or listening long enough to get details of the research method and analysis.

Given the varied pathways early-career audiences take through news content, we encourage news organizations to continue providing links to evergreen content as a way of advancing STEM literacies. Journalists should also continue to report stories that cut across all subjects included in STEM while varying how they structure content, keeping in mind the audience motivations that this study identifies. Lastly, engaging with audiences helps journalists understand emerging questions in the public domain, which may in turn impact what

content is created and how it is structured. For example, a story about using robotic prostheses that gathers commentary on social media may be the springboard for stories that explore questions and concerns about the increasing role of automation in daily life.

In a nutshell, this study confirms that news makers have embraced new media platforms and are thoughtful about ways to present their content that match audience expectations for these new formats. It also points to ways that these organizations can keep pushing the envelope.

Accomplishments & Impacts

Over the four years of the grant, the joint NewsHour-Knology team developed an integrated working style that allows research and production to inform one another closely. In that time, the production team produced 886 STEM news reports across more than 15 platforms. These used a range of styles and hooks, as well as touching on an enormous diversity of STEM disciplines, including many interdisciplinary stories. Meanwhile, the research team solidified our understanding of working millennials' (a) motivations for consuming this type of news and (b) news habits and practices across a range of platforms. Altogether, this project has resulted in 11 reports, 14 public data sets, 1 white paper, 1 peer-reviewed paper, 2 working manuscripts, and 12+ conference presentations to date.

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Introduction

Outside of formal education settings, adults turn to the media to learn about STEM and STEM related-topics (Falk & Dierking, 2010; Su et al., 2015). Media's affordances for learning are constantly changing, and each cohort of adults comes of age alongside a new set of platforms, norms, and practices. Not to mention, existing research shows that on average, people switch between electronic devices as many as 21 times per hour (Smith, 2014). How does the newest cohort of adults use STEM media, and how can media organizations support them to continue learning after they leave the formal education system?

A collaboration between PBS NewsHour and Knology (formerly New Knowledge Organization Ltd.), Experiments in Transmedia, sought to understand how people who left formal education fairly recently use science content from news media. We refer to this group as either *working millennials* or *early-career adults*. Specifically, this study sought to understand how this cohort uses information from news media to continue building their STEM knowledge, competencies, and skills. Insights into this group will help news media create STEM-related content that supports early-career adults' needs and interests.

A critical early step in this research was to understand how this group interacts with the different formats that news content currently takes, as well as the ways they prefer to access news content. This project, which was funded by the National Science Foundation (NSF) (Award #1516347), focused on creating content and gathering feedback from a target audience of 18- to 35-year-olds, with an eye towards understanding how media-based tools and platforms affect their engagement with STEM news.

Over the course of this four-year project, NewsHour produced and reported STEM news stories covering trends across all fields of science in its regular weekly broadcasts and through multiple digital platforms including Twitter, Facebook, Facebook Live, Instagram, and YouTube.

Figure 1. Members of the 2017-2018 *Experiments in Transmedia* team.

Through PBS NewsHour's programming, Experiments in Transmedia provided three types of STEM learning experiences for early-career adult audiences. These included STEM reports published on air and online on specific days of the week; multiple STEM broadcast pieces repackaged for presentation on multiple digital platforms; and a news assistant (apprenticeship) program at NewsHour designed to train the next generation of STEM communicators.

These learning experiences targeted a range of goals. In particular, the first two learning experiences were designed to increase awareness of STEM topics and STEM media literacy across early-career audiences. The news assistant program was intended to:

- Increase early-career journalists' interest in STEM communication careers through hands-on exposure to the news reporting and production process, expanding the pipeline of trained professionals who can engage with and apply STEM content; and
- Provide insights from working millennials to the NewsHour team to help them create STEM news products that speak more directly to this audience.

Research Activities

Knology, a non-profit research organization, led research activities, while NewsHour led production. Experiments in Transmedia focused on three main research questions:

- How do early-career adults acquire and share STEM news?
- How does the structure and shape of STEM news stories serve the needs and interests of early-career adults?
- How can media organizations tailor the presentation of STEM news stories to advance the STEM knowledge, interests, and competencies of early-career adults?

We used a mixed-methods approach to answer these questions, that involved collecting qualitative and quantitative data from three different sources. We engaged in participatory research activities with the NewsHour production team through quarterly meetings and reviewed journal entries written by production team news assistants, as well as interviews with those news assistants. We also gathered information from early-career adults including details of their overall news consumption and sharing habits, in addition to their reactions to multiple versions of several NewsHour STEM stories. A third series of research activities focused on the news stories themselves.

Project History

Experiments in Transmedia was conceived as an exploratory collaboration. It was an opportunity for NewsHour to experiment with different forms of storytelling and understand how integrating research and production could improve the way STEM news stories are told.

Year 1, Developing a Participatory Action Research Lab and Common Vocabulary: The NewsHour and Knology teams set up procedures and processes, including practices for participatory research and reflection. We also recruited early-career news professionals – the NewsHour news assistants – as reflective ethnographers. The group worked closely together to document the unique affordances of the NewsHour brand. For Knology, this involved familiarizing ourselves with the ways that NewsHour stories, both broadcast and online, differ from other STEM news brands. We considered factors such as the relatively longer length of NewsHour's reports (six-minute videos on average, versus maximum three minutes on other outlets) and on the NewsHour's unique positioning as facilitators of first-person storytelling by scientists about their research, without the reporter or news analyst inserting themselves as a translator or knowledge expert. Other research activities for the year included:

- a small set of baseline studies to better understand NewsHour's early-career adult audience's STEM news habits and preferences; and
- three audience tests of stories that were produced prior to the start of the grant.

The goal of those studies was to gain a sense of baseline product consumption and preferences. In defining parameters of the transmedia study as a whole, the project partners had to negotiate how far experiments with new platforms, styles, tones, and voices could push the envelope of the NewsHour brand. We also considered what approval processes for publishing in these new ways and platforms might look like.

Year 2, Testing and Hypothesis Building: In this year, we took a deep-dive into user conceptions and understanding of news products and began testing new formats for NewsHour. These tasks were intended to provide a more sophisticated understanding of early-career adults as an audience as well as clarify the researchers' understanding of cause and effect. The team made a strategic change in the hiring process and workplan for news assistants by increasing the length of their contracts from six months to one year. The longer timeframe gave news assistants more time to master production strategies and to participate in the experimental testing of different platforms and formats.

We used largely quantitative approaches for our audience research because it surfaced consistent differences in the reactions to STEM stories designed for different platforms. We confirmed some of the findings from these quantitative studies in focus groups. A review of the minutes from quarterly reflective practice meetings held throughout the year confirmed that the joint NewsHour-Knology team had developed a shared vocabulary for describing the research. This formed the foundation from which we could develop a hypothesis about the implications of new formats.

Figure 2. Transmedia team members on location.

Year 3, New Theoretical Models: By Year 3, the team had clarified possible strategies and theories of news production and process that we believed would increase early-career adults' STEM news consumption. We used these strategies and theories to inform the news reports' development, and we triangulated between different types of data to identify changes in both process and outcome.

One audience study collected data from individuals before and after certain news reports were aired. Another study tested multiple versions of a single broadcast report to see if it affected audiences differently. We also began comparing NewsHour products to better understand systematic differences between content designed for different platforms. This year, we also expanded our focus groups to include comparisons with older audiences. The comparison allowed us to determine which factors are unique to early-career adults and which are more general.

We concluded Year 3 with testable hypotheses within our data, including a model of the emerging transmedia documentary format that reconciled a range of news reports with self-directed user exploration and included links to "evergreen" content in the NewsHour archive. We also began thinking about the meta-cognitive processes involved in creating news stories and how audiences choose the content they engage with.

Year 4, Sharing Findings: In the last year of the project, we began sharing our findings publicly in a number of ways. This included publishing a peer-reviewed paper co-authored by most members of the project team (Barchas-Lichtenstein, et al., in press).

About This Report & Other Publications

This report summarizes the research questions, methods, and results for the four years of the Transmedia project.

Full details of the research activities and results from prior project years are provided in the research reports for Year 1 (Roberts, Flinner, Norlander, Reese-Lerner, & Fraser, 2016), Year 2 (Roberts, Norlander, Barchas-Lichtenstein, & Flinner, 2017), and Year 3 (Fraser et al., 2018).

Other project publications, presentations, and products include:

- Five brief reports:
  - *Opioid Epidemic News Consumption* (Barchas-Lichtenstein, et al., 2018)
  - Topline memos from the baseline survey (NewKnowledge, 2016a) and three early audience panel tests (NewKnowledge 2016b, 2016c; Roberts, 2017).
- A white paper, *STEM News in the Lives of Early Career Adults* (Fraser & Barchas-Lichtenstein, 2018);
- One peer-reviewed paper exploring the role of genre in working millennials' STEM news habits (Barchas-Lichtenstein, et al., in press);
- More than a dozen conference presentations to a range of audiences (see Appendix A);
- Fourteen datasets and
- Two additional manuscripts:
  - A language-centered analysis of responses to survey questions about relevance (Barchas-Lichtenstein, Voiklis, Glasser, & Fraser, m.s.); and
  - Analysis of the same data set in terms of psychological theories of spheres of moral concern (Voiklis, et al., m.s.; for *moral concern* see Janoff-Bulman & Carnes, 2018).

Adapting the Concept of "Transmedia" to Journalism

One of the goals of this project was to test Henry Jenkins's (2007) contention that transmedia storytelling creates "different points of entry for different audience segments," thereby expanding the potential audience. Yet it is important to note that Jenkins's (2003, 2006) original notion of *transmedia* focused on fictional worlds, particularly entertainment franchises – Pokemon, The Matrix, Indiana Jones. As such, the *storyworld* was central to his definitions, which creates a challenge for applying this body of theory to emerging journalism practices. After all, the stories of journalism take place in our familiar world.

More recently, Kevin Moloney (2019) has articulated a model that encompasses fiction and non-fiction alike by categorizing media along three dimensions: content, form, and channel. We find Moloney's model valuable for framing our work.

In collaboration with the grant's external evaluation team at See Change Institute, during the final year of the project, the Knology team reflected on key contrasts between fictional entertainment and the documentary and journalistic practices we explored with our NewsHour partners.[1] None of these distinctions are unique to STEM news; instead, they reflect larger differences between entertainment fiction, on the one hand, and journalism on the other. All the same, we present them here because they provide necessary context for this report:

- ***Temporal Constraints***: Journalistic and entertainment media face different temporal constraints. While fictional media need not adhere to a particular schedule, timeliness has long been a core news value. However, its meaning is undergoing change as technological change affords ever-quicker distribution. Notably, online distribution channels facilitate immediacy and continuous updating in a way that was not possible thirty years ago. This practice has been dubbed "liquid media" (Widholm, 2016).
- ***Goals***: News media tend to construe their audiences as publics (Butsch, 2011) while entertainment media treat theirs as individuals. That is, there is a general understanding that the goals of news media include public understanding, public discussion of issues of general concern, and informed participation in democratic decision-making. Meanwhile, fictional media can appeal primarily to individual taste.
- ***Story structure***: Unlike fictional narratives, news stories present factual information as it emerges and build on a foundation of prior reporting. Where fictional narratives may follow an alternative chronology, news stories are nearly

[1] Entertainment media and journalism are far from mutually exclusive. However, a discussion of editorial genres, satire, and parody news remains beyond the scope of this report.

always presented in a linear fashion. Furthermore, journalistic pieces may be updated over time as new information becomes available, and later developments sometimes render earlier pieces false.

- ***The role of character***: Different supporting pieces in transmedia entertainment may follow entirely different characters. Unlike fictional characters, the characters in news stories arrive with full lives and backstories that are messy, intersectional, and often inconvenient.
- ***Intellectual property***: Any news report opens the question of boundary conditions: there is no possibility of trademarking a news story, and multiple reporters and news outlets tell versions of the same story within their beat and their editorial paradigm.

Methods

Over the life of the project, we collected data from the NewsHour team – including several news assistants (NAs) – as well as from early-career adults. We tracked and analyzed NewsHour STEM stories in several ways to assess their impact on early-career adult audiences. The table below summarizes the tasks for each year, and which groups were involved in each activity.

Table 1. Research activities in each project year.

	Research Activity	Year 1	Year 2	Year 3	Year 4
NewsHour Team	Production team discussions	■	■	■	■
	Collecting and coding NA journal entries	■	■	■	■
	Exit interviews with NAs		■	■	
	Round table with news assistants			■	
Early-Career Adults	Audience panel recruitment	■	■	■	
	Baseline survey with audiences	■	■		
	Story-testing surveys with audience panel	■	■	■	
	Audience focus groups		■	■	
	#AmericaAddicted pre- / post-production study			■	
	STEM fields survey				■
News Stories	Tracking & coding story discipline	■	■	■	■
	Tracking & coding story frame			■	■
	Most & least popular stories			■	
	STEM content in other NewsHour pieces			■	
	#AmericaAddicted transmedia case study			■	
	Secondary analysis				■

Data from the NewsHour Team

Research activities conducted with the NewsHour team followed the principles of participatory action research. One of the hallmarks of this approach is that "some of the people in the organization or community under study participate actively with the professional researcher throughout the research process from the initial design to the final presentation of results and discussion of their action implications" (Whyte, Greenwood, and Lazes 1989, 514).

In addition to reviewing various other research protocols and findings throughout the project, members of the NewsHour team participated in the following activities:

Production Team Meetings

Knology held quarterly discussions with the NewsHour STEM production team during which we presented research results and discussed how best to incorporate audience feedback into the news production process. A separate Knology researcher who was not involved in the discussions reviewed all audio recordings and transcriptions and identified key themes from the meetings.

News Assistant Reflections

Funding for this research included support for the NewsHour news assistants who worked with the production team on the STEM stories. With one exception, all STEM news assistants were also members of the target audience for this study. In Years 1 and 2, pairs of news assistants joined the team for six months and participated in all aspects of story development and production. In Years 3 and 4, news assistants remained with the NewsHour team for a full year based on a recommendation from the second year of the project. Finally, in Year 3, the research team collected and analyzed reflections from six additional news assistants who worked in assorted non-science roles. Journal and interview prompts changed slightly from year to year, both because we learned more about early-career adults' interest and because NewsHour social media practices changed over time. Sample prompts included the following:

- What role do you see yourself playing in improving the appeal of Newshour stories for millennials? Talk about how your own skills and strengths can be utilized by staff at NewsHour.
- If you could design your own science news show for millennials, what would that program look like? What topics would you choose? Why? How would you reach your audience? What challenges do you foresee and how would you overcome them?
- How would you describe the boundaries of the NewsHour brand? Compare and contrast to the brand of another outlet that your friends and peers use regularly for STEM content. How might this information inform your work?
- Thinking back over the last week, what are three STEM stories that kept you reading or watching? What do they have in common? Please insert a link for each. How might this information inform your work?

Data from News Audiences

In the first year of the project, we began recruiting panel participants for story testing using Amazon's Mechanical Turk platform. We continued recruiting panel members through the second year of the project and testing stories through Year 3. As of July 2017, we had recruited 1,270 individuals in the US, ages 18 through 35, and not currently in school. We tested this same pool of individuals in Year 3 of the study.

Baseline Survey

In Fall 2016, we surveyed panel members in two phases to investigate their news interests, news consumption and sharing patterns, as well as social media use. This data provided the baseline needed to understand how members of this demographic interact with STEM news.

We used the results from Phase 1 of the survey to identify a subset of respondents who followed STEM news at least once per week. This subset of respondents then filled out the second survey, which asked questions related to how they access and use STEM news. We also asked this group to describe a specific STEM news story that they had consumed in the two weeks prior to completing the survey. We received 595 responses to the first survey, and 90 responses to the second survey.

Analysis

We calculated summary statistics (specifically, mean and standard deviation) for all closed-ended questions. For the descriptions of STEM stories that were provided by respondents to the second survey, we coded the story topics using the same categories used to track NewsHour stories. We then reviewed all open-ended responses to identify common themes.

Audience Feedback Surveys

In Years 1-3, we used a series of surveys to get our panel's feedback on stories presented in different formats. The list of story topics and formats are summarized in the table below. For each story topic, respondents generally saw one of several different formats. We used iterative survey instruments, and generally included an open-ended verification question as well as open- and closed-ended questions to get feedback on the story and gauge interest in the topic.

Table 2. Stories and formats tested in each year.

	Story topic	Broadcast video	Short or social video	Article	Other
Year 1	Ceres asteroid (pilot survey)	Broadcast video			
	San Francisco earthquake				Twitter; Storify
	Tree frogs		Facebook video (captioned)	Article with video (captioned)	Instagram post
Year 2	Lionfish	Broadcast video			Infographic
	Ocean Trash	Broadcast video	Short video		
	Holograms		Short video	Article	
	TRAPPIST1	Broadcast video		Article	Infographic
	Ice Shelf	Broadcast video	Short video		
	Tornadoes		Short video	Article	
Year 3	Lyme Disease	Broadcast video	Facebook video	Article	
	Opioids	Broadcast video	Explainer video	Article	Twitter story
	Dolphin Graveyard	Broadcast video (3 versions)			

Analysis

For all survey data collected across the four project years, we reviewed responses and calculated summary statistics for the close-ended questions. We used t-tests to identify significant differences in responses across formats for each story. We used open-ended questions to solicit feedback about stories and identified common themes in the responses.

In Years 2 and 3, we ran separate models for each target outcome: reactions, interest, and willingness to share stories. We used story format, science identity, and gender as predictors, and the target outcome as the dependent variable. We included story topic as a random effect in all models to control for clustering. We viewed story format as a categorical variable comprised of four categories: article, broadcast, short video, and infographic. Lastly, we used ANOVA tests to compare the full model including all predictor variables to the base model without the format variable. This approach let us measure the overall effect of story format on target outcome. When we observed a significant difference between the models, it was an indication that format affected audience response. If format was a significant predictor, we examined the effect of the specific format types in the full regression model.

Audience Focus Groups

To further contextualize the survey responses, we began running audience focus groups in Year 2 in four cities across the country. Researchers recruited five or six individuals at each location who met the stated criteria of the project, and asked them to discuss how they use media to build their STEM knowledge and interest. In Year 3, we ran six focus groups that included eight to ten individuals at each location. About half of the participants were between 18 and 35 years old, while the other half were 36 or older. We expanded recruitment at this point to identify unique factors about early-career adults. We did this by comparing them to slightly older individuals; including adults as young as their late 30s. All focus group participants saw several NewsHour pieces including at least one traditional broadcast report and a social media-first piece that relied more heavily on music, graphics, and quick cuts. We analyzed and grouped data collected from these focus groups according to key themes.

#AmericaAddicted: National Pre- / Post-Production Study

In Year 3, NewsHour produced and released more than 30 opioid-related news reports over a two-week period. The research team used the opportunity to gather information on news consumption related to opioid addiction in the US. We did the study in two waves. The first wave collected baseline information on audiences before the content aired. In the second wave, we collected data from a subset of respondents, who were asked to view one of four NewsHour reports and then fill out a survey to identify how their knowledge had changed. Participants were recruited through SoapBox Sample. A total of 796 US adults ages 24 to 33 participated in the first survey, and 199 responded to the second survey. The research team used Multivariate Analysis of Variance (MANOVA) to test the effects of story format, relevance, and science identity on the survey modules addressing reactions, willingness to share, and interest in more information (see Barchas-Lichtenstein, et al., 2018 for detail).

We refer to this activity in brief as the #AmericaAddicted audience study to differentiate it from the #AmericaAddicted content study.

STEM Fields Survey

Over the first three years of the project, the responses that we got from interviews and focus groups suggested that variations in people's confidence and enjoyment of the four STEM disciplines might help to explain the way they engage with STEM news overall.[2] In Year 4, we conducted a survey to try to explore this question. The full instrument is available in Appendix B.

The survey addressed the following topics:

- News consumption by topic;
- News consumption by outlet;
- Confidence in the four STEM disciplines;
- Enjoyment of the four STEM disciplines; and
- Age and student status.

[2] We did not attempt, however, to disentangle "selection effects" from "media effects" (Putnam 2000, 218).

Participants

We recruited participants through TurkPrime (Litman, Robinson, & Abberbock, 2017).[3] The total sample included 1,026 US citizens and residents, of whom 991 completed the survey. Among those who provided age and enrollment status, we compared early-career adults (*n* = 459) to adults of the same age who were in school (*n* = 109), and adults over the age of 35, both in school (*n* = 15) and out of school (*n* = 386).

Data Analysis

We used descriptive statistics as well as ANOVA, Tukey's post-hoc test, and linear regression to explore the data collected for the STEM fields survey. We were particularly interested in differences between respondents' attitudes towards the four STEM fields as well as the impact of engaging with different media sources and topics on both confidence and enjoyment.

Data from News Stories

Tracking & Coding STEM stories

The discipline codes used for tracking and coding STEM stories were based on research areas described by NSF. They included seven main categories and several sub-categories. The main categories are: 1) *Biological Sciences*, 2) *Computer and Informational Sciences*, 3) *Engineering*, 4) *Geosciences*, 5) *Math and Physical Sciences*, 6) *Social, Behavioral, and Economic Sciences*, and 7) *Other*. In Year 2, we rearranged some sub-categories because it allowed a more logical grouping by academic discipline. In Year 4 we did away with the subcategories entirely and coded stories only at the top level of main categories. Researchers used two codes to indicate whether each category was a primary or secondary focus for the story. We assigned all stories a single primary focus and coded multiple secondary foci as appropriate.

Story Framing

In Years 3 and 4, we used two sets of codes for news stories including ones based on a Pew Research report (Hitlin & Olmstead, 2018), to identify patterns related to the overall framing of stories. The initial codes used were:

- New discoveries;
- News you can use;
- Explanations of concepts;
- Profiles of scientists;
- Education issues; and
- Visuals with little or no text.

[3] While samples recruited through Amazon's Mechanical Turk and TurkPrime are not fully representative, respondents are as or more diverse than typical internet samples (Buhrmeister, Kwang, & Gosling, 2011).

We added *Coverage of specific event* to code stories focused on science-related events rather than scientific advances. All stories received primary framing codes and a few were assigned secondary codes as well.

Most and Least Popular Stories

In Year 3, the research team used viewer analytics to identify Facebook videos that had the highest and lowest percentages of viewers in the target age range. We graphed these data in several ways to try to visualize factors that might have impacted story popularity.

STEM Content in Other NewsHour Pieces

In Year 3, we tested a hypothesis that a substantial amount of STEM content is produced by NewsHour teams other than the science team. We did this by coding 160 broadcast and web pieces that appeared on the NewsHour website over a two-week period. These results are reported in Fraser, et al., 2018.

#AmericaAddicted: Transmedia Case Study

In the third year, NewsHour coded stories from NewsHour's America Addicted series about the opioid crisis as a case study of transmedia production, to consider the set of content as a network. This included all broadcast pieces, website articles, and social media videos as well as any promotion done on social media.

We refer to this activity in brief as the #AmericaAddicted content study to differentiate it from the #AmericaAddicted audience study.

Secondary Analysis

In Year 4, we conducted secondary analysis across activities. In some cases, we used a dataset that combined data from this project with data from a related project (Barchas-Lichtenstein, Fraser, LaMarca, Voiklis & Thomas, 2019).

These secondary analyses include:

- A language-centered analysis of responses to survey questions about relevance (Barchas-Lichtenstein, Voiklis, Glasser, & Fraser, m.s.); and
- Analysis of the same data set in terms of psychological theories of spheres of moral concern (Voiklis, et al., m.s.; for *moral concern* see Janoff-Bulman & Carnes, 2018).

How Early-Career Adults Acquire & Share STEM News

Accessing News

Our baseline research, conducted in 2016, indicated that early-career adults get their STEM news in various ways but prioritize online and social media sources, including online newspapers (69%); Reddit (56%); and Facebook (50%). Many respondents also got news from television (45%). We caution, however, that data about usage of specific platforms is always a snapshot of a particular moment in time and so these percentages may not be exact.

Responses to the baseline survey indicated, among other findings, that early-career adults consume STEM news about once a week on average. The follow-up study, which included only those who consumed STEM news at least this often, asked respondents to name and describe a specific story they had consumed in the two weeks prior to filling out the survey. The most frequent topic area they mentioned was *Computer and Informational Sciences* (30%). Stories involving *Math and Physical Sciences* (22%) were also commonly mentioned, followed by stories about *Biological Sciences* (18%) or *Engineering* (15%).

Most respondents reported accessing the story on their computers, and smartphones were the next most common device. Nearly half of respondents (46%) found the STEM story that they read while browsing general news headlines, many of them using online news aggregators or RSS feeds. Nearly as many respondents (41%) found stories through social media sites.

In Year 3, our focus groups and production team meetings focused on trends and personal choices related to accessing and sharing STEM news. Our data confirms that audiences consume and share news that they perceive as relevant to them, but there are differences in what they deem relevant. Specifically, focus group participants of all ages listed convenience as the biggest motivator in determining ***how*** they consume news. Younger participants reported using their phones more to access news, while participants aged 36+ reported consuming news on a range of devices.

All participants described themselves as somewhat quick to judge in their news consumption behaviors. For example, news assistants said that they often use the headline or first paragraph to determine whether a story topic is engaging. Similarly, focus group members said they tend to advance ahead or skip around when watching videos online, or to use multiple devices to get news from different outlets at the same time.

Findings from our study of the #AmericaAddicted transmedia story suggest that audiences' interest level in a topic may affect their news source preferences. We found that respondents who knew someone connected to opioids were more likely to find the opioid content relevant. Respondents who got more news about opioid addiction were more likely to say they would go to journalistic sources like news outlets, while those who got less news

said they were more likely to go to medical sources like WebMD or their doctor. We did not see big differences in their self-reported likelihood to use curated sources (e.g. news aggregators or search engines) or social sources (e.g. Facebook, Twitter, word of mouth).

Sharing News

Despite their interest in STEM news stories, 62% of participants in the baseline survey said that they did not share the story they described to us. Six percent said that they intended to share the story but had not yet done so at the time they filled out the survey. Meanwhile, the 32% of respondents who did share the STEM stories reported doing so via various methods including face-to-face conversation, email, text message, and social media platforms.

Year 3 research participants had various habits and opinions related to sharing news. News assistants were more inclined to see online news sharing as a positive experience that they practiced. In contrast, more than half of panel respondents said they had no intention to share the Lyme Disease report via social media or email. The responses to the Dolphin Graveyard report showed a similar pattern: About half of the panel respondents reported no intention to share the story via social media or email. For both stories, participants who said the story was relevant were more likely to report intentions to share it. More than half of the respondents to both surveys said that they were likely to describe the news stories to third parties in conversation.

This preference was a robust finding across story topics and years. On average, respondents were more likely than not to describe a news report in conversation, but neutral or less likely to share it through either social media or email. For all news reports and topics, respondents were more likely to describe them to someone than to share on social media, which in turn was higher than the likelihood to share by email. This finding is further corroborated by findings from another project. See Appendix C for further details.

Figure 3. Dolphin Graveyard Story.

As professional journalists, news assistants may see lower barriers to online sharing than members of the general public. Open-ended responses to survey questions appeared to confirm this interpretation. Those who read the Lyme Disease article were significantly less likely to mention that the story was important or interesting compared to panel participants who viewed either video version. In terms of the Dolphin Graveyard story, a quarter of the respondents said they would not share it because they found it uninteresting or unimportant. Meanwhile, a third of respondents said that while they did not share content online typically, they would discuss it in person.

Figure 4. Lyme Disease Story.

For participants who viewed news related to the opioid epidemic, we found evidence for interactions between relevance and science identity for two variables — perception of significance and likelihood to share. Across the board, relevance was more important for low science identity respondents than it was for those with high science identity. In other words, appealing to relevance is more likely to impact the behavior of audiences who do not see themselves as "science people." At the same time, participants in the #AmericaAddicted audience study who said they were active news consumers (n = 62) were more likely to find the opioid story relevant. Those who did not indicate active news consumption found the news depressing (n = 12) or not to be trusted (n = 5).

In focus groups, the early-career adult participants reported sharing stories that are personally relevant to them. However, participants were divided on whether they would share the NewsHour clips. Interestingly, focus groups also provided some evidence that younger and older adults may understand the word *share* to mean different things: 36+ participants used this word to refer to telling someone about a news report or sending it to them through a closed communication channel, while many under-35s used it exclusively to describe public broadcasting via social media.

News Routines

In general, Year 3 focus groups indicated that older adults have more time- and place-based news routines, while younger adults have more convenience-based news routines. According to a survey completed by Year 3 focus group participants, local newspapers are the most popular legacy news outlets across age groups. Of 26 participants, 24 reported reading the major local paper in their city. The second most popular individual news source was CNN (*n* = 20) followed by the *New York Times* (*n* = 19), ABC or BBC (*n* = 17), local TV (*n* = 16), and *The Washington Post* (*n* = 15). Around half selected Fox, NBC, or the Wall Street Journal (*n* = 14 each); or MSNBC or the NewsHour (*n* = 13 each). All 26 respondents read at least one newspaper online, and 22 participants watched at least one TV show online.

Early-career adults use digital sources to check news regularly, and intentionally seek out news less frequently than participants in the older cohort.

Figure 5. Reporting on the opioid epidemic.

Our research showed that respondents use two filtering strategies to determine what to read: some respondents chose news from specific outlets while other rely on referrals. In general, participants in the 36+ age group chose to read or watch videos from specific trusted outlets while younger participants initially get their news from aggregator sites, search engines, and social media, becoming more selective about their go-to outlets over time. Older participants reported consuming news directly from more legacy news outlets than early-career adults. We also found that the 18 to 35 demographic seems to find STEM stories focused on technological advancements and "explainers" that describe how things work most appealing.

Motivational Pathways to STEM News

We assessed three motivational pathways to consuming STEM news for early-career adults. These were identity motivations, motivations grounded in personal and moral relevance, and genre and form motivations.

Science Identity

Individuals who see themselves as "science people" are more likely to consume news stories on STEM-related projects. This suggests that to increase consumption of its STEM content, NewsHour needs either to increase the number of self-identified "science people" or to find ways to engage more audience members who do not identify in this way.

We also found that science identity is not the lone motivating factor for STEM news consumption. Indeed, the other two types of motivations took on more importance for individuals with low science identity.

Personal & Moral Relevance

Overall, early-career adults consume STEM news content when they find it relevant to their lives. If they consider themselves "science people," they find most STEM content relevant to their lives. But this is not the only reason early-career adults might find a STEM story relevant.

Our research also shows that people who perceive a story to be relevant conceptualize this relevance either broadly or narrowly. Those who have a narrower perspective see a story as relevant only if there is an immediate personal connection. Those who take a broad view consider a story relevant if it is of larger societal importance, whether or not they see a direct personal connection. More information on this topic is available in Fraser & Barchas-Lichtenstein, 2018.

Poetic Motivations

Finally, some audiences are drawn to stories that use form strategically. Both focus groups with audiences and participatory research with early-career journalists indicates that working millennials are drawn to stories that are exemplars of their genre, and meet expectations about form and content. These stories may, for example, use visual tools that evoke immediate responses such as "cool" or "weird" or "gross," that create a pathway to greater audience engagement. We call this motivation *poetic*, following Roman Jakobson (1960), whose *poetic function* of language centers form.

By analyzing Facebook videos, we identified four different categories differentiated primarily by length (see Fraser et al., 2018). These length categories correspond to different genres with different audience expectations: social-first videos, shortened broadcast videos, broadcast videos, and livestreamed videos. While longer videos generally performed worse, live content often performed well despite being, on average, the longest category. Although some of the longest videos began slowly with less visual interest, they were ultimately popular. This suggests that the promise of truly live content makes early-career adult audiences willing to put up with a slow start.

Both producers and consumers have different expectations for social videos compared to broadcast pieces. Perceptions of the short-lived nature of social media creates expectations on both sides for more vulnerability and authenticity. Audiences expect social videos to be less scripted and produced. On the other hand, they expect more reflection and depth from broadcast pieces. See Barchas-Lichtenstein, et al., in press, for more information.

How STEM Stories' Structure & Shape Serves Early-Career Adults' Needs

Story structure and format plays a role in whether or not audiences choose to consume content. Across project years, audiences described articles as lengthy and favored more concise and novel ways of presenting stories. We also found that audiences have different expectations for engaging with news stories depending on the medium through which they are presented.

STEM Story Format & Early-Career Adults

In each project year, we found some quantitative differences between audiences' experience of different story formats, but many of these were small differences that required further contextualization. Rather than a straightforward takeaway that one format is better than others, research findings consistently showed that the various platforms have different affordances.

For example, viewers of the Year 1 earthquake story either saw (1) a story that unfolded on Twitter over the course of a several hours via more than 40 tweets or (2) a Storify post that combined all of those tweets into a single story. Although both versions contained the same amount of text, audiences found the Storify version a better length than the Twitter version. They also found the Storify version to be more novel, although it bore more similarity to other article formats than did the Twitter version.

In Year 2, respondents were more interested in infographics than articles. They also consistently found articles to be both less accessible and too long when compared to all other formats. Open-ended responses confirmed this difference, with respondents noting that NewsHour articles were sometimes quite dense. In Year 3, viewers of the three Lyme Disease stories considered the article and broadcast piece the right length, while a number of them found the Facebook Live story too long. Similarly, respondents who saw one of the opioid reports were also most likely to consider the article somewhat too long.

We found that interpreting these results required a clearer understanding of the systematic differences of reports in these different formats. We discuss our assessment of these differences in detail in the next section.

Genre: Systematic Differences between Stories

We assessed variations between the various story types that NewsHour used including broadcast videos, social videos, articles, and so on. This allowed us to explore the role and importance of genre expectations in the context of audience feedback. We defined *genre* as formal features and structures that set expectations "for the production and reception of discourse" (Bauman, 2004, p. 4). A story's genre may change if the story is moved to a different medium. For example, the same text may appear in a print newspaper and on the newspaper's website, but readers would likely have different expectations for how to engage with each medium.

In general, broadcast videos traditionally treat audiences as overhearers rather than interlocutors, while the reverse is true for social media pieces (Barchas-Lichtenstein et al., 2019). These tendencies also shape audience expectations for each genre. For example, the participatory nature of social media genres is compatible with a more candid and informal tone.

STEM: Differences between Disciplines

Focus groups and conversations with news assistants suggested that there might be differences between working millennials' confidence in the four major STEM disciplines, or their enjoyment of these disciplines. We set out to test that assumption with this study.

This exploratory study found evidence of differences in enjoyment and confidence between the fields. Enjoyment of math was meaningfully lower than enjoyment of science and technology, and confidence in math was meaningfully lower than confidence in technology. Enjoyment and confidence were more highly correlated for mathematics than they were for the other three fields, and enjoyment was typically higher than confidence in the non-mathematical fields. Media consumption did not appear to be strongly related to confidence in any of the four STEM fields. Full results are available in Appendix D.

What Media Organizations Can Do for Early-Career Adults

As noted above, news media play an important role in informing and educating early-career adults about STEM-related research. As part of this study, NewsHour experimented with a wide range of platforms and formats including several new platforms and formats. It also tested single stories that touched on a wide range of science topics and disciplines as well as broader investigative journalism story focused on opioid addiction in America. In this section, we discuss the breakdown of the stories by subject area, consider framing, and also report on insights from journalists who themselves are included in the millennial cohort.

Story Disciplines & Frames

NewsHour created stories over the four project years that touch on a wide range of science topics and disciplines (Figure 6 below).

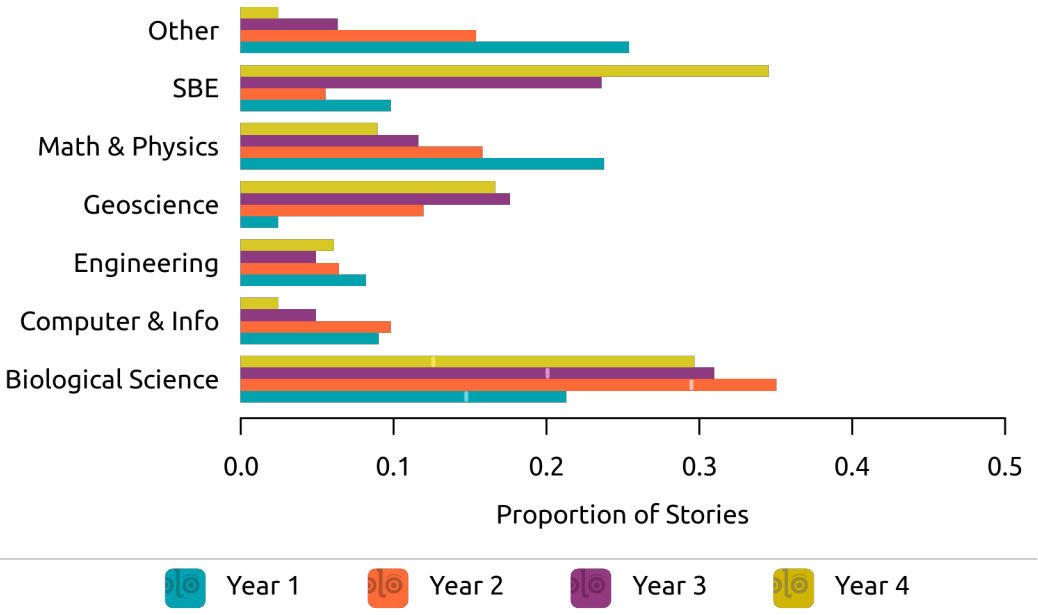

Figure 6. Primary story disciplines in each year.

Notes: Within biological sciences stories, *human health* stories are to the right of the white vertical line.
Other stories included topics such as scientific ethics or tools used across disciplines.

The current events of each year were the subject of a large number of stories, often natural disasters (e.g. hurricanes, tsunamis, floods), disease threats (e.g. Zika virus), and new technological advancements (e.g. space exploration development, 3D printing). For example, popular story topics in Year 4 were wildfires, space exploration, and connections between climate change and natural disasters – which coincided with events happening throughout the world at that time.

Biological Sciences stories were always one of the most frequent disciplines, and they accounted for between 21% and 35% of all STEM stories each year. This consistent emphasis is likely due to the breadth of topics considered biological (human health, conservation, etc.). Meanwhile, the number of *Geosciences* and *Social, Behavioral, and Economic (SBE) Sciences* stories both increased considerably over time: less than 3% of Year 1 stories were about *Geosciences*, while 16% of Year 4 stories were. Similarly, only about 10% of Year 1 stories focused on *SBE* disciplines, while these made up 35% of Year 4 stories. Coverage of *Mathematical and Physical Sciences* was the only category that decreased considerably over time, from 24% of Year 1 stories to 9% of Year 4 stories. Coverage of stories with primary codes of *Engineering* and *Computer and Information Science* remained comparatively low through all four years, never surpassing 10% of stories produced in a year.

In Year 2, *Biological Sciences* was the most common secondary discipline, but *Social, Behavioral, and Economic Sciences* became the most common secondary disciplines in Years 3 and 4, with *Biological Sciences* in second place. Social science topics appeared as a secondary focus in 60% and 41% of stories in Years 3 and 4, respectively (*note*: these calculations do not include stories with a primary focus on SBE sciences). In other words, social sciences appeared in 69% of all Year 3 stories and 61% of all Year 4 stories. This increased focus on the social sciences, across primary and secondary disciplines, reflects the team's shift towards drawing explicit connections between scientific concepts and audiences' lives. For example, 39% of *Geosciences* stories covered in Year 4 had a secondary focus on the social sciences, which may reflect coverage linking climate change to social impact.

Story framing was relatively consistent between Years 3 and 4. Explanations of concepts and new discoveries were the two most common frames, followed by event coverage (Figure 7). Because these codes were based on research originally published in 2018 (Hitlin & Olmstead, 2018), we applied these codes only after that point in time.

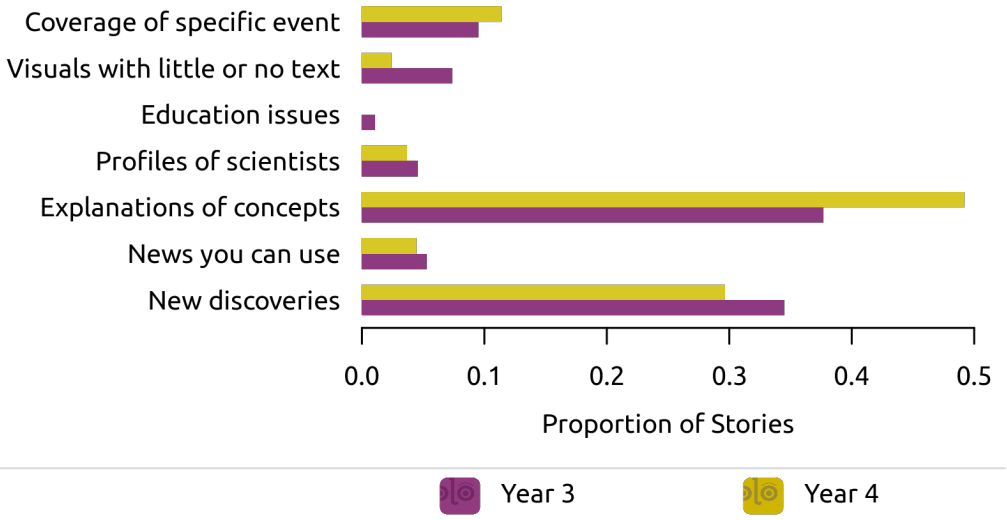

Figure 7. Story framing codes in Years 3 and 4.

Platforms & Formats

Over the four years of the project, NewsHour experimented with a wide range of platforms and formats (Table 3). The team made a point of exploring several new platforms and

formats shortly after they were introduced, including Facebook 3D, Instagram Stories, and Instagram TV. Innovating with new platforms and formats required not just stylistic experimentation but often creating new approval processes within the NewsHour for various types of content.

Table 3. Platforms and formats used in each project year.

Platform	Year			
	1	2	3	4
Broadcast	■	■	■	■
Facebook	■	■	■	■
Facebook 3D*			■	
Facebook Live	■	■	■	
Infographic		■	■	■
Instagram	■	■	■	■
Instagram Story*		■	■	■
Instagram TV*				■
Instagram Video	■	■	■	■
Podcast	■	■	■	■
Snapchat		■		
Tumblr	■	■	■	
Twitter	■	■	■	
Twitter/Periscope		■	■	
Twitter Story	■	■		
Website	■	■	■	■
YouTube	■	■	■	■
YouTube Live		■	■	

Notes: Facebook 3D technology was introduced in 2018. Instagram introduced the Story format in late 2016 and the TV format in late 2018.

True Transmedia Production

In Year 3, the team produced its largest transmedia series to date. The #AmericaAddicted series includes 14 broadcast reports, 10 articles on the NewsHour site, 4 livestreams, 3 Twitter chats, and more than 200 associated videos and posts on a half-dozen platforms. The anchor reports alone add up to twelve hours of content that tell one overarching story: an epidemic of opioid abuse is overwhelming the United States. The different reports take a wide range of perspectives and focus on different aspects of this crisis. For example, one report focused on a city where approximately 10% of the population struggles with addiction. Another provided an opportunity for people in recovery to share personal narratives. Other reports focused on the chemistry of the drugs, the treatments available, the scope of the issues, and the role of race in public reaction to the crisis.

The series is a decentralized, non-linear documentary. Each anchor report is embedded in dense networks of content, with some connections appearing before or long before the report's original release (Figure 8). Audience members may come to this documentary through any of hundreds of entry points, and it's likely that no two audience members access identical content in an identical manner.

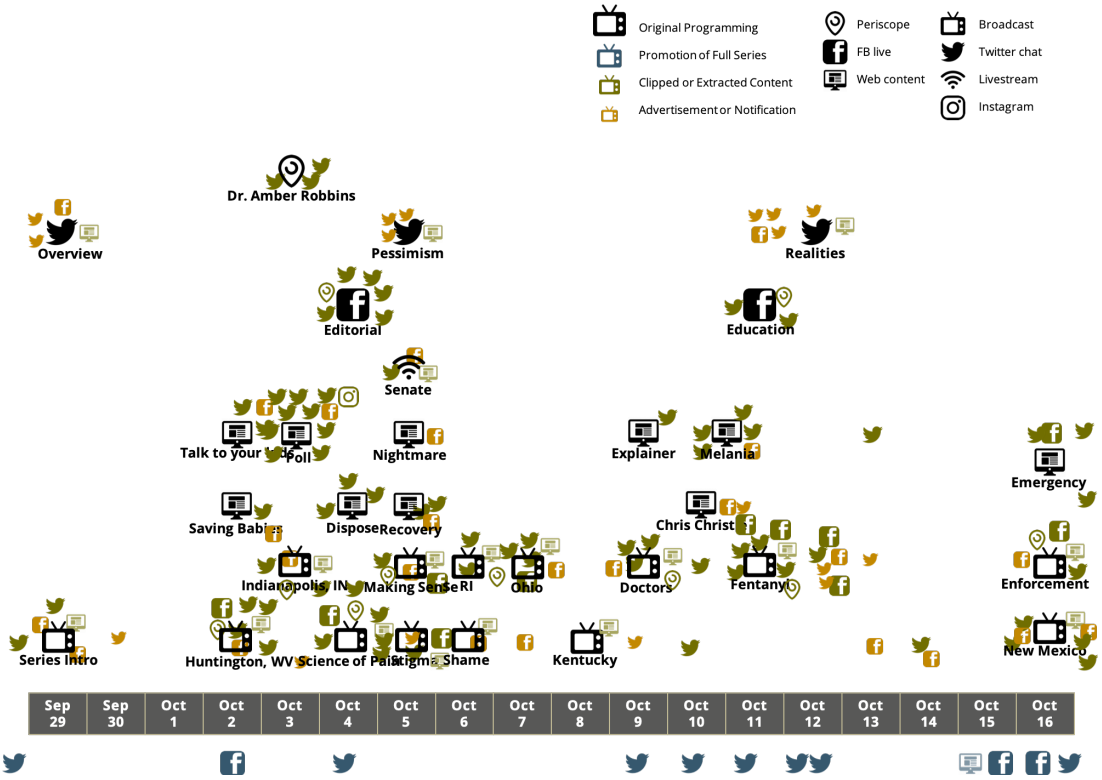

Figure 8. Networks of content in #AmericaAddicted.

The Value of Early-Career Journalists

NewsHour's news assistants were central to the participatory action research, offering insights both as early-career adults and as journalists working in an established newsroom. As noted earlier, the duration of the news assistant position changed, as did the strategy for engaging news assistants as participatory action researchers. Irrespective of these differences, a key theme that consistently emerged was a struggle to balance the more formal style of the NewsHour with more relaxed ways of telling stories that are a hallmark of early-career adult engagement with media.

We focus in this section on the work of the Year 4 news assistants for detail, as these results reflect the current state of affairs at the NewsHour. Additional details related to the results in earlier years are available in prior reports (Roberts, Flinner, et al., 2016; Roberts, Norlander, et al., 2017; Fraser et al., 2018).

Learning Through Active Social Media Use

Year 4 news assistants, like their predecessors, brought a nuanced understanding of their peer group to the newsroom. Both news assistants explained that early-career adults engage with science news primarily on social media – specifically Twitter, Facebook, and Instagram. Yet the way this audience engages (e.g. how they share, comment on, or "like") with that news often depends on the STEM literacy of each individual.

> ***"I am working to find a balance between adding my own humor and personal voice while still keeping the tone of the piece professional for the NewsHour style. I'm hoping to find a balance between interesting, young story topics to attract an audience my age and keeping a slightly more formal tone."***

For example, one news assistant said that those more familiar with science are more likely to share things with hopes of stimulating conversation around a subject, while those less familiar with science more often simply share things that appeal to poetic motivations, regardless of the stories' rigor. As one assistant wrote, "*I have two kinds of friends: ones who share real science, care about the scientific content, and discuss/debate scientific content… and the ones who repost IFLScience, viral Facebook posts, and misinformation.*"

One news assistant observed that news stories they see posted to social media by researchers and other STEM-related accounts (e.g. National Geographic) greatly influence the stories they pitch and ultimately report on. Their own social media use helps them determine which topics are trending, intriguing, and interesting to 18-35-year-olds.

Being active on social media also helps younger journalists understand how to use jokes, puns, and catchy titles to draw the attention of their peers. One assistant said that consuming news from other sources influences the way they write their stories for NewsHour. In particular, when they read other news publications, they said that the pieces that stand out are concise while managing to (a) share information about a topic and (b) offer connections to real life that make the topic feel relevant to the user.

Writing for Multiple Audiences at Once

As with previous years, Year 4 news assistants were challenged by the task of writing for a heterogeneous audience that includes both younger and older people. Part of the challenge, according to the news assistants, is that NewsHour style guidelines sometimes require them to *"tone down"* light hearted language and jokes (e.g. when reporting on scientists giving MDMA to a group of octopi) that they would like to see in science reporting. As one news assistant wrote, "*I am working to find a balance between adding my own humor and personal voice while still keeping the tone of the piece professional for the NewsHour style. I'm hoping to find a balance between interesting, young story topics to attract an audience my age and keeping a slightly more formal tone.*"

One news assistant suggested that NewsHour could engage with a younger audience by presenting content in a way that is more fun or quirky. However, they also wrestled with finding a balance between writing things that would draw in a younger audience, but not wanting to write titles that are simply *"click bait."* This topic emerged in each year as a challenge that one Year 4 news assistant summarized by saying, *"part of my mission here is to cover science stories that [NewsHour] wouldn't normally think of, but are relatable for people my age."*

Early-Career Adult Perspectives on the NewsHour Brand

The news assistants brought a valuable youth perspective to the NewsHour brand. One news assistant explained that PBS NewsHour's strong reputation is the main reason people view it as a reputable source. But its scientific reputation can also be a weakness: those who aren't necessarily drawn to scientific studies may not seek out the NewsHour in the first place.

Another news assistant pointed out that NewsHour already prioritizes well-researched reporting that relies on multiple sources, rather than pumping out quickly-written breaking news reports (compare Stephens, 2014). They suggested that NewsHour could take advantage of this reputation to position themselves as a critical voice that helps audiences identify what's real and what's fake.

General Principles for Engaging Early-Career Adults

Both Year 4 news assistants agreed early-career adults are drawn to short, concise stories that move them through the article or video and avoid *"teasing with unfulfilling questions."* In general, they prefer simple subject matter combined with *"astounding facts"* that aren't over-hyped. One news assistant emphasized the importance of the format, and particularly the length, of stories. They wrote that *"a piece needs to earn the space it takes up. Some stories are worth thousands of words, and some are worth 35 seconds of video."*

"A piece needs to earn the space it takes up. Some stories are worth thousands of words, and some are worth 35 seconds of video."

Media organizations can tailor STEM news for early-career adults by prioritizing connections to how the information is relevant to a younger reader (e.g. "science you can use"). And these organizations can make particular use of journalists who are early-career adults, who can ensure they're focusing on topics and titles that will draw attention from their target audience.

Discussion

After four years of study that included iterative testing of a range of story content and concepts, a new picture of early-career adults' use of STEM news emerged. We emphasize six main principles that can guide media makers. Specifically, early-career adults are:

- ***Stable STEM Consumers***: Those early-career adults who self-define as "STEM people" represent a relatively stable audience who engage with content across a range of disciplines, as long as the reporting treats its audiences as knowledgeable.
- ***Selecting for Relevance***: Early-career adults seek STEM stories that situate content in a humanistic frame as part of the lede. This is particularly true for those who don't identify as science people.
- ***Willing Learners***: If STEM content is presented in connection with topics that they find relevant, those early-career adults who do not self-define as "STEM people" remain interested in learning STEM content;
- ***Skilled Media Feed Curators***: Working millennials manage their news feeds carefully and make quick decisions about content, having little patience for long introductions or equivocation;
- ***Less Brand Loyal***: Early-career adults are less likely to rely on particular news outlets for content, and are more likely to consume information from across a variety of sources including those they are less likely to trust; and
- ***Looking for Dialogue***: Early-career adults expect opportunities for participation in story development and co-creation. They are also more likely to bring up stories in conversation rather than to share them through social media or email.

Motivations & STEM News

Our research revealed that early-career adults choose stories that interest them. Their decision not to engage with certain content is not an indication of low attention span. Specifically, early-career adults seek out STEM news for three primary reasons. ***Science identity*** is the most stable of these three, accounting for consistent interest in STEM news. Meanwhile, ***relevance*** and ***poetic motivations*** may account for some volatility, since particular news reports may appeal more or less to these affinity users.

Given the stability of science identity as a motivation, it is not surprising that relevance is a more important motivator for people who do not have high science identity. Explicit appeals to both individual and societal relevance, then, are likely to draw additional audiences without affecting a report's appeal to high-science-identity audiences. The growing number of stories that focus on social science topics appears to be linked to an effort to do just that.

Sharing & Measuring

While some recent research (e.g. Kümpel, Karnowski, & Keyling, 2015) treats news sharing as a behavior that exists exclusively on social media, early-career adults' practices call such definitions into question. Across topics and years, audiences said with an unusually high

level of consistency that they were more likely to describe a news story in conversation than to *share* it via either email or social media.

In other words, the act of sharing news reports is not necessarily a digital one (cf. Hermida, Fletcher, Korell, & Logan, 2012), even if the word *"sharing"* now carries strong, perhaps unavoidable, associations with social media (cf. Lange, 2018). Simply put, people talk about the news they see, both online (Weeks & Holbert, 2013; Johansson, 2017) and off (Southwell & Torres, 2006).

Though we distinguish between conversation and sharing news reports via social media and other platforms in this study, we note that it may be helpful to think of these activities as belonging to a larger set of news sharing practices. If anything, the overemphasis on digital forms of sharing may reflect the temptation to center that which is more easily measured and tracked. However, doing so likely neglects a great deal of the social learning that happens around news content.

These findings suggest avenues for future research. In particular, studying private conversations about news reports (cf. Bird, 2011) can help us better understand the social nature of learning from news. Doing so may also help journalism organizations provide news reports that provoke conversation.

Transmedia Practices

Looking at adults' – and not just young adults' – news routines makes it clear that transmedia practices are now pervasive in the U.S. audience. Few, if any, adults in the U.S. get their news from a single outlet or even a single platform. For example, you might listen to radio in your car, scroll through headlines on your phone while you're waiting in line, and read a physical newspaper only on airplanes. If you're a heavy social media user, you might see headlines from thirty different outlets in a single afternoon, but only click through and read one story (cf. Groot Kormelink & Costera Meijer, 2018). You might access newspaper, radio, and television content only through websites. You might compare multiple organizations' coverage by browsing while watching TV, or fact-check a particularly surprising element or the backstory of a featured individual or company.

Similarly, most news organizations have moved beyond a single modality. Newspapers now produce podcasts, videos, and immersive media. Television networks produce text articles and various web interactives. And all types of news organizations distribute content through websites, social media platforms, and more. At the same time, individual journalists are often asked to manage their own social media feed, while their on-air and web content remains subject to editorial review.

These practices have a number of implications for news creators:

- Given new pathways to explore the news, news creators interested in advancing STEM literacy may get higher traction among audiences if they focus on interactivity. They can also cross-reference and hyperlink to create multiple pathways for moving back and forth between different assets.
- News creators should build the assets the story needs and create each piece with a vision of the whole. Reports don't need to provide the same exact

information, as long as the pathways exist to move between different formats and platforms.

- News creators should generate evergreen pieces, particularly explainers, that can be hyperlinked to more timely content. Doing so will help them connect better to early-career adults' exploratory news routines.

Conclusion

Early-career adult learners likely experienced a science education that was focused primarily on facts, and included little contact with the practices and realities of scientific research. Informal education environments, including news media, are one important option for continuing science learning throughout the life course. As Falk & Dierking (2010) note, the integration of broadcast media and web delivery for adults remains substantially understudied in STEM learning, though this is where most adults report encountering STEM content. Various digital platforms can offer different points of entry for early-career adults to access and engage with content. Producers and presenters of this content can also help audiences understand how to relate what they hear and read about to their daily lives and make more informed decisions.

Our research indicates that legacy media outlets have embraced new media platforms and continue to come up with innovative ways to present their content using the affordances of these new formats. This study provides tools to help media producers structure stories produced across all STEM disciplines in ways that continue to engage audiences. News reports can be the link to STEM content for people who do not identify as science people, and who may not seek out some of the same programming that individuals who identify as science people do.

Our research reveals that to reach these types of audiences, news organizations should use more humanistic frames for stories that appeal to either moral, personal, or poetic motivations. But they also should continue producing traditional science reporting because this kind of content appeals to audience members who identify as science people. Given the multiple ways that audiences engage with content, news organizations should continue situating emerging stories in the content of evergreen content and prior reporting.

The partnership model in which this project was based was particularly important to its outcomes. As an embedded research partner on the Transmedia study, Knology could ask more complex questions and create opportunities for reflection to help refine NewsHour's news production practices. The news assistants were crucial to this process because they could speak from the perspective of both early-career adults familiar with their peers' nuanced habits on new media platforms, and science journalists invested in learning to tell good news stories.

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