

EMPIRICAL RESEARCH

A Narrative Analysis of Stories Told about Engineering in the Public Discourse: Implications for Equity and Inclusion in Engineering

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Background: Stories are a natural and powerful way for humans to make sense of complex situations. Prior research suggests that when people are faced with complex problems, like underrepresentation in engineering, they construct and defer to stories, sometimes even in the face of contradicting evidence, as a basis for decision making and action.

Purpose/Hypothesis: We examined the public discourse to identify stories about underrepresentation in engineering, and about engineering more broadly, that inform and underwrite efforts to address the dual problem of a general lack of interest in engineering careers and a lack of diversity in engineering graduates and professionals.

Design/Method: Drawing on the theory of framing and concepts from narrative policy analysis (NPA), we qualitatively analyzed one year of online news articles (from August 2011 to August 2012) sourced from a news briefing service for engineering educators.

Results: We describe five dominant stories about engineering that define the field in terms of math and science, building things, the need for societal appreciation, diversity-driven innovation, and hard-earned career rewards, respectively. These stories share a common premise—that a chronic shortage of engineers threatens the economic growth and international competitiveness of the United States. Each story includes explanations for perceived low levels of interest in the field and recommendations to address this problem. We note that increasing the participation of groups from diverse ethnic backgrounds was not a prominent theme in the discourse we analyzed compared to, for example, attracting more women or increasing the overall number of young people who are interested in engineering careers. Consistent with NPA, we also describe a nonstory that critiques the premise of the dominant stories.

Conclusions: We discuss how the dominant stories reflect a particular set of values and practices, centered on competition, economic gain, and the design of technological artifacts that, in turn, shape efforts to attract, educate, and retain students. We further discuss how alternative narratives may open up new opportunities for systemic, cultural change in engineering education with important implications for diversifying the field.

Keywords: diversity; recruitment; discourse analysis; narrative policy analysis; mass media

Introduction

On November 12, 2011, CNN published an online news article describing the low number of women and persons of color in science, technology, engineering, and mathematics (STEM) fields. CNN's report contained the following quote from Janice Cuny, then director of computing education at the U.S. National Science Foundation:

Together, women and [persons of color]¹ make up more than two-thirds of our population ... We cannot afford to cede that much talent, creativity and breadth of perspective if we are to remain globally competitive in a world that is becoming increasingly well-educated and technologically advanced. (Morales, 2011)

This story, entitled “Building more [persons of color and women] engineers – As early as elementary school,” points to one way in which the lack of diversity in engineering was, in 2011, framed in the public discourse: as a threat to the United States’ global, economic competitiveness. According to literary theorist and policy analyst Emery Roe (1994), whose work informed this study, “Stories commonly used in describing and analyzing policy issues are a force in themselves, and must be considered explicitly in assessing policy options” (p. 2). Roe outlined a methodological framework called narrative policy analysis (NPA) to examine the stories different groups construct to make sense of complex, uncertain, and polarized problems, such as the issue of underrepresentation in engineering. He argued that when people are faced with such problems, they construct and defer to stories, sometimes despite evidence to the contrary, as a basis for making decisions and taking action. This approach parallels literature on discourse analysis, which similarly discusses the *action orientation* or *function orientation* of discourse (Gill, 2000, p. 175). In this study, we examined how stories, like the one Cuny alluded to above, serve to reduce the complexity, uncertainty, and polarization associated with what we repeatedly saw described in our dataset as a “chronic shortage of engineering students” (Paul Otellini, *The Washington Post*, Aug. 4, 2011). In doing so, we suggest that these stories both reflect and shape the culture and values of engineering and engineering education in the U.S., and inform the underlying logic and design of outreach, recruitment, and retention efforts, both broadly and with respect to women and persons of color in particular.

The data we examined in this study, which comprised news articles sourced from the American Society for Engineering Education’s *First Bell* bulletin service, date back to a one-year period from August 2011 to August 2012. At that time, the U.S. had a Black president who strongly promoted STEM education. The country was also recovering from the Global Financial Crisis (GFC). Within engineering education, there was a sense of urgency about how to prepare engineers for a world where “technological change [was] occur[ing] at a faster and faster pace” and “new challenges and opportunities [were] emerging as a consequence of rapidly improving technological capabilities in such nations as India and China” (National Academy of Engineering, 2004, p. 1). In *The World is Flat: A Brief History of the Twenty-First Century*, Thomas L. Friedman (2005a) had described the United States as unprepared for the increasingly globally connected, digitalized, and competitive nature of the modern workplace. He wrote “math and science are the keys to innovation and power in today’s world” (Friedman, 2005b, p. 27) and called for more workers in science and engineering fields. Two further publications – *Rising Above the Gathering Storm: Energizing and Employing America for a Brighter Economic Future* and *Is America Falling Off the Flat Earth?* – from the National Academies Press (National Academy of Sciences, National Academy of Engineering, and Institute of Medicine, 2007a, 2007b), similarly expressed concerns about the nation’s ability to compete in the 21st-century global economy. In this context, STEM education, and therefore engineering education, was regarded as a critical way to ensure the continued recovery, growth, and competitiveness of the U.S. economy.

Until the COVID-19 pandemic emerged in early 2020, the U.S. economy did, indeed, recover from the GFC. Women and persons of color in engineering, however, did not experience the same levels of success. In fact, the proportion of bachelor degrees awarded to African American students dropped from 4.2% in 2011 to a low of 3.5% in 2014 before recovering back to 4.2% in 2018 (Roy, 2019; Yoder, 2012), despite a 50% increase in bachelor degrees awarded to engineers (from 81,371 to 121,956), which equates to a 1.6% increase in degrees conferred to engineers compared to the overall number of bachelor degrees awarded by postsecondary institutions (from 4.5% in 2011–2012 to 6.2% in 2017–2018; National Center for Education Statistics, 2019). Participation of women in engineering increased by only 3.8% over the same period (from 18.1% in 2011 to 21.9% in 2018; Roy, 2019; Yoder, 2012). In comparison, the Standard & Poor’s 500 Index, a market-capitalization-weighted index of the 500 largest publicly traded companies in the U.S., grew by over 220% from August 2011 to August 2018.

While the proportion of bachelor’s degrees awarded versus an overall measure of economic growth is not an equal comparison, the undeniably stark contrast in progress suggests a need to closely examine stories that connect the two. This examination is necessary, because following the logic Roe (1994) laid out in his NPA approach, dominant stories “underwrite and stabilize the assumptions for decision making in the face of complexity and uncertainty” (p. 69). In other words, the stories told to make sense of a lack of interest in engineering careers, particularly among women and persons of color, inform the actions that engineering educators and outreach and recruitment specialists take in response. Yet the data suggests that these narratives are continuing to fail in changing the face of the field.

We thus have three goals in this paper. First, we aim to lay bare, with rich empirical evidence, five dominant stories about engineering, and about underrepresentation in engineering, that we identified in *First Bell* news articles from August 2011

¹ Williams (2020) described the term *underrepresented minority* as racist language. To prevent further microaggressions toward African American, Native American, Alaska Native, Hispanic, Latinx, Asian, Asian-American, Middle Eastern, or North African readers, we have changed all further instances of *minority* and *minorities* in quotations to *persons of color* or *persons of color and women*, depending on the original context.

to August 2012. Second, we challenge readers to consider how, if at all, these stories are different today, when we are in an arguably comparable time of economic uncertainty and an arguably different time of social upheaval and national leadership around race and gender (and racism and sexism). Finally, we invite readers to join us in imagining and constructing stories that might inspire the next generation of engineers.

Connection to Prior Research

This study extends prior research examining how discourse intersects with underrepresentation in engineering. This prior work spans how engineering educators conceptualize (Lee, 2019) and problematize (Beddoes, 2011) the challenge of broadening participation; the role of messaging in increasing interest in the field and attracting more diverse students (National Academy of Engineering, 2008, 2013); and basic beliefs and assumptions about the discipline (Pawley, 2009).

In a recent editorial published in the *Journal of Engineering Education*, Lee (2019) discussed the affordances and limitations of three metaphors (pipelines, pathways, and ecosystems) commonly used in conversations about broadening participation. Lee argued that we should examine these metaphors because “our use of metaphors shapes the forms of research, practice, and policies we pursue, and informs what we think others should pursue” (p. 8). For example, if we use the pipeline metaphor, our actions may be informed by efforts to increase the flow of engineers by plugging leaks (Sochacka, Walther, Wilson, & Brewer, 2014). We might visualize success as a pipeline with no leaks that delivers a high product flow. Alternatively, if we conceptualize engineering education as an ecosystem, we might create niche environments where underrepresented students can thrive, or perhaps identify systemic conditions that prevent underrepresented students from thriving. This paper draws on a similar logic: The stories we tell about the lack of interest and diversity in engineering inform our efforts to address these problems.

Beddoes (2011) similarly examined how discourse intersects with broadening participation in engineering. Specifically, she investigated different ways in which engineering educators problematize underrepresentation in engineering (i.e., “why should we care?” versus Lee’s (2019) focus on “what, metaphorically speaking, is the problem?”). Beddoes (2011) used discourse analysis to examine the engineering education literature to find “reasons ... given to explain why underrepresentation [of women] is a problem” (p. 1117). Drawing on 13 years of data from 1995 to 2008, Beddoes identified four categories: economic competitiveness; professional service and representativeness; women’s attributes; and social justice and equality. Paralleling our findings, Beddoes (2011, p. 1126) identified economic competitiveness as a “common and compelling framing of the problem of underrepresentation ... in both STEM fields and business more broadly” (see also Baber, 2015). She further noted that, despite the longstanding nature of economic competitiveness arguments, representation of women in engineering has not markedly improved, suggesting that “critiques of this discourse are warranted” (p. 1126). Beddoes further observed that only one category (social justice and equality) framed underrepresentation as a problem for women (versus a problem for the economy or for the profession), “because they [women] are subject to unjust, unfair, unethical, or immoral barriers that prevent them from entering engineering in equal numbers” (p. 1126).

Like Lee’s (2019) editorial, Beddoes’ categorizations demonstrate that the engineering community uses different forms of discourse to make sense of the problem of underrepresentation. The contrast between *economic competitiveness* and *social justice and equality* further demonstrates how different discourses reflect different priorities and values and, therefore, motivate different approaches to student outreach, recruitment, and retention. For example, stories that frame engineering as being “all about building things” (reported by Sarah Campbell in *The Salisbury Post*, Apr. 9, 2012) within an economic competitiveness paradigm² follow a logical trajectory toward designing hands-on activities to increase students’ interest. What might alternative outreach and recruitment efforts look like if engineering were all about “hold[ing] paramount the safety, health, and welfare of the public” (National Society of Professional Engineers, 2007, p. 1) within a social justice and equality paradigm?

The U.S. National Academy of Engineering’s (NAE) (2008, 2013) work on messaging arguably provides the most widely cited example of how the engineering education community is attempting to leverage discourse to increase interest in engineering careers. In contrast to Lee’s (2019) editorial, which asks, “What is the problem?” and Beddoes’ study, which asks, “Why should we care?” the NAE uses discourse to answer, “How do we solve the problem?”

In 2008, the NAE’s Changing the Conversation report challenged our community³ to reframe the ways engineering is spoken about in the public domain. Using insights from focus groups conducted with parents, teenagers, and children ages 9 to 12, the NAE recommended that instead of describing engineering in terms of “required skills and personal benefits” (p. 11) (e.g., mathematics, science, and competitive salaries), efforts to promote the field should emphasize engineering as “inherently creative and concerned with human welfare, as well as an emotionally satisfying calling” (p. 5). In fact, the NAE even concluded that “continuing to emphasize math and science in marketing or rebranding engineering is unnecessary and may damage rather than increase the appeal of engineering” (p. 11). To facilitate the shift from required skills and

² See the second dominant story in the *Findings*: Building things.

³ The NAE (2008, p. viii) noted that their work would “be of special interest to engineering professional societies, technology-intensive industries, colleges of engineering, science and technology centers, and other organizations that communicate with policy makers, K–12 teachers and students, and the public at large about engineering.”

personal benefits to how engineers make a difference in the world, the NAE (2008) recommended four messages to inform outreach and recruitment efforts: engineers make a world of difference; engineers are creative problem solvers; engineers help shape the future; and engineering is essential to our health, happiness, and safety (p. 12). As our findings illustrate, these messages represent a significant departure from characterizations of engineering in the public discourse we analyzed. We concur with the NAE that such a departure, or at least broadening of the conversation, is necessary to connect with the broadest and most diverse population of future engineers possible. We return to the NAE's messages later in this article.

A study by Pawley (2009) similarly demonstrates how the NAE's messages represented a new framing, this time compared to basic beliefs and assumptions about engineering that faculty convey to students in the course of their "daily work" (p. 309) of teaching and research. Pawley interviewed ten engineering faculty members at a research-intensive university and found that their "descriptions moved within and among the narratives of engineering as applied science and math, as problem-solving, and as making things" (p. 309). Pawley called these three stories "universalized narratives" because of their "broad-sweeping discursive application within and across participants' interviews" (p. 309). Like the NAE, Pawley questioned whether these universalized narratives are the "best narratives to tell in order to attract a diverse population of future engineers" (p. 309). She further noted that naming such narratives is essential so that engineering educators can critically evaluate them and "develop and practice telling contrasting narratives to future and current engineering students" (p. 309). The study we present arrives at a similar conclusion: we must develop and practice telling alternative narratives, particularly if we hope not only to increase overall numbers, but also to create a more diverse and inclusive profession.

Relevant Theory

We have used the term *framing* several times in this article. Coming from the field of media studies, the term warrants some explanation. The power of stories and storytelling is a core tenet of media studies. As the late media scholar George Gerbner stated, "We experience the world through stories. Whoever tells the stories of a culture defines the terms, the agenda, and the common issues we face." In critical media studies, Ott and Mack (2014) described this influence as a "socializing force," where socialization is defined as a process "by which persons—both individually and collectively—learn, adopt, and internalize the prevailing cultural beliefs, values, and norms of a society" (p. 13). According to scholars in this field, the media influences how the public makes sense of topical issues through two key mechanisms: *agenda setting* and *framing*. McCombs and Ghanem (2001) defined agenda setting as "a theory about the transfer of salience from the mass media's pictures of the world to those in our heads" (p. 67). In other words, agenda setting posits a strong correlation between the emphasis the mass media places on issues and the importance the public attributes to those issues (Scheufele & Tewksbury, 2007). Sometimes referred to as second-level agenda setting, framing goes beyond *what* the media reports to posit that *how* the news characterizes an issue also influences how the public understands it (Weaver, 2007). Referring more explicitly to how framing intersects with the construction of narratives, Entman (1993) defined framing as follows:

To frame is to select some aspects of a perceived reality and make them more salient in a communicating text, in such a way as to promote a particular problem definition, causal interpretation, moral evaluation, and/or treatment recommendation for the item described. (p. 52)

In our study, we drew on agenda setting and framing to theoretically anchor our focus on stories about engineering and about underrepresentation in engineering, as reflected in publicly available online news articles. To paraphrase Entman (1993, p. 52), we were interested in the particular problem definitions pertaining to a general lack of interest in engineering and to underrepresentation in engineering that were selected and communicated through publicly available online news articles, their associated causal interpretations and moral evaluations, and the treatment recommendations put forward.

Research Design

Data Collection

To investigate how engineering and underrepresentation in engineering are framed in the public discourse, we qualitatively analyzed news articles from one year of the American Society for Engineering Education's (ASEE) *First Bell* news briefings (from August 4, 2011, to August 3, 2012). *First Bell* summarizes key engineering education and practice reporting from the preceding 24 hours; it is emailed to ASEE members daily, Monday through Friday. Bulletin Media curates *First Bell* for ASEE, sourcing news from "tens of thousands of media sources, including newspapers, magazines, television (all national and local markets), radio, trade press, etc." (Bulletin Media, 2014). Bulletin Media analysts select approximately 25 news items for each edition of *First Bell* based on perceived relevance to the field and provide article summaries and links to the articles. ASEE reserves the right to vet the contents of the newsletters.

We chose *First Bell* as our data source for two reasons: First, the newsletter offers access to a large number of publicly available online news articles pre-selected for engineering relevance. Second, we wanted to stay close to the public discourse with which U.S.-based engineering educators and other advocates (e.g., outreach specialists) engage. Replication studies (Benson & Borrego, 2015) that use different data sources (e.g., televised news), data types (e.g., social media), and time periods, or that focus on geographical contexts outside of the U.S., would provide different perspectives.

Methods

Two senior researchers and two undergraduate students (the authors of this article) collaborated to analyze the *First Bell* news articles. This interpretive process, which we have described in detail elsewhere (Sochacka, Walther, & Pawley, 2018; Walther, Pawley, & Sochacka, 2015; Walther et al., 2017), involved multiple iterations, shared experiences of interpretive dissonance (Walther et al., 2017, p. 418), and ultimate convergence towards an understanding of the data that captured both the “coherence and [the] complexity” of the social reality under investigation (Walther, Sochacka, & Kellam, 2013, p. 643). With the goal of ensuring high quality findings, the team discussed and initiated multiple quality strategies from the outset, including peer debriefings in weekly meetings (see communicative validation in Walther et al., 2013), openness to an emergent research design (see theoretical validation in Walther et al., 2013), and individual log trails (see process reliability in Walther et al., 2013). These strategies led us to five phases of qualitative data analysis, as outlined in **Table 1**. We highlight how we purposely integrated the theories of framing and agenda setting

Table 1: Five phases of qualitative data analysis.

Phase	Methods	Data	Outcomes
1. Preliminary data analysis (exploratory)	Used constant comparison (Strauss & Corbin, 1997) method to code the data into categories and sub-categories. Used three research questions to guide this coding: How is engineering portrayed in the media? What explanations are given for the lack of interest in engineering among high school and college students? And, what initiatives are reported on to address the perceived lack of interest?	Months 1 to 3 of the news articles (n = 804)	Hierarchal coding tree (see Appendix A)
2. Focused data analysis (generative and emergent)	Examined the data for dominant, counter-, and nonstories. Used theoretical saturation (Glaser & Strauss, 1967) to focus and prioritize the data analysis. When categories (i.e., parts of stories) reached theoretical saturation, we directed our attention to other parts of the narrative model.	Months 4 to 8 of the news articles (n = 94)	Preliminary narrative models (see Appendix B for example) Theoretically saturated master quote documents Five draft dominant stories, one draft nonstory, and one draft counterstory
3. Confirmatory analysis (conducted parallel to Phase 4 below)	Tested and affirmed the authenticity and appropriateness of the codes for the stories (Patton & Fund, 2002).	Months 9 to 12 of the news articles (n = 60)	Final model (see Figure 1)
4. Development of story reports	Further enriched understandings of the stories through structured story reports.	All 12 months of data	Seven story reports that included: in-vivo descriptors, word clouds, a brief description, key quotes, subthemes and relevant quotes, connections to other stories, and outstanding questions and musings
5. Writing of five dominant stories and the nonstory	Developed a narrative approach to present each of the five dominant stories, the nonstory, and possible directions for counterstories.	All 12 months of data	Dominant stories 1 through 5 and the nonstory, presented in the <i>Findings</i>

Analysis of the coding tree from Phase 1 led us to adopt theoretical concepts from critical media studies (i.e., framing and agenda-setting) and methodological cues from Roe's (1994) work on narrative policy analysis (NPA) (i.e., dominant, counter-, and nonstories) to inform the development and presentation of our research findings. We refined the research questions to reflect these theoretical and methodological frameworks, i.e., How is engineering *framed* in the public discourse? And, what *dominant, counter-, and nonstories* shape the ways in which we collectively understand, and seek to address, the problem of an apparent general lack of interest in engineering, and the very real lack of diversity, in engineering?

with ideas from Roe's (1994) narrative policy analysis (NPA) approach following Phase 1. This move aligned with our decision to adopt an emergent research design as we allowed the data to inform the theoretical and methodological development of the study. In the following section, we describe aspects of NPA that informed our study in more detail.

Narrative Policy Analysis (NPA)

As outlined in **Table 1**, based on the patterns we observed in our exploratory data analysis, in Phase 2 we incorporated concepts from Roe's (1994) work on NPA to inform how we interpreted the data and constructed our research findings. Grounded in the fields of narrative inquiry and public policy analysis, NPA is a research approach designed to examine the stories that underpin complex, uncertain, and polarized policy issues (Roe, 1994). NPA has been used to examine a wide range of issues, such as sustainable development (Roe, 2012), zero-carbon homes (Lovell & Corbett, 2018), economic growth and degrowth (Berg & Hukkinen, 2011), public involvement in water resource planning (Hampton, 2009), and global health partnerships in African countries (Ngoasong, 2009).

The first criterion for conducting NPA is to determine that the issue in question is indeed complex, uncertain, and polarized; we argue that the issue of underrepresentation in engineering meets this criterion. According to Roe (1994), complexity refers to "the issue's internal intricacy and/or its interdependence on other policy issues" (p. 2). Discussions of intersectionality speak to the internal intricacy of underrepresentation in engineering (Bruning, Bystydzienski, & Eisenhart, 2015; Charleston, Adserias, Lang, & Jackson, 2014; Kirn et al., 2016; Ro & Loya, 2015). Diversity work focusing on institutional cultures and barriers has further confirmed how underrepresentation is linked to broader, systemic structures (Pawley, 2019). Roe (1994) defines uncertainty as "a lack of knowledge about what matters" (p. 2) and polarization as that which "crystallizes as the concentration of groups around extremes in the issue" (p. 2). On the surface, it might seem that there is general agreement in the engineering education community that diversity matters. At the same time, as our review of prior work has shown, there is substantial uncertainty regarding *why* diversity matters in engineering (e.g., equality, ethics, or economic competitiveness), *how* to address lack of diversity, and *what* to do about the more general perceived lack of student interest in engineering (NAE, 2008, 2013). The uncertainty about what these problems even look like was reflected in the metaphors Lee (2019) discussed, some of which have led to conflicting and even polarized opinions in the community (Pawley & Hoegh, 2011).

Another core tenet of NPA is the theoretical understanding of how systems of dominant and less dominant stories inform policy decisions. Specifically, Roe (1994) differentiates between three different kinds of stories: *dominant stories*, *nonstories*, and *counterstories*. Dominant stories are those that "underwrite and stabilize the assumptions for decision making in the face of complexity and uncertainty" (1994, p. 69). In other words, they serve to remove or at least reduce the complexity, uncertainty, and polarization associated with a problem so it becomes more amenable to policy making. Dominant stories conform to the conventional definition of a story in that they are recognized as scenarios with beginnings, middles, and ends or as arguments with premises and conclusions. Importantly, while dominant stories may be the ones most present in a particular system, their important feature is how they function to reduce complexity, uncertainty, and polarization so that actionable solutions can be conceived and implemented. A story becomes dominant because it provides a complete and compelling narrative that explains a problem and its causes and provides potential avenues for solutions. Keeping in mind the focus on how dominant stories function within a greater system of stories, Roe explains that dominant stories typically do not lend themselves to empirical subversion (i.e., the use of evidence to undermine them). Instead, such critiques may actually increase uncertainty and, therefore, increase the pressure to retain the dominant narratives in question.

Roe refers to critiques of dominant stories as nonstories. Berg and Hukkinen (2011) observed that, "nonstories may take the form of critical point-by-point rejoinders of dominant arguments ... [or] can deal with hopeful discussions about what *should* happen in a particular case" (p. 153). Unlike dominant stories, nonstories do not conform to the definition of a story—they do not have beginnings, middles, and ends—and therefore do not, and cannot, offer coherent narrative explanations of complex problems.

Instead of critiquing dominant stories, Roe (1994) argues that a better way to shift the discourse and create new avenues for policy making and problem solving is to create a counternarrative or counterstory. In contrast to nonstories, which "only tell us what to be against, not what to be for" (p. 5), an effective counterstory offers a compelling alternative framing of the problem that allows consideration of other causes and different solutions. Like dominant stories, counterstories also have beginnings, middles, and ends or premises and conclusions.

These concepts allow us, then, to re-examine the four messages proposed by the NAE (i.e., engineers make a world of difference; engineers are creative problem solvers; engineers help shape the future; and engineering is essential to our health, happiness, and safety). At one level, the NAE's messages wisely sidestep the potential pitfall of "only tell[ing] us what to be against, not what to be for" (Roe, 1994, p. 5). However, while the NAE's messages do not directly critique dominant stories about engineering that focus on math, science, and high salaries, they fall short of providing a compelling narrative arc. Following Berg and Hukkinen (2011), the NAE's messages could be classified as nonstories because they offer "hopeful

discussions about what *should* happen in a particular case” (p. 153). Engineers *should* be regarded as creative problem solvers who make a world of difference. Engineering *should* be about shaping the future and *should* be essential to our health and happiness. But what impacts might the NAE’s messages have if they were woven into fully fledged counterstories?

From an analytic perspective, the challenge in identifying counterstories is that they are often peripheral due to the definitional influence that dominant stories exert on discursive systems. We experienced this difficulty in our data analysis. As such, in this article we offer some preliminary directions from the data that could inform the construction of alternative narratives. We invite the engineering education community to join us in this effort.

Finally, we note that a complete NPA typically involves four steps: identifying the “scenarios or arguments that dominate the issue in question” (Roe, 1994, p. 155) i.e., the dominant stories; identifying counter- and nonstories; comparing the “two sets of narratives in order to generate a metanarrative ‘told’ by the comparison” (p. 155); and, finally, determining “if or how the metanarrative recasts the problem in such a way as to make it more amenable” (p. 156) to other problem-solving methods and approaches. In this study, we focused on identifying the dominant and nonstories relevant to our areas of interest. Developing counterstories, generating a metanarrative, and recasting of the problem are best suited for future work.

Findings

Figure 1 shows our model of stories told about engineering and about underrepresentation in engineering in the public discourse. This model comprises five dominant stories that share the common premise that a chronic shortage of engineers threatens the United States’ economic recovery, growth, and international competitiveness. We also identified one nonstory

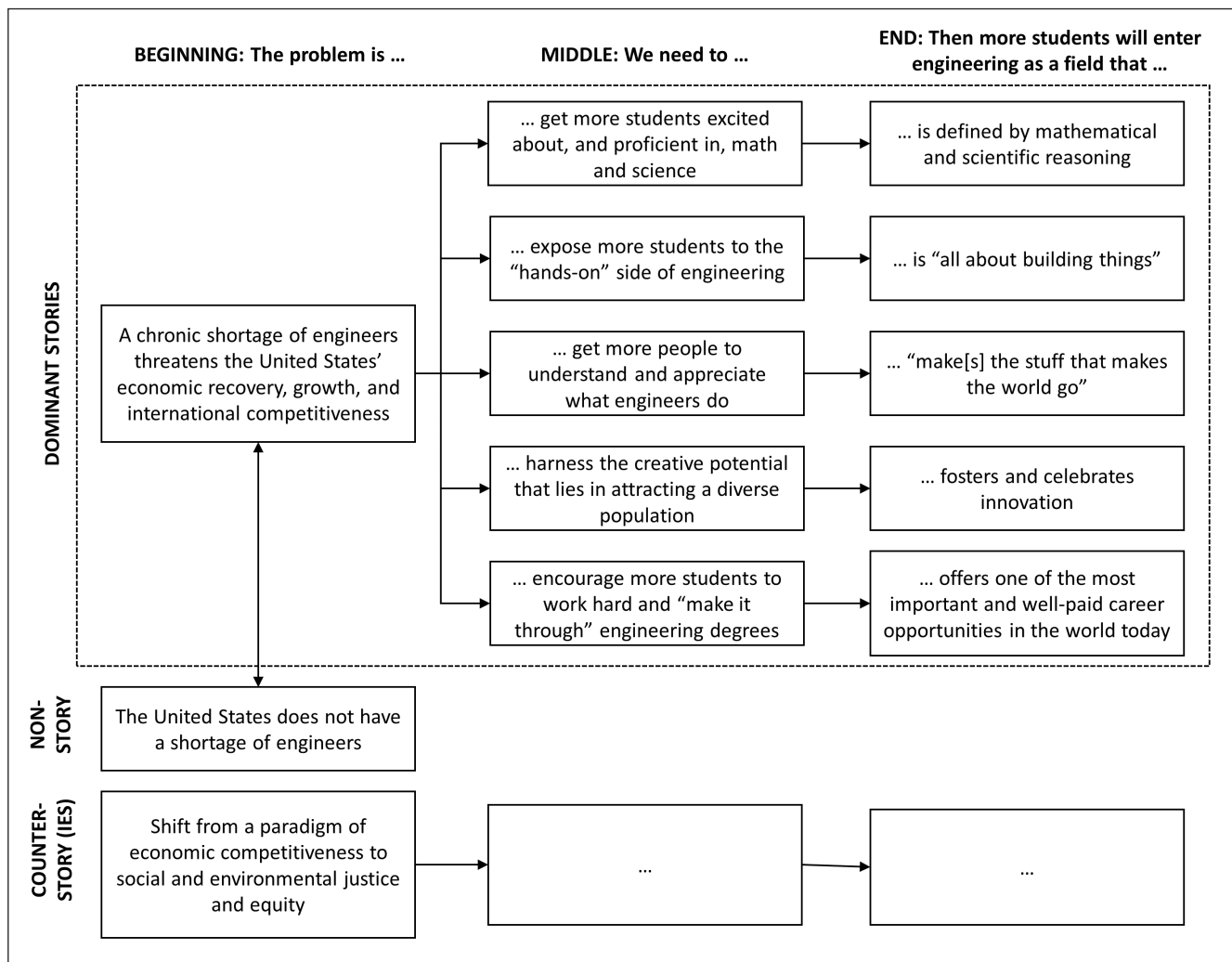


Figure 1: Illustrative model of five dominant stories and one nonstory identified in the data analysis. The stories show how different framings and assumptions about the field lead to different solution pathways. The figure also shows a possible direction to inform the construction of alternative narratives or counterstories.

that critiques this shared premise. Although we did not identify or develop a counterstory, in the *Discussion* we offer potential starting points from our data.

It is important to note that the five dominant stories shown in **Figure 1** were not always outlined explicitly by individual news stories. Rather, these stories emerged from the entirety of the discourse. In other words, while single actors (i.e., reporters) may not have discussed all aspects of a story in a single article, the public discourse, through the varied contributions of individuals, told these stories.

The following sections unpack these stories. We introduce each dominant story with a representative quote, and then analyze how the story defines “the problem” and constructs and morally justifies corresponding solutions (Entman, 1993). Our development of these findings was informed by Polkinghorne’s (1995) concept of *narrative configuration* or *emplotment*, whereby a thematic thread, or *plot*, is used “to lay out happenings as part of an unfolding movement that culminates in an outcome” (p. 5). Put another way, as we co-constructed these findings from our story reports and master quote documents (see **Table 1**), we sought to provide storied—in the sense of rich, accessible, and temporally logical—accounts of the dominant stories as they emerged from our analysis of the articles. In addition, we wished to draw attention to the storied nature of the dominant narratives, in the sense of involving dramatic narrative elements such as dire challenges, grand quests, and heroes and villains.

After presenting the five stories, we lay out the nonstory and its interactions with the dominant narratives. The cumulative result is a picture of how the field of engineering, the perceived low levels of interest in engineering, and the very real lack of diversity in the field were framed in the public discourse as represented through online news articles curated for the American Society for Engineering Education over the 12-month period from August 2011 to August 2012.

Dominant Stories

Dominant Story 1: Math and Science

We need to provide [students] with the math and science at an early age to whet that appetite and to prepare them ... Certainly you won’t produce an engineer when they’re still in high school, but you’ll set them on a pathway where they’re engaged with the topics. (Conner Hammett, *Star Local Media*, Oct. 19, 2011)⁴

The narrative trajectory of the first dominant story is based on, and developed through, the perception of mathematics and science as the primary pathway into, and essential nature of, engineering careers. Like each of the dominant stories, this story is firmly anchored in calls to advance the United States’ economic interests:

Despite America’s knack for ingenuity, the forces of change face some heavy crosswinds. A wheezing economy, a dearth of college engineering students, sagging high school math and science scores, and sinking research-and-development investments have heightened concerns about the USA’s ability to compete with rising powers China and India. (Jon Swartz, *USA Today*, Nov. 9, 2011)

This story attributes the “chronic shortage of engineering students” (Paul Otellini, *The Washington Post*, Aug. 4, 2011) in “America’s STEM education pipeline” (Rebecca Lucore, *NBC News*, Jun. 12, 2012) to shortcomings in pre-college mathematics and science instruction. As Amy Lavalley from the *Post-Tribune* reported (Aug. 28, 2011):

Young students who have a bad experience in a math or science class often won’t consider majoring in either subject, setting off a domino effect of sorts. “Those people will be less likely to pursue a career in STEM (science, technology, engineering, or math) or in teaching,” said Robert Clark, assistant professor of chemistry.

The discourse offers a range of explanations for students’ lack of preparation in math and science. As outlined by Earl L. Murman, emeritus professor at Massachusetts Institute of Technology:

The reasons for inadequate math and science education abound ... inadequate teacher preparation; a focus on testing outcomes rather than broad concepts; a perception by students that they don’t need math skills; and inadequate home support for math and science education. (Quoted by Gordon Oliver in *The Columbian*, Oct. 11, 2011)

Perceptions of math and science as “not cool” also feature prominently in this story:

⁴ We chose to use non-APA formatting for excerpts from the *First Bell* newsletters to enable readers to immediately see which sources the quotes were drawn from and when they were published.

Because it's not cool, adolescents often avoid the advanced courses necessary for STEM majors in college. "It's a lot more difficult when you get to college and say, 'Huh, I think I'd like to be an engineer.' But you have to take three years of math before you can take your first university course." (Michele duVair, *Chicago Sun-Times*, Oct. 21, 2011)

The discourse outlines several solutions to this multi-faceted problem, one of which is to comprehensively integrate, or "front-load" (William J. Bennett, *CNN Opinion*, Feb. 9, 2012), science and math into early childhood education:

Each and every class taught, where possible and relevant, should adopt forms of mathematical and scientific methods in its pedagogy, engage in practices of "building models, arguing from evidence and communicating findings" so as to "increase the likelihood that students will learn the ideas of science or engineering and mathematics at a deeper, more enduring level," as two STEM scholars recently suggested. (William J. Bennett, *CNN Opinion*, Feb. 9, 2012)

Such approaches are assumed to work because they have the potential to "tap into children's natural curiosity" (William J. Bennett, *CNN Opinion*, Feb. 9, 2012):

If schools start by incorporating STEM programs very early on, the right students will naturally lean that direction. (Mary Toothman, *The Ledger*, Apr. 9, 2012)

A variation on this strategy calls for educators "to re-invigorate young people into discovering the worlds of science and engineering" (Dave Douglass and Conan Nolan, *NBC Los Angeles*, Apr. 9, 2012) by emphasizing the lifetime of "fun" that can be had from a career in STEM:

"... really celebrate students and let them know that you can have fun, you can play sports you can do all those things but at the same time, there's a lot more fun, a lot more longevity, even, in studying math science technology," Moore said. (Michael Moore, admissions counselor at Rensselaer Polytechnic Institute, quoted by Brandon Walker in *Time Warner Cable News*, Apr. 4, 2012)

Calls to frontload childhood education with more math and science are further justified through implicit statements that cast STEM fields as ultimately more valuable to students than non-STEM fields. As William J. Bennett (*CNN Opinion*, Feb. 9, 2012) articulated:

In the end, the test of whether we should do better at teaching STEM education does not require an analysis of what our leaders of industries say they are looking for or what international tests show as our failings. It is simply this: Ask any adult not employed in a STEM area of work: "Don't you wish you studied and appreciated math and science courses earlier in school?" The answer almost always is going to be: "yes." And so, too, should it be for students now ... not adults later.

More extreme versions of this story even suggest that non-STEM-oriented students are lacking in some way. As a study released by Georgetown University's Center on Education and the Workforce found:

Students interested in STEM are primarily motivated by academic and career achievement, while "the academic focus for non-STEM students concerns college as a general life experience and suggest prior gaps in acquisition of critical academic skills." (Reported by Olga Khazan in *The Washington Post*, Jan. 6, 2011)

The problems and solutions that define this story are implicitly informed by an understanding that proficiency in math and science is the key to increasing interest in engineering careers. As D.C. Public Schools' 2011 Teacher of the Year, Shira Fishman, stated:

I always did well in math and science, so it made sense to do engineering. (Reported by Meredith Somers in *The Washington Times*, Sep. 19, 2011)

Similarly, as described by Ioannis Miaoulis in a *U.S. News* article (Dec. 7, 2011):

Engineering is the great connector that uses math and science to solve real problems and often create new technologies that fuel innovation. School curricula traditionally focus more on the natural world, not the technological one. But it is the human-made world that facilitates 95 percent of daily experience.

In summary, the first dominant story frames engineering as a field that is not only characterized by the application of math and science but also derives its intellectual superiority and societal relevance from that foundation. Through such narrative logic, this story provides a self-contained explanation for the low levels of student interest in engineering, and points to and morally justifies a coherent set of actionable solutions (i.e., math and science education is the key; if we can improve student experiences in these areas and make them fun, more students will pursue engineering). In this way, the first dominant story sanctions and underwrites efforts to increase interest in engineering that focus on providing opportunities for pre-college students to engage in “fun” math and science-based learning experiences.

Dominant Story 2: Building Things

Mokros said the students the Reach Center aims to, well, reach are not necessarily the ones scoring highest on math and science tests. “A lot of students are falling through the cracks,” Mokros said. “They may not be achieving top grades in science, but they’re building elaborate Lego structures in their basements. Very few of them take a standard pathway and know they want to be a scientist when they’re 12 and pursue that singlemindedly. Engineering is very rarely taught in middle schools or even in Maine high schools, for instance, but a lot of our kids enjoy tinkering.” (Seth Koenig, *BDN Maine Education*, Nov. 23, 2011)

The second dominant story in our model casts engineers as the protagonists in a plot that revolves around “building things” as both the purpose and practice of engineering. As Dr. Marcy Corjay, Dean of Science, Biotechnology, Mathematics, and Information Technologies at Rowan-Cabarrus Community College, explained:

“Science deals with our natural and physical world. Technology has given us the iPads, smart phones and computers we use every single day. Engineering is all about building things.” (Reported by Sarah Campbell in *The Salisbury Post*, Apr. 9, 2012)

This story is also firmly anchored in calls to advance the United States’ economic interests:

It’s really about global competitiveness, but don’t tell the students that. For them, Panic at the Point, a weeklong camp [in which students investigate “a mock bioterrorist attack”] ... provides a fun way to learn and to get career information about those [STEM] fields. (Jill Thurston, *Pittsburgh Post-Gazette*, Jul. 26, 2012)

Comments from Bruce Niemeyer, Chevron vice president of the Appalachian/Michigan Business Unit, further illustrate how this story connects experience-based, hands-on learning to increased interest in STEM-based careers which, in turn, enhances the nation’s globally competitiveness:

“A company like Chevron needs thousands of talented professionals—engineers, geologists, geophysicists, and information technology specialists—to produce energy for the world every day ... By supporting the efforts of Carnegie Science Center, we hope to build capacity for the kind of experience-based, hands-on learning that will encourage students to choose STEM-based careers and continue to enable the Pittsburgh region to remain competitive in a twenty-first century global economy.” (Reported by Malia Spencer in *The Pittsburgh Business Times*, Nov. 30, 2011)

A related excerpt similarly links hands-on learning, specifically designing, creating, and building technological artifacts, to future careers in the global economy:

In Kim Forbes’ classroom—behind the boomerang-shaped desks, power tools, computers, wind tunnel and slew of competition trophies—is a case full of technology textbooks. Students rarely open them. Instead, they design video games, create cold-case files and build bottle rockets and miniature fuel cell cars ... Leaders believe a focus on STEM education ... will better prepare young people for the technical jobs of the future. “It’s critical for the kids to make the connections,” Forbes said. “It sounds so pat to say that we have a global economy, but we’ve got to make them competitive. I don’t think you can start too early.” (Morgan Josey Glover, *greensboro.com*, Oct. 3, 2011)

The second story speaks to the importance of making, tinkering, and experimentation, and calls for educational opportunities that allow students to “figure out how stuff works” (Satenik Sargsyan, *HJnews.com*, Jan. 10, 2012) and “take things apart and put them together” (Marlene Sokol, *Tampa Bay Times*, Oct. 15, 2011). As Jay Stencel, a civil engineering technology instructor at South Central College, expressed:

“It’s a high-tech workshop for tinkerers ... It’s a way to throw problems at them for which they don’t just find theory solution, but they build the solution to that problem.” (Reported by Amanda Dyslin from *The Mankato Free Press*, Feb. 8, 2012)

In spite of this narrative's focus on building things to "solve complex problems" (Becky Voss, *The Post-Standard*, Feb. 9, 2012), few of the articles coded for this story provided details about what sort of problems engineers actually solve. In other words, this story is characterized by the development of artifacts, not the problems these artifacts are meant to address.

Providing a counterpoint to the first story, this story attributes low levels of interest in engineering to an *overemphasis* on scientific and mathematical theory:

The humanities are often ridiculed for their focus on "theory." But as the NYT article makes clear, one of the problems that STEM majors find with their fields—and this is in addition to the low grades and hard work—is that there is a lot of emphasis on theory there as well. Despite all of the possibilities for practical applications, hands-on experimentation, and project-based learning, much of what's taught is, well, "theory." (Audrey Watters, *Inside Higher Ed*, Nov. 9, 2011)

The problem of too much theory in math and science was discussed across all levels of education. For example, in an article about a GE-funded program designed to "transform [a middle school] math and science curriculum, from a standard textbook-and-chalkboard approach to a more hands-on, 'inquiry-based' approach that focuses on learning by doing," one participating student commented:

Science "is really boring when all you do is read," said the 13-year-old ... "You visualize it better and understand it better when you're using all this technology in the classroom." (Reported by Erica Erwin at *goerie.com*, Mar. 7, 2012)

Similarly, at the college level, Christopher Drew from *The New York Times* (Nov. 4, 2011) reported on a student who "bailed out of engineering ... in the fall of his sophomore year" due to frustration about the lack of opportunities to apply engineering principles:

"I was trying to memorize equations, and engineering's all about the application, which they really didn't teach too well," he says. "It was just like, 'Do these practice problems, then you're on your own.'" And as he looked ahead at the curriculum, he did not see much relief on the horizon.

While this preference for application over theory could be interpreted as undermining the first story, we suggest that this tension actually strengthens both stories by providing actors in the system with a sense of complexity and choice. In other words, one story alone may allow for the construction of other stories to explain the apparent lack of interest in engineering, but as a system, the stories balance out one another's most apparent shortcomings: "Engineering is about more than math and science/Of course, engineering is about building things, too!" Or, "Engineers do more than just build things/Of course, engineers use science and math to solve problems!"

Like the first story, the second includes an implicit belief that STEM fields are inherently interesting; students just need to see STEM in action:

Working in small groups and teams, students programmed the high-tech robots to pick up colorful plastic balls, paper clips or glue sticks ... "They are so excited, that's all they needed was to see (engineering) in action," Nix said. "Every one of them is wanting to continue when they get to Broome [High School]." (Lee G. Healy, *goupstate.com*, Mar. 5, 2012)

At the same time, the second story portrays engineering as preferable to other, often unspecified, "mediocre" (Charmaine Smith-Miles, *Independent Mail*, Feb. 8, 2012) life choices. As noted in an article that described a Society of Automotive Engineers-sponsored project in which fifth graders built air-powered cars:

The challenge came in figuring out how to build their cars so they could travel farther, straighter and smoother than their competitors' cars ... It's a way to teach students the same principles that engineers use ... It is also a way of introducing the students to engineering early, and it keeps them interested in their studies so they are less likely to dropout later ... It plants a seed ... If we do not plant those seeds early, there's so much that will pull them away later. And they run the risk of dropping out of school. We have to teach them they can be more than mediocre. (Charmaine Smith-Miles, *Independent Mail*, Feb. 8, 2012)

In summary, the second dominant story frames engineering as a field defined by its artifacts as both a means and an end. Engaging students in hands-on activities that involve manipulating materials enables students to embody what it means to

be an engineer. Such activities are considered valuable regardless of whether they focus on the actual problems engineers build artifacts to solve.

Dominant Story 3: Appreciate What Engineers Do

To get students interested in STEM, America has to hold up successful engineers as idols. “How many of our students in third, sixth, or ninth grade know they want to be like [former Lockheed Martin CEO] Norm Augustine when they grow up? We’ve got to get the truth out there—that this is the way to success, that this works, that this is cool.” (Jason Koebler, *U.S. News*, June 29, 2012)

The third dominant story develops its plot around the central, yet underappreciated, role engineers play in society. As described in an article entitled “Where are the American engineers?”:

Engineers make the stuff that makes the world go. The stuff they make builds our technological devices, our cities and takes basic research and turns it into economic gain. They build rockets. They build medical devices. (Eric Berger, *Chron.com*, Sep. 20, 2011)

Similar to the second story (Building Things), this story emphasizes the connection between what engineers do and the nation’s long-term economic success. As then-President Obama expressed to the press during the 2012 White House Science Fair:

I’m going to make a special plea to the press—not just the folks who are here, but also your editors—give this some attention. I mean, this is the kind of stuff, what these young people are doing, that’s going to make a bigger difference in the life of our country over the long term than just about anything. And it doesn’t belong just on the back pages of a newspaper; we’ve got to lift this up. (*thewhitehouse.gov*, Feb. 7, 2012)

In contrast to the content focus of the first story (Math and Science) and the pedagogical focus of the second story (Building Things), the third story attributes the low interest to a lack of understanding of and, most of all, a lack of appreciation about how engineering and other STEM fields contribute to society:

Look what we take for granted in our everyday lives: the Internet and cellphones, MRI scanners and microwave ovens, FM radio and transistorized hearing aids, lasers at the checkout counter, and cancer treatments made from bacteria we’ve programmed for benevolence. All these American innovations and thousands more come to us from science, mathematics, engineering, and technology. (Mortimer B. Zuckerman, *U.S. News*, Sep. 27, 2011)

The solution to this framing of the problem is to “raise awareness” and “spread the word” (*www.wabi.tv*, Mar. 3, 2012) about careers in engineering, as illustrated in the following excerpt:

“Awareness of opportunities is another key toward increasing the number of women in science and engineering professions,” said Dr. Johanna Krontiris-Litowitz, YSU professor of biological sciences ... “We’re showing these girls that there are so many careers out there that they probably weren’t even aware of,” Krontiris-Litowitz said. (Bob Jackson, *vindy.com*, Mar. 4, 2012)

These awareness-raising efforts are underpinned by a firm belief in the central role that engineers play in solving the world’s greatest challenges. This focus on the problems that engineers solve stands in contrast to the second story’s emphasis on technological artifacts:

“Engineers are critical to solving some of the biggest problems in the world today. Whether it be energy, clean environment, advancement in medicine. Engineers are at the core of that,” said Dean of Engineering for University of Maine, Dana Humphrey. Organizers say the children seemed very interested and they hope it’s made them think about pursuing a career in engineering. (*www.wabi.tv*, Mar. 3, 2012)

Similar to the tensions between the first and second stories, differences between the second and third dominant stories further strengthen the dominant stories’ ability to function as a system of narratives that provide lively, robust explanations for perceived low levels of interest in engineering, particularly among women and persons of color.

Another feature of the third story is how it holds up successful engineers as role models:

"You look at Steve Jobs. He was the ultimate nerd and how cool was he? How many cool gadgets this 'geek' created!" (Haya El Nasser, *USA Today*, US Edition, Apr. 11, 2012)

While this story questions the stereotype of engineers working in offices:

"They don't sit in cubes and work by themselves and mumble all day long," said Karen Spencer, Intel global education integration director. (Wendy Owen, *The Oregonian*, Dec. 6, 2011)

It makes no attempt to debunk the profession's "nerd" status:

The dot-com boom of the late '90s that turned obscure programmers into millionaires helped, too. "Forget the fact that they can't make eye contact," says Robert Thompson, professor of popular culture at Syracuse. "If you're worth \$20 million, who needs eye contact?" (Haya El Nasser, *USA Today*, US Edition, Apr. 11, 2012)

In fact, the third story moves quite purposefully in the other direction:

"There's been a shift in the portrayal," says Sherry Turkle, an MIT psychologist and author of *Alone Together: Why We Expect More From Technology and Less From Each Other*. "We're all techies now. We're dependent on these people, so there's a power shift, a new kind of respect" (Haya El Nasser, *USA Today*, US Edition, Apr. 11, 2012)

To summarize, the third dominant story frames the perceived lack of interest in engineering as a public relations (PR) problem that calls for a PR solution that presents what engineers do as inherently good, world-shaping, and deserving of respect and recognition. The importance of the field to the functioning of the world transcends perceptions of the nerdy engineer—the problem lies not with engineering, but with the public's lack of awareness of the crucial role that engineers play.

Dominant Story 4: Diversity and Innovation

Here at Cornell, we see diversity as an opportunity, not an obligation. We have to leverage an increasingly diverse pipeline of students if the university—and the country—is to remain competitive, and as engineers we firmly believe that a diverse population leads to better, more creative solutions to the problems we face. If we are successful at building diversity, it will pay dividends for Cornell. (George Lowery, *Cornell Chronicle*, Nov. 15, 2011)

In contrast to the first three stories, which are broad in their appeal, the fourth dominant story focuses specifically on the field's need for diversity. A recent editorial in the *Journal of Engineering Education* proposed that researchers should no longer need to justify the importance of diversity in engineering (Pawley, 2017). Instead, Pawley argued that a "state ... where the demographics of our profession reflect those of the general population [should be the field's] 'default' position" (2017, p. 531). The discourse we analyzed was similarly emphatic about the self-evident need for diversity in STEM. However, consistent with all five stories in our model, the "default position" of the fourth dominant story focuses less on social equity and justice and more on the ability of the U.S. to compete internationally. As stated by "Tech wonder woman," Weili Dai at *CNN* (Mar. 20, 2012):

I believe the single best way to grow the struggling global economy is to fully engage women as business leaders in new and emerging industries.

This said, Pawley's emphasis on social equity and justice was not entirely absent from our data. Such principled arguments, however, rarely appeared without a supporting statement linking "equality of opportunity" (Paula Allen-Meares and Mrinalini C. Rao, *Huffington Post*, Oct. 27, 2011) to "America's future as a global leader in technology and innovation" (Meares and Rao, 2011). The following quote clearly exemplifies this coupling:

We cannot envision a sustained U.S. economic recovery in our increasingly competitive world without a steady supply of highly trained professionals in the STEM disciplines, nor can we imagine full economic equality and opportunity unless the diversity of STEM professionals mirrors that of our nation as a whole. (Meares and Rao, 2011)

As indicated in its opening quote, the fourth dominant story frames the lack of diversity in engineering as a barrier to innovation. As stated by Joanne Stanley, founder of the volunteer network, Canadian Women in Technology:

"If a country is going to be successful and competitive, it has to be innovative and have leading-edge, knowledge-based industries," Stanley says. "My opinion is that we need to get women at the top and get a critical mass, and they will bring women behind them." (Zoe McKnight, *The Star*, Nov. 4, 2011)

According to this dominant story, women are innovative, African Americans and Hispanics are innovative, and underrepresentation across these groups significantly limits the creative potential of the U.S. STEM enterprise:

A Commerce Department report released last month found underrepresentation of [B]lacks and Hispanics in STEM fields. "Educational attainment may affect equality of opportunity in these critical, high-quality jobs of the future," the report said. "... by increasing the numbers of STEM workers among currently underrepresented groups through education we can help ensure America's future as a global leader in technology and innovation." (Paula Allen-Meares and Mrinalini C. Rao, *Huffington Post*, Oct. 27, 2011)

Another central feature of this story is how it frames diversity, first and foremost, in gendered terms: The overwhelming majority of articles coded for this story cast women and girls as the absent protagonists in America's race to "out-innovate ... the world" (M. Nagaraja, *Women@NASA*, Jun. 21, 2012):

"We have an opportunity to reach out to the next generation and inspire today's girls to pursue science and technology careers," said Rebecca Keiser, the agency's associate director for agency-level policy integration and representative to the White House Council on Women and Girls. "Expanding opportunities in these fields will give our country perspectives and expertise that will help us out-innovate, out-educate, and out-build the world. It's key to our future."

A subplot focused on the need to make it easier for skilled immigrants to join and remain in the U.S. workforce. As noted by Ashish Singh, a 22-year-old native of Nepal majoring in computer engineering:

"America needs to acquire a system that can use innovative foreign brains, providing them a legal status and not going through the hassle of getting sponsored by a company," Singh said ... U.S. Sen. John Cornyn, R-Texas has proposed helping former international students with graduate degrees to live and work legally in the United States ... "The U.S. attracts the best and the brightest, but because of our cap on the number of visas, we usually send these people home. Then they turn around and compete with us by creating jobs in their native countries", Cornyn said. (Diane Smith and Chris Vaughn, *McClatchy DC Bureau*, Jun. 4, 2012)

Hispanics, Latinos, African Americans, and Native Americans received the least attention in this story and, if mentioned, were often listed together alongside women as examples of untapped resources for the global marketplace:

With major demographic changes in the United States, the disparity of persons of color, [and] women, is becoming an increasing problem for the STEM disciplines. A study by the National Action Council for Minorities in Engineering, Inc. on U.S. engineering degrees found that African Americans, American Indians, and Latinos account for 34 percent of the total U.S. population (ages 18 to 24), but earn only 12 percent of all undergraduate degrees in engineering. In fact, the share of engineering degrees earned by these three groups declines at higher educational levels: 12 percent bachelor's, 7 percent master's, and 3 percent doctorates. Meanwhile, women account for nearly half—46 percent—of the U.S. labor force but account for just 10.8 percent of U.S. engineers. In order to remain competitive in the global marketplace, our education system must progress alongside our nation's evolving demographic. (Dr. Irving Pressley McPhail, *U.S. News*, Oct. 11, 2011)

Articles coded for this story attributed the lack of diversity in STEM to a variety of factors, including stereotypes, lack of role models, biases, and sexism in the workplace. As described by Linda Kekelis from the *Harvard Business Review* (Feb. 8, 2012):

Role models make the difference by connecting with our girls on a personal level and sharing their passion and the personal stories of how they came to be the professionals they are. They help dispel stereotypes about engineering and who can be a computer scientist. Their enthusiasm conveys that these careers are personally and professionally rewarding. The work they describe shows that as a scientist or engineer you can make the world a better place—an aspiration for many girls.

The last part of this quote illustrates the solution that this story proposes to address the problem of underrepresentation. This solution, which focuses on emphasizing the positive contributions engineers make to society, differs subtly from the

solution suggested in the third story (Appreciate What Engineers Do), which seems to celebrate elements of engineering stereotypes. An Intel-commissioned study of 1,000 teenagers highlighted this distinction:

While money-focused stats left the young ladies cold, they were motivated by how much social benefit engineers can create. “As other studies have indicated, messages that emphasized the emotional appeal of engineering—for example, that engineers play a role in delivering clean water to communities in Africa—were most effective in getting girls to change their minds about the field,” the spokesperson continued. (Reported by J. O’Dell in *venturebeat.com*, Dec. 11, 2011)

In summary, the fourth dominant story frames the lack of diversity in engineering as an impediment to innovation. This framing is reflected in the striking emphasis this story places on the lack of women in STEM fields, who account for around half of the population, and thus are perceived as low-hanging fruit for inclusion; the only challenge is to get the message right. Concerns that the U.S. is not doing enough to attract and retain skilled workers from other countries further affirms this story’s focus on diversity for innovation’s sake and re-affirms all stories’ common underlying theme of global competitiveness. Specific solutions to address underrepresentation of persons of color, such as African Americans, Native Americans, Latinos, and Hispanics, do not feature prominently in this narrative.

Dominant Story 5: Making It Through

But, it turns out, middle and high school students are having most of the fun, building their erector sets and dropping eggs into water to test the first law of motion. The excitement quickly fades as students brush up against the reality of what David E. Goldberg, an emeritus engineering professor, calls “the math-science death march.” Freshmen in college wade through a blizzard of calculus, physics and chemistry in lecture halls with hundreds of other students. And then many wash out. (Christopher Drew, *The New York Times*, Nov. 4, 2011)

The fifth and final dominant story in our model portrays engineers as heroes who, through hard work and perseverance, have overcome the challenges of a demanding education, and can now reap the rewards of a participating in a globally significant and well-paid profession.

The reality is that most STEM majors have topics that are extremely difficult and sometimes they are just too hard too complete. How did I deal with this? I just worked harder. Was it worth it? It was for me. (Dan Reich, *Forbes*, Nov. 9, 2011)

The hero theme of this story is reflected in the language used to describe STEM defectors who, in contrast to those who persist, “aren’t willing to work hard enough” (Christopher Drew, *The New York Times*, Nov. 4, 2011), “flock to other majors when their science and math courses become too demanding” (Priya Natarajan, *The Washington Post*, Feb. 2, 2012), or “get ‘pulled away’ by the higher average grades of the humanities” (Olga Khazan, *The Washington Post*, Jan. 6, 2012). Such language leaves little room for students to make empowered and informed decisions about switching out of STEM, while reinforcing perceived hierarchies between STEM and non-STEM fields. As described by one author:

To specialize [in science or medicine] at age 18, I would need to drop my writing seminar for chemistry or physics courses with tons of homework and fearsome lab projects. I preferred reading novels and arguing about first principles. So I ducked organic chemistry for economics, real science for social science—another doctor or engineer or microbiologist lost to America. I wouldn’t have been a great scientist, but I might have been a good one. (*American Science Education – Slate Hive*, Jun. 8, 2012)

A subplot acknowledges that the culture of STEM education may contribute to the high levels of attrition:

Many college students who are initially drawn to math and science end up changing majors, reports Christopher Drew in a *New York Times* piece today. Why? In short, the classes are abstract, difficult and often large and impersonal, so it’s easy for those who are bored or struggling to fall between the cracks. (Dana Goldstein, *The Nation*, Nov. 4, 2011)

Multiple references to “weed out” courses further suggest that the problem of retaining STEM majors may be more complicated than students simply not embracing “the joys of hard work” (Steven T. Corneliussen, *Physics Today*, Feb. 6, 2012):

There’s definitely the sense that the purpose of the introductory freshman classes in the STEM fields are designed to “weed you out”; the humanities, arguably, try to “woo you in.” (Audrey Watters, *Inside Higher Ed*, Nov. 9, 2011)

Similarly, Freeman Hrabowski, President of the University of Maryland stated:

Two thirds of the students that enter college as an engineering major switch majors, and we assume that's OK ... They say that the first year of science and engineering is made up of weed-out courses. I'd argue that it does not have to be that way. (Jason Koebler, *U.S. News*, Jun. 29, 2012)

To address this problem, some sources recommended more academic support through tutoring and mentoring, as evidenced by this discussion between Ira Flatow and Susan Singer on the *NPR* show "Science Friday":

FLATOW: Susan Singer, if you had to put your finger on one of the main reasons that college kids drop out of science and engineering majors, as majors, what would you say?

SINGER: Well, I think what happens is they're not feeling successful and they feel like they're working very, very hard and beating their heads against a wall and not making progress. And I think what we can collectively do in a way is like the mentoring piece, if we have better professional development for the people that are teaching them, to help structure their learning in a way that they make progress and feel good about what they're learning. (Ira Flatow, *Science Friday, NPR*, 11 Nov. 2011)

Most of the articles coded for this story, however, simply emphasized that the best jobs await those who make it through: engineering graduates can expect employability, high salaries, and important and fulfilling work. As then President Obama explained:

... If you are a skilled engineer, if you are a skilled computer scientist, if you've got strong math and technical skills, you are going to be very employable in today's economy. (*Times of India*, Aug. 18, 2011)

In a sense, this story lies at the end of the pipeline narrative initiated by the first four stories (see also Lee, 2019). It assumes that students have a solid foundation in math and science, are excited about the hands-on nature of the profession, and appreciate the societal significance of engineering enough to enroll in a major; the challenge now is to retain them through graduation. While the first four stories focus on recruitment, the fifth focuses on retention and uses personal reward as the final incentive to encourage students to persevere and participate in the global economy:

Proponents of STEM education speak of the importance of ensuring that the United States remains competitive in the global marketplace, producing the next generation of innovators and enabling students to have well-paying careers. (Michelle Cerulli, *boston.com*, Nov. 13, 2011)

To summarize, the fifth dominant story frames engineering and other STEM degrees as challenging but worthwhile. Students are the heroes who must overcome the temptations of easier non-STEM majors. While this story gets closest to suggesting that "it does not have to be that way" (Jason Koebler, *U.S. News*, Jun. 29, 2012), the overall consensus across the discourse indicates that the "eventual payoff" (Priya Natarajan, *The Washington Post*, Feb. 2, 2012) justifies the struggle.

Nonstory: Too Many Engineers

As outlined in our introduction to NPA, the nonstory we describe here is, in fact, not a story in the sense of having a beginning, a middle and an end, but rather a series of critiques of the dominant stories. It is important to reiterate here that, in sharing this nonstory, we are not attempting to empirically discredit or disprove the dominant stories—we are using concepts from NPA to understand how dominant stories function to reflect and shape the culture and values of engineering education and to underwrite recruitment and retention efforts. Therefore, as readers engage with the non-story, we urge them to resist the temptation to focus on whether the nonstory offers accurate and empirically sound arguments. As Roe (1994) explained, it is not the accuracy of such arguments that matters but how nonstories function to *increase* the complexity and uncertainty of perceived problems and, consequently, elicit stronger commitments to dominant framings.

Most of the critiques coded for the nonstory in our model either relate to experiences of unemployment or use unemployment data as evidence to dispute claims about the shortage of STEM graduates. A less common but still present critique questioned the relationship between STEM activity and economic growth. The following quote, drawn from a review of economist Paula Stephan's book, *How Economics Shapes Science*, exemplifies the first type of critique:

If the country has such need of more graduates in the sciences, why do so many of them have trouble finding jobs? (Serena Golden, *Inside Higher Ed*, Mar. 9, 2012)

The next excerpt builds on this critique to question the assumed relationship between a more highly trained STEM workforce and economic growth:

On Global Public Square last month, Fareed Zakaria made the case that the U.S. economy is struggling in part due to poor investment in science. He based this conclusion on two claims: First, that federal research and development (R&D) investment has declined over the past several years and, second, that American students have fallen behind in science education ... Zakaria's concern is understandable because everybody wants a more educated society, but there's little evidence that creating more scientists will actually help get the economy back on track. Careers in academia are extremely difficult to find, as any post-doctoral researcher will testify ... Much of the existing evidence instead indicates that America has too many highly educated people, and simply not enough jobs for them to fill. Because of this, *The Economist* recently concluded that earning a PhD may often be a waste of time. Obviously the solution isn't less education. But education itself is not a magic bullet, and we simply can't turn every person into a scientist. Science is difficult and jobs are limited. (Alex Berezow and Hank Campbell, *CNN World*, Jul. 26, 2012)

Several critiques against the presumed shortage of STEM professionals point to market dynamics as the source of un/underemployment. As one unemployed electrical engineer explained:

Jonathan Mercado isn't seeing it from his perch. "I think it's a lie. They say they can't find enough talent, but what they really mean is that they can't find enough people at the rate they want to pay." (Jane M. Von Bergen, *The Inquirer Daily News*, Apr. 13, 2012)

A related argument blames foreign workers for unemployed STEM graduates, as detailed in an article entitled "Obama's high-tech labor lies":

We have no shortage of skilled engineers. Corporations would just rather import foreign ones on lower wages ... Though the unemployment rate for the high-tech industry is certainly lower than the overall unemployment rate, the sector is far from the full-employment status that tech CEOs claim. No matter what the industry is "telling" Obama, there remain thousands of highly skilled engineers in America who are either underemployed thanks to tech companies [*sic*] use of the controversial "permatemp" status, or completely out of work. (David Sirota, *Salon*, Feb. 6, 2012)

While the majority of articles analyzed were from U.S. news outlets, *First Bell* periodically includes reports from abroad. Comments from an article published by the BBC outlined similar doubts regarding the perceived security of an engineering degree:

Nearly a quarter of UK engineering graduates are working in non-graduate jobs or unskilled work such as waiting and shop work, a report suggests. The study says it is "not easy or automatic" for qualified engineers to find related employment in the UK. Employers and industry leaders have repeatedly raised concerns about a lack of good quality science and engineering graduates. But research from Birmingham University research challenges this viewpoint. The report—entitled *Is there a shortage of scientists?*—is being presented to the British Educational Research Association (Bera) annual conference in London on Thursday ... The report says: "Perhaps, because of recent initiatives, there seem to be too many people studying science for the labour market to cope with, or perhaps graduates are no longer of sufficient quality. It is more likely, however, that all of these scientists are without relevant employment every year because the shortage thesis is wrong and there are no jobs waiting for all of them ..." (Katherine Sellgren, *BBC News*, Sep. 8, 2011)

Another common feature of the critiques in this nonstory was their "yes, but" nature—yes, there may not be a shortage of engineers, but we still need more (and better educated) ones. Or yes, there may not be a shortage of engineers generally, but there are shortages in specific sectors. The following excerpt contains both arguments, beginning with the latter:

Then there is the question of whether there is a shortage of engineers in the United States. Salaries are the best indicator of shortages. In most engineering professions, salaries have not increased more than inflation over the past two decades. But in some specialized fields of software engineering in Silicon Valley and in professions such as

petroleum engineering, there have been huge spikes. The short answer is that there are shortages in specific fields and in specific regions, but not overall. Graduating more of the wrong types of engineers is likely to increase unemployment rather than create jobs. The U.S. does, however, have a problem: Some of its best engineers are not doing engineering, and some of its best potential engineers are not even studying engineering, leaving us short-changed in solving the important problems of the day. (Vivek Wadhwa, *The Washington Post*, Sep. 1, 2011)

The next excerpt follows a similar pattern, conceding first that, yes, perhaps graduating more engineers just because India and China are doing so may not be a great idea, but then invoking the third dominant story (Appreciate What Engineers Do):

Graduating more engineers just because India and China graduate more than the United States does is likely to create unemployment and erode engineering salaries. One of the biggest challenges for the engineering profession today is that engineers' salaries are not competitive with those of other highly trained professionals: It makes more financial sense for a top engineering student to become an investment banker than an engineer. This cannot be fixed directly by the government. But one interesting possibility can be seen in China, where researchers who publish their work in international journals are accorded status as national heroes. U.S. society could certainly offer engineers more respect and recognition. (Vivek Wadhwa, Gary Gereffi, Ben Rissing, and Ryan Ong, *Issues in Science and Technology*, Volume XX111 Issue 3, Spring 2007, referenced in Sep. 2, 2011, *First Bell* news briefing)

The pervasiveness of the “yes, but” dynamic speaks to both the power of the dominant narratives and to Roe's (1994) point that dominant narratives cannot be effectively changed by challenging them with evidence. As the following excerpt illustrates, “reports” about engineering job openings do not matter; the new technologies and devices that engineers develop are inherently positive (see also the second and third dominant stories: Building Things and Appreciate What Engineers Do):

While reports say engineering job openings are often far and few to find, Williams says those jobs will never go to the wayside. “There's always new technologies, engineers are always going to be needed to design some of these devices and [the] new next generation of devices that's going to enable our society, enable our nation to move forward,” says Williams. (Sarah Bleau, *wxfl.com*, Oct. 12, 2011)

One challenge with critiquing dominant stories such as the shortage of engineers is that these critiques leave change agents without an agenda. This lack of an agenda, we argue, leads to a strengthening of the dominant narratives, as illustrated through the “yes, but” dynamics described above. Instead, the way to create a new agenda, Roe (1994) argues, is to identify or construct a counterstory, as we explain at the end of the Discussion.

Discussion

Earlier, we defined framing as a process whereby authors “select some aspects of a perceived reality ... in such a way as to promote a particular problem definition, causal interpretation, moral evaluation, and/or treatment recommendation” (Entman, 1993, p. 52). In this way, the set of five dominant stories outlined above offer compelling narrative explanations for low levels of student interest in engineering and a range of avenues to solve this problem. For example, by attributing low levels of interest to deficits in early education, inadequate exposure to hands-on learning, and lack of awareness about what engineers do, solutions are relatively simple to conceive (i.e., address perceived deficits in early math and science education; promote hands-on learning; and increase awareness of what engineers do).

In addition to underwriting intervention efforts, we suggest that these simplifications of a complex problem also function to remove the need for the field to engage in introspection, that is, for us to ask uncomfortable questions like, “How does who we are, what we stand for, or what we do, contribute to the (perceived) problem of a lack of interest in engineering?” To the contrary, while the dominant stories differ in their recommendations, they coherently reflect and promote a particular set of values and practices centered around economic growth, competition, and technological artifacts, which, in turn, shape our efforts to attract, educate, and retain students in engineering. While these narratives have, over the last decade, corresponded to a slight increase in the percentage of bachelor's degrees awarded in engineering (National Center for Education Statistics, 2019), we see no parallel changes in the demographic profile – and in some cases, the numbers have gone backwards.

That said, we do not seek to entirely dismiss or discredit the dominant stories; similar to Lee's (2019) discussion of broadening participation metaphors, we are not suggesting that the dominant stories should “die or retire” (p. 9). Engineering does contribute to economic growth and, to varying degrees, it does involve math and science, technological artifacts, and difficult coursework. Moreover, prior research shows that some elements of the dominant stories, such as engineers' high salaries (Samuelson & Litzler, 2016) and prestige (Foor, Walden, & Trytten, 2007), do resonate with members of groups who are traditionally underrepresented in engineering. Other studies, however, document

student experiences of dissonance with portrayals of engineering that emphasize math over professional skills (Secules, Gupta, Elby, & Tanu, 2018), getting good grades over sense-making (Danielak, Gupta, & Elby, 2014), or contributing to economic growth over humanitarian ends (Brewer, Sochacka, & Walther, 2015). Further, a growing body of literature suggests that STEM students of color may be more motivated by the desire to help others—an equity ethic—than by the financial benefits of STEM fields (McGee & Bentley, 2017; Naphan-Kingery et al., 2019). As noted by McGee and Bentley (2017):

[Black and Latinx] Students' desire to help others indicates a need to revisit the emphasis on financial success in STEM fields. Furthermore, results point to the need for STEM education programs that present broader STEM career possibilities, including careers that integrate social justice, empathy, and equity matters. (p. 1)

Thus, instead of challenging the dominant stories, we advocate for finding ways to disrupt how the dominant stories function to monopolize the discourse and marginalize other ways of framing engineering. One way to do this is through constructing counternarratives.

Earlier drafts of this article included an attempt to construct a counterstory. As some reviewers pointed out, however, our attempt lacked depth and empirical support. Counterstories can be particularly challenging to identify because they are often peripheral in nature. We experienced this challenge: the dominant stories overwhelmingly permeated the discourse and left little space for alternative narratives to emerge.

Here, then, we limit our discussion of potential counterstories to the following excerpt from the data that illustrates how alternative narratives about what it means to be an engineer may create new avenues for attracting different populations:

For MaST junior Jackie Mogensen, saving the planet is a priority. "I'm not really into engineering," she said. "Things that save our environment—that is my passion. Power conversion, absorbance and the efficiency of polymer solar cells—those are the things that really interest me," she said. (Jennifer Shea, *Herald Tribune*, Feb. 8, 2012)

Alternative narratives, for example stories that include a focus on helping others and saving the planet, could help students like Mogensen feel more like they belong in engineering—but we must construct them together.

Conclusions and Future Work

In this study, we used the theories of framing and agenda setting in concert with narrative policy analysis to examine stories in the public discourse about engineering and its lack of diversity. Our findings illustrate the ways the five resulting dominant stories function to reduce the complexity, uncertainty, and polarization associated with the perceived lack of interest and well-documented lack of diversity (Yoder, 2012, 2016) in engineering, and point to simplified, actionable solution strategies. Moreover, by monopolizing the discourse and marginalizing other ways of framing engineering, these stories limit opportunities to attract and retain diverse groups in the field. But our findings also caution against telling nonstories that critique the dominant discourse, such as those surrounding a shortage of engineers in the U.S. Instead, we suggest developing credible alternative narratives, or counterstories, and see four main areas for future work.

First, our study only examined online news articles. Future work could examine documentation and key stakeholder perspectives associated with outreach, recruitment, and retention efforts to discern the influence dominant, and potentially other, stories have on these programs.

Second, our data were drawn from ASEE *First Bell* newsletters from August 2011 to August 2012. Since then, the engineering education community has evolved considerably, particularly in relation to diversity. While a comprehensive review of these changes is beyond our scope, several key events are illustrative. In 2014–2015, ASEE declared a Year of Action in Diversity. Safe Zone Workshops and Ally Trainings are now ubiquitous at ASEE conferences. In 2018, ASEE ran the first Collaborative Network for Engineering and Computing Diversity Conference (CoNECD). In engineering education research, intersectional (Banda, 2020; Bruning et al., 2015; Kirn et al., 2016; Ong, Jaumot-Pascual, & Ko, 2020; Pawley, 2013; Ro & Loya, 2015; True-Funk et al., 2021) and critical theories of race and gender (Mejia, Revelo, Villanueva, & Mejia, 2018; Ong et al., 2020; Slaton, 2015) have emerged as widely accepted frameworks, as has the value of examining populations with "small n's" (Pawley, 2013; Slaton & Pawley, 2018). Dr. Lisa Benson, the current Editor in Chief at the *Journal of Engineering Education*, delivered a distinguished lecture at the ASEE 2020 annual conference focused explicitly on "aspects of our culture that generate disparities based on gender, sex, race, ethnicity, and other bases for marginalization" (Benson, 2020). Increasing public awareness of gender and race issues has been reflected in the Me Too and Black Lives Matter movements. Paralleling these developments, public concern for ecological issues such as climate change and plastic waste in the oceans has accelerated over the past decade. Future work could compare our findings to stories told about engineering in news articles that have been published since these developments.

Third, future work could focus on how the stories we identified manifest at an institutional level and influence the culture of engineering education. We have already begun this research and have found that the dominant stories do, indeed, seem to define and delineate how faculty members communicate the nature and goals of engineering to students, often regardless of their own beliefs and commitments (Brewer et al., 2015). Connected to this line of inquiry, future work could also engage faculty to recognize the influence that dominant stories may be having on their practices (Pawley, 2009). It may also be useful to examine engineering and STEM-related discourse in K–12 settings.

Finally, we argue for future work that entails a collaborative and participatory effort to create counterstories to inspire the engineers of tomorrow. In a speech given at Rice University on September 12 in 1962, President John F. Kennedy said:

“We set sail on this new sea because there is new knowledge to be gained, and new rights to be won, and they must be won and used for the progress of all people. For space science, like nuclear science and all technology, has no conscience of its own. Whether it will become a force for good or ill depends on man, and only if the United States occupies a position of pre-eminence can we help decide whether this new ocean will be a sea of peace or a new terrifying theater of war.”

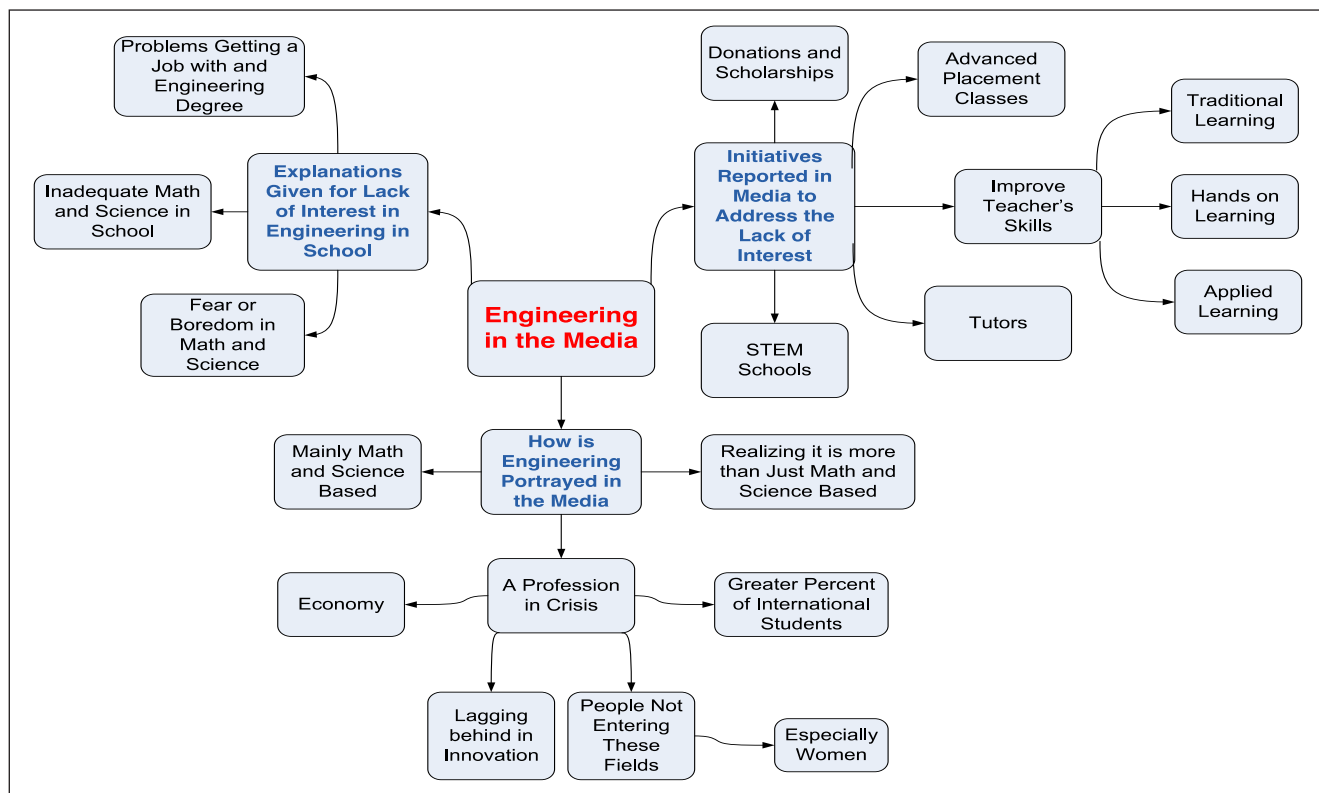
He continued:

“We choose to go to the moon. We choose to go to the moon in this decade and do the other things, not because they are easy, but because they are hard, because that goal will serve to organize and measure the best of our energies and skills, because that challenge is one that we are willing to accept, one we are unwilling to postpone, and one which we intend to win, and the others, too.”

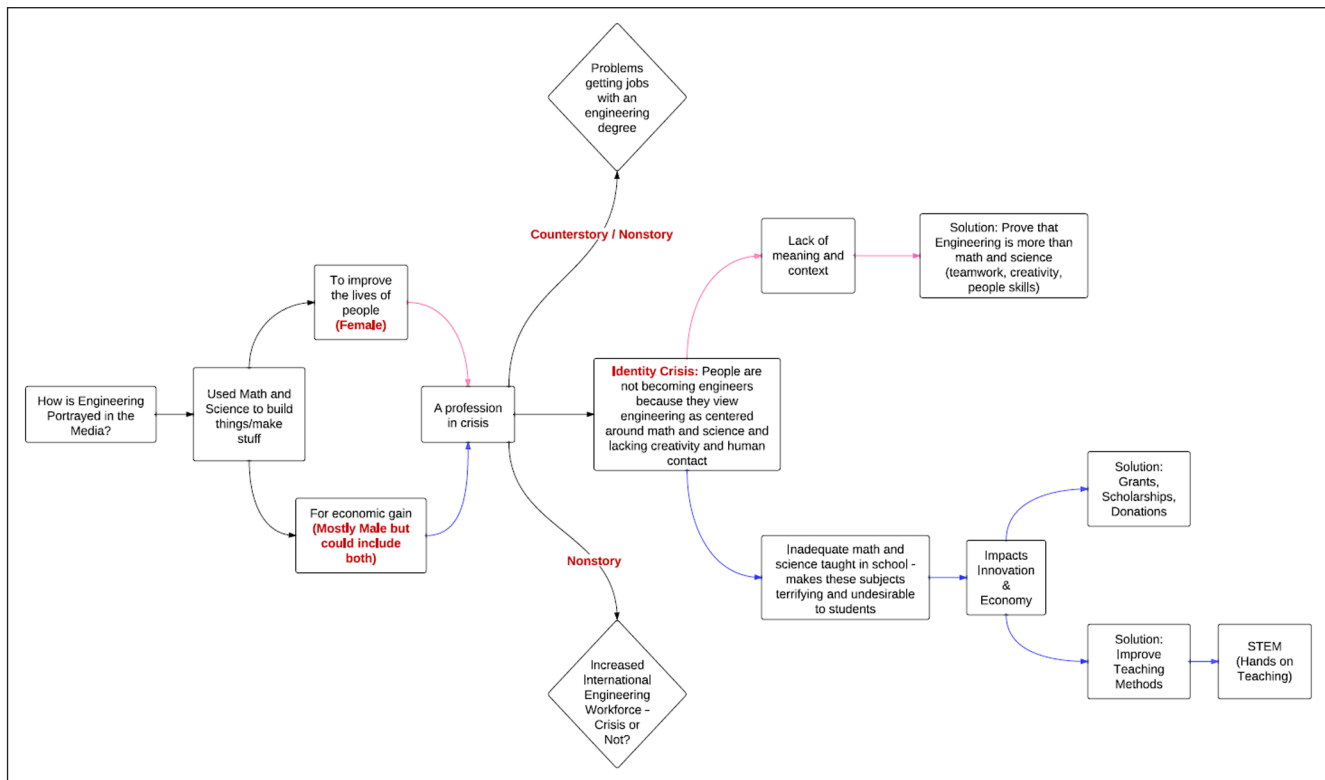
This speech, this *story* about the need for science to be a force for good, about exploring new frontiers, and about working hard to achieve a common goal inspired a generation of scientists and engineers, albeit majority White and male. In closing we ask, what stories will inspire tomorrow’s engineers? What stories might effectively attract men and women from all socio-economic and cultural backgrounds to join the profession and become the engineers of 2050?

Appendix A

Example outcome from Phase 1: Preliminary data analysis.



Appendix B



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