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# Narrative Holes in STEM Storytelling:

A Field Frame Analysis

**A FRAMEWORKS RESEARCH REPORT**

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## Introduction

The American public's thinking about Science, Technology, Engineering and Mathematics (STEM) education is informed by many sources — from the media and research scientists to practitioners and STEM advocates themselves. Previous FrameWorks research found that media coverage of STEM education focuses on individualized examples of STEM teaching and learning, and devotes little attention to gender, racial and ethnic or socio-economic disparities in STEM education outcomes.<sup>1</sup> Media coverage also represents formal and informal STEM learning as distinct, rather than integrated, domains.<sup>2</sup>

Researchers and other experts in STEM learning seek to tell a different story. They identify systemic problems facing STEM education in the United States — including a shortage of qualified STEM teachers; pathways to STEM careers that systematically exclude women, people of color and those from under-resourced communities; and entrenched perceptions of STEM education that value rote memorization and passive models of learning. STEM researchers and experts also assert that out-of-school learning opportunities in STEM can strengthen and complement in-school STEM learning and vice versa. These experts consistently argue that quality universal STEM education is a vital part of civic engagement in the twenty-first century.

What accounts for the gaps between the stories that researchers and STEM experts want to tell and the existing media discourse? FrameWorks looks to the communication habits of an organizational field as one way to understand these disconnects. In this report, we map the diverse narratives that organizations advocating for improved STEM education — including nonprofit associations, government agencies, membership organizations and private industry — use to frame the debate on STEM education reform. This approach — what FrameWorks calls a Field Frame Analysis — identifies the various framing strategies currently employed by influential organizations in the domain of STEM education, particularly as it occurs in informal settings; analyzes the effects of these strategies on public thinking; and highlights those narratives that are likely to be most successful in building public support for this issue. In so doing, we are able to make recommendations about how to reframe existing communications in ways that create a consistent and coherent narrative around STEM education, and thereby deepen public understanding and engagement with the issue.

We define an organizational field as “those organizations that, in the aggregate, constitute a recognized area of institutional life.”<sup>3</sup> While all of the organizations examined in this analysis are working to improve STEM education in the United States, we find that they employ diverse narrative strategies to do so. As such, these organizations are engaged in a

“framing contest” over the issue’s guiding narrative.<sup>4</sup> The research presented here is designed to capture the dynamics of this framing contest and to interpret its consequences for those seeking to build public support for STEM learning policies and programs.

The FrameWorks Institute conducted this research as part of a larger multi-method collaborative project sponsored by the Noyce Foundation. The overarching goal of the project is to design and test communications strategies that can be used to generate broader public understanding of the importance of STEM education, particularly in informal and out-of-school contexts.

# Executive Summary

## Findings

- **Three narratives characterize organizational communications about STEM education reform: an *Expansionary* narrative, a *Practical/Civic Engagement* narrative and a *Gender Disparities* narrative.**
  1. The *Expansionary* narrative advocates for recruiting *more* STEM teachers, engaging *more* students in STEM learning by addressing racial disparities in STEM outcomes, and creating *more* places outside of formal education contexts that offer access to meaningful STEM learning opportunities.
  2. The *Practical/Civic Engagement* narrative focuses on the “real world” applications of STEM learning and its role in the development of an engaged citizenry.
  3. The *Gender Disparities* narrative focuses on improving STEM education for young girls in order to increase their earning potential.
- **The *applications* of STEM are separated from discussion of STEM learning.** Advocacy organizations focus considerable attention on the “real world” *applications* of STEM and its potential role in building an informed and civically-engaged public. However, these efforts lack explanations of *how* STEM skills are developed in formal or informal educational contexts and transferred to other domains. In short, in focusing on the *end* application, the field ignores the *process* through which STEM is learned.
- **Organizational discussions of STEM educational disparities focus on specific groups rather than on the common systemic processes that give rise to these inequities.** Organizational materials that address racial disparities in STEM education are unlikely to also discuss gender disparities, and vice versa. Furthermore, organizations document disparate outcomes, but do not explain why such disparities are so prevalent. This creates a pattern wherein advocacy

organizations focus on specific impacted groups, rather than on systemic processes by which disparities are created and sustained.

- **Addressing gender disparities in STEM educational and career outcomes is primarily framed as an economic benefit that accrues to individual women.** While advocacy organizations that promote STEM learning opportunities for girls argue that such programs increase women’s earning potential, they do not explain how greater inclusion of women in the STEM fields will improve general economic development or other non-economic social factors more generally (i.e., greater diversity of perspectives in the development of scientific knowledge).
- **Advocacy organizations present an integrated, collaborative and complementary portrayal of informal and formal STEM learning contexts.** Advocacy organizations that promote out-of-school STEM programs are not doing so at the expense of traditional educational settings. Rather, they *explain* how informal STEM programs can strengthen STEM education in formal contexts.

## Implications

- **Narrative holes and the focus on individual economic gain invite the public to apply consumerist models of education.** Previous FrameWorks research has shown that *Consumerism* is among the dominant cultural models that the public uses to think about education and educational reform.<sup>5</sup> When this model is operative, it reduces the goal of education to individual financial gain and positions the educational system as just another type of private industry in which cost effectiveness and efficiency — rather than measurable learning outcomes or collective social benefits — are the primary measures of success. Organizations that employ the *Expansionary* narrative leave space for the public to fall back on this dominant understanding by failing to consistently employ values that collectivize the purposes of education. The focus in the *Gender Disparity* narrative on individual financial gain is very much aligned with the consumerist model, and therefore more directly risks reinforcing this unproductive pattern of thinking.
- **Framing disparities as differences between groups rather than places will likely heighten models of *Self-Makingness* and zero-sum thinking.** Previous FrameWorks research on disparities in education and in other social contexts has demonstrated that, rather than looking to systemic or structural explanations for differences in outcomes, members of the public tend to rely on cultural models that pathologize the “values” and character of marginalized communities.<sup>6</sup> These

explanations reduce educational inequality solutions to “fixing” pathological parents or students, rather than designing structural interventions to increase educational equity.<sup>7</sup> When this understanding is coupled with *Consumerist* thinking, the education system becomes one in which all groups compete for access to a set of finite resources for individual benefits. Policies aimed at improving STEM education for disadvantaged groups are perceived as threatening and counter-productive.

- **Organizations’ representation of the relationship between formal and informal STEM learning can be leveraged to expand public thinking.** Organizations successfully demonstrate the value of an integrated and collaborative relationship between formal and informal contexts of STEM learning. As opposed to the media, when STEM organizations make the case for increasing quality, informal STEM learning environments, they do so without undermining support for STEM education that occurs in the traditional school system. Building upon this part of the field’s extant communications practice can increase public receptivity to the idea that learning spaces and opportunities should be diversified and integrated. It will simultaneously avoid triggering pessimism about the possibility of STEM education reform.<sup>8</sup>

## Recommendations

- **The *Pollination Points* Explanatory Metaphor will create stickier messages and help the public think more productively about the relationship between formal and informal learning contexts.**
- **The *Weaving Skill Ropes* Explanatory Metaphor will explain *how* STEM learning happens and the process of skill transfer.**
- **The *Charging Stations* Explanatory Metaphor can help *explain* educational inequality and *shift* public focus towards contexts and systems as the sources of and solution to disparities in STEM education.**
- **The *Workforce Preparation* Value highlights the collective benefits of increasing women’s participation in the STEM fields and inoculates against individualistic thinking about STEM education reform.**

## Theoretical Background

Research in the social sciences on communication by organizational fields offers insights into which messaging strategies are likely to be effective during framing struggles. The vast majority of this literature focuses on the *content* of issue frames, and assesses whether the substance of the message resonates with — and ultimately mobilizes — an intended audience. Along with content, however, social movement scholars are also concerned with how the *representational form* of a message affects public support, and the importance of narratives in building social movements and recruiting potential supporters.<sup>9</sup> Narrative can be defined as “discourses with a clear sequential order that connect events in a meaningful way for a definite audience and thus offer insights about the world and/or people’s experiences of it.”<sup>10</sup> In short, narrative, as applied to social mobilization, concerns not only *what* is said, but also *how* it is said. Communications that adhere to a culturally and cognitively familiar narrative form, in which diagnostic claims about social problems are logically linked to values and solution claims, have shown to be more effective in mobilizing collective action.<sup>11</sup> Values, because of their ability to motivate people’s engagement with an issue and provide a goal around which to structure their beliefs, are a particularly important component of the framed content of narratives.<sup>12</sup>

Based on this literature and previous FrameWorks research, the following analysis not only describes the content of the stories being told by STEM advocates, but also focuses on how that content is organized into a coherent narrative structure, and where it comes up short. We argue that the more an organization’s framing is organized into a cohesive narrative, the more effective it will be in building public understanding and support.



## Methods

Two specific questions guide this research:

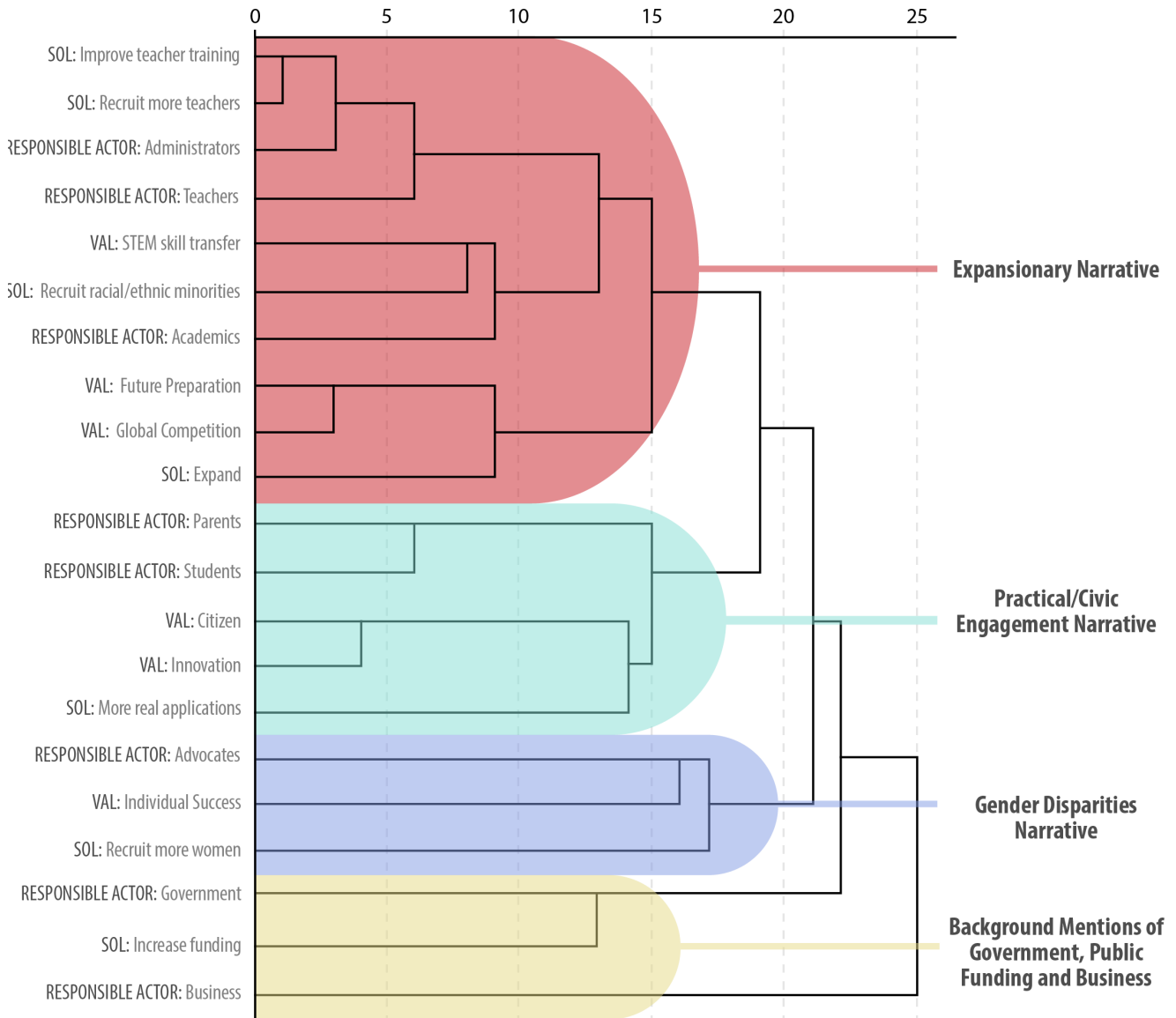
1. *What are the types of narratives that influential organizations in the STEM education reform field are telling, and how are these narratives structured?*
2. *What are the implications of the field's narratives on public understanding of and support for STEM education reform?*

We addressed these questions using a multi-staged research process. The first step involved a link analysis that identified 22 influential organizations in the STEM advocacy field. Approximately eight communications materials — including press releases, mission statements and reports — were gathered from each of these organizations' Web sites. This resulted in a sample of 176 documents. Each document was coded using a coding structure designed to track all the narrative components (e.g., values, solutions, plot line) present in a given organization's materials. The last stage of analysis used a technique known as hierarchal clustering or cluster analysis to identify patterns of narrative components within the data.<sup>13</sup> This approach allows us to examine the different narratives being told within the organizational field, and their content and construction (for example, whether they include logically aligned values statements and solutions). A more detailed explanation of these methods can be found in the Appendix.

## Findings

The analysis found that the STEM organizational field’s communications practice is organized around three narrative structures. Figure 1 presents these three narratives, each represented by a different color. The left side of the figure lists each narrative component. Where a narrative component is joined to another narrative component by a vertical line, the further to the left that line appears, the likelier those components will be found in the same piece of communication. For example, the Solution “Recruit more teachers” and the Responsible Actor “Administrators” are highly likely to appear together in the same communication, while the “Recruit more teachers” and “Government” themes are highly unlikely to occur together. In addition, three variables that appear at the bottom of the figure shaded in yellow—“Government” and “Business” as Responsible Actor, and “Increase funding for STEM-related initiatives” as Solution — are distal elements of all of the narrative clusters described below.

*Figure 1: Three Narratives of STEM*



### The Expansionary Narrative

The first narrative employed by STEM organizations is centered on four main policy solutions. These consist of (1) recruiting more qualified STEM teachers, (2) investing resources into ongoing training in the STEM fields for teachers already in the profession, (3) addressing racial disparities in STEM learning outcomes by recruiting more mentors of color for students and young professionals, and (4) expanding STEM learning opportunities in communities of color. Although not as central to the narrative, this cluster also includes proposals to expand out-of-school learning opportunities for all students. In short, this

narrative advocates for *increasing* the number of STEM teachers, the types of students who receive STEM education and the places that provide STEM learning opportunities. The actors responsible for implementing these solutions typically included teachers, educational administrators (principals, superintendents, etc.) and academics.

This narrative is primarily concerned with the formal education system, with the exception of calls to expand out-of-school STEM learning opportunities. Organizations that employ this narrative regularly explain the importance of integrated, complementary and collaborative learning opportunities in both in-school and out-of-school settings. In their materials, organizations represent these contexts as part of a mutually reinforcing partnership, rather than as distinct sectors in which one must “pick up the slack for the other,” as is the case in media representations.<sup>14</sup> As discussed in further detail below, this is a promising feature of this narrative. The following press release, from the Association of Science and Technology Centers with the Afterschool Alliance, illustrates this very productive narrative tendency.

*Supporters of Lights On Afterschool believe that schools can't do it alone and that meaningful, active collaboration with out-of-school programs is critical. We know that access to an array of quality, informal STEM learning opportunities can make a huge difference in the lives of youth. We also know that strong partnerships between informal learning institutions can help to maximize the use of shared resources and foster creative solutions to community needs. Lights On Afterschool events can help showcase program offerings and deepen ties between informal learning institutions and community organizations.<sup>15</sup>*

The above quote is an important description of the integrated relationship between several educational contexts. However, while the authors assert that STEM learning *does* occur in these various contexts, they do not explain *how* STEM learning actually occurs. That is, readers are not told how access to an array of quality learning opportunities results in the development of STEM skills. In fact, most organizations that employ the *Expansionary* narrative do not explain how learning happens in their materials.

The *Expansionary* narrative draws upon three core values to make the case for the importance of improved STEM training in the United States. The most central of these values positions STEM as a valuable mode of inquiry, with applications that extend well beyond its constituent disciplines. That is, strong training in the STEM subjects develops skills that can be transferred to other domains. More distal to the core of this narrative are the values of future preparedness and global competition. The first of these focuses on STEM training as an important means of career and workforce preparation, while the

second argues that a workforce well-trained in STEM is critical to the United States' economic competitiveness and national security. The following press release from the U.S. Department of Energy illustrates these latter two values. It asserts the importance of workforce development and global competition to argue for greater inclusion of Latinos in the STEM fields.

*If we want America to succeed in the 21<sup>st</sup> century, making sure we offer the nation's students a world-class education is more than a moral obligation, it's an economic imperative. In the long term, our country faces a stark choice: we can invent and manufacture the clean energy technologies of tomorrow in America for export around the world, or cede global leadership by importing those technologies from China, India, Germany and elsewhere. As Americans, we never back down from a challenge — and the Energy Department's Office of Economic Impact and Diversity knows it is mission-critical to get more minorities involved in Science, Technology, Engineering and Mathematics (STEM) fields. Ensuring America's competitiveness depends on making sure that Latinos — and Americans of all races — have the education and technical skills they need to advance their careers.<sup>16</sup>*

There are several structural characteristics of the *Expansionary* narrative that are of particular note. Policy solutions constitute the core of the story, indicating that solutions appear frequently in communications from organizations that employ this narrative. Although the above excerpts include value statements, in general organizations are less likely to employ values, compared to the other narrative elements (see Figure 1). The relatively infrequent use of values indicates that organizations using the *Expansionary* narrative are telling an incomplete story. That is, their materials often focus on solutions without explaining *why these solutions matter*. The following press release from the Department of Education illustrates this more general tendency in narrative form; it covers recommendations for policy solutions without reference to values or the effects of reform.

*Economists project strong growth in careers related to science, technology, engineering and math (STEM), but far too few American students are proficient in mathematics and interested in a STEM career. The Obama administration proposes an aggressive STEM push that will improve the delivery and impact of STEM education.<sup>17</sup>*

## *The Practical/Civic Engagement Narrative*

The *Practical/Civic Engagement* narrative deals squarely with the relationship between STEM education and civic engagement and other non-educational pursuits. Organizations that employ the *Practical/Civic Engagement* narrative argue that countering perceptions of laboratory-bound, white-coated scientists by instead emphasizing “real world” applications of the STEM disciplines is critical to improving STEM education. Organizations that employ this narrative often use the value of innovation, or the assertion that STEM provides a source of innovative solutions to public concerns. They also argue that STEM education prepares young people to be engaged citizens. The primary actors associated with this narrative cluster are parents and students.

The most notable characteristic of the *Practical/Civic Engagement* narrative is that it does *not* specify particular educational contexts and contains a very limited set of responsible actors. That is, the applicability of STEM education to real world contexts, including civic engagement, are not discussed in association with the *settings* in which STEM education takes place. Actors typically responsible for the provision of STEM education (i.e., teachers, administrators and out-of-school program managers) are also absent from this narrative. The following press release from the American Association for the Advancement of Sciences, summarizing a summit in which career scientists were asked to comment on the state of STEM education, illustrates the focus on real-world applicability.

*When asked which single technology held the most promise for helping students advance in science, technology, engineering and math (STEM), Megan Smith of Google[x] answered without hesitation. "The Web. I would give the kids the Web," she said at a recent symposium at AAAS. "Because what's so interesting about the Web is, it's the content and us." The Internet's capacity to connect people to information and to each other, fostering cooperation among people who want to solve problems, could make education in STEM disciplines much more engaging and accessible for students around the world, Smith said in her keynote address at the event.<sup>18</sup>*

In this example, Smith's description of how STEM education can be improved — through greater student access to the Internet — lacks any description of the educational contexts in which this learning would occur or the actors who would facilitate it. The sole settings and actors are the “content and us.” It is an excellent example of the absence of important narrative components from the *Practical/Civic Engagement* story.

The emphasis on STEM education as critical to an engaged, well-informed citizenry is also evident in this statement below, from Change the Equation. As in the example above, the

settings, actors and systems that structure STEM education are absent from this narrative; instead, the sole focus is on the role of STEM education in building a strong democratic society.

*STEM literacy has a profound and growing impact on our day-to-day lives. It helps us make critical decisions about our health care, our finances and our retirement. It illuminates the ever more complex issues that govern the future of our democracy, and it reveals to us the beauty and power of the world we inhabit.<sup>19</sup>*

In sum, the organizations that employ the *Practical/Civic Engagement* narrative are asserting that STEM education fosters skills that can be transferred to domains well beyond the classroom. However, similar to the *Expansionary* narrative, they do not explain the process by which STEM skills develop in various educational settings and then are transferred to other domains. Thus, these narratives do not specify the potential targets of STEM education reform.

### *The Gender Disparities Narrative*

The final narrative observed in organizational materials concerns gender. According to this narrative, the primary solutions for improving STEM education are to recruit more women into the STEM fields, provide mentors for female students in STEM and expand STEM learning opportunities for women. This narrative positions advocates and program managers as the responsible actors and draws upon the value of individual financial gain, or the idea that STEM education is important because it provides the means for women to move into higher-paying careers.

This narrative relies on the value of individual financial gain to argue for greater inclusion of women in the STEM fields. That is, initiatives to improve STEM outcomes for women and attract more women to STEM careers accrue solely to these women themselves. There is little discussion about how having more women in the STEM fields would yield collective societal benefits. Instead, providing STEM opportunities for women is about addressing the wage gap.

*At Girls Inc., we believe girls have the right to prepare for interesting work and economic independence. It is why we work to build girls' confidence in themselves, perseverance to overcome serious obstacles, and needed skills. Our research-based, comprehensive Economic Literacy curriculum teaches saving, banking, credit, investing, avoiding predatory lending, and entrepreneurship. We help girls understand issues related to how they fit within the global*

*economy, including the concept of equal pay for equal work. It's also why we introduce girls at a young age to STEM (science, technology, engineering, math) fields, which generally offer higher salaries and are in demand.<sup>20</sup>*

In short, this narrative makes the case that young girls should care about STEM education because it is critical to their individual economic well-being. In so doing, however, the narrative fails to show the *collective* benefits — both financial and non-financial — that come from including more women in the STEM fields. Furthermore, this narrative constructs the wage gap as a problem of disparities *between* fields — that is, women make less than men simply because they choose not to pursue high-paying STEM careers, not because they earn less for doing the same type of work as men in the same professional field. In reality, although women constitute a small minority of STEM professionals, getting into these fields does not automatically close the wage gap: women in STEM careers are still paid less than their male counterparts.<sup>21</sup>



## Cognitive Implications

Based on FrameWorks' analysis of the cultural models that the public employs to reason about STEM learning,<sup>22</sup> we conclude that exposure to the organizational narratives described above is likely to activate the following ways of thinking about STEM education reform.

**The relative absence of values in the *Expansionary* narrative will leave holes in public thinking about the importance of STEM education reform.** FrameWorks research on several aspects of the educational system has shown that *Consumerism* is the most dominant model the public employs to think about education and reason about education reform. This model likens the education system to private industry, focuses attention on efficiency and cost-effectiveness, and promotes individual financial gain as the most important outcome.<sup>23</sup> The model is singularly deficient in explaining why STEM is a public good, not merely a private advantage, and why public resources should be devoted to improving STEM learning and access. Without clear and consistent discussion of *why* STEM education reform is important — particularly as it pertains to teacher recruitment and retention, and addressing racial disparities — the public is likely to “fill in” this component of the story with their dominant individualist models. Given the public’s tendency to default to *Consumerist* understandings of the education domain, these will likely include focusing on STEM education as a matter of individual professional and financial benefit rather than as a collective concern.

**The frequent use of the *Global Competition* value in the *Expansionary* narrative is likely to inspire crisis thinking.** Educational advocates frequently argue for education reform by telling stories about how American students are rapidly falling behind their international counterparts. FrameWorks has tested this communications strategy on several occasions and has shown that it decreases support for higher education system reforms<sup>24</sup> and that the public is overwhelmed with the severity of the problem to the point of inaction.<sup>25</sup> The *Global Competition* value will likely have similar impacts in the domain of STEM education reform. The public will focus on the crisis of American education at the expense of strategies designed to improve the system. **Moreover, the *Global Competition* frame ignores the internationally collaborative nature of science in favor of a more nationalistic and proprietary view; it is important to question whether this communications strategy is consonant with the expert view of science.**

**Separation of “real world” applications of STEM from educational contexts will further entrench unproductive models of compartmentalized learning.** The real-

world applications of STEM — including its role in increasing civic engagement — are rarely discussed in combination with the educational contexts where STEM learning takes place. Previous FrameWorks research has shown that the public holds extremely compartmentalized views about the settings in which certain kinds of learning can and should occur.<sup>26</sup> Separating real-world applications of STEM from formal educational settings will undermine public support for structural and systemic reforms to improve STEM learning *within* traditional educational contexts. Furthermore, previous FrameWorks research has shown that the public tends to focus on education as a means to individual financial security. Less cognitively available is the role that education plays in building an engaged citizenry and ensuring a vibrant democratic society.<sup>27</sup> When civic engagement is systematically divorced from educational contexts, as in the *Practical/Civic Engagement* narrative, it allows *Consumerist* models of education to dominate public thinking about education, and STEM learning in particular.

**Focusing on groups allows people to fill in with individual-level explanations of inequality.** Organizational narratives treat gender and race-based disparities in STEM educational outcomes as distinct and fail to discuss the common structural causes that underlie these disparities. Previous FrameWorks research suggests that this framing strategy is likely to reinforce public thinking that disparities result from individual or group deficiencies.<sup>28</sup> When this understanding is active, it is difficult for the public to understand how policies and programs can address *structural* causes of STEM disparities.

**Framing gender disparity as a matter of individual financial gain obscures collective benefits and heightens “zero-sum” thinking.** Some organizations included in this analysis frame women’s participation in STEM fields as a matter of individual economic benefit, which is likely to have several unintended framing consequences. First, it obscures the collective benefits of having more women in the STEM fields. These include a stronger and better prepared workforce, but also non-financial benefits like diversity of perspective in the development of scientific knowledge.<sup>29</sup> Second, this framing is also likely to instigate zero-sum thinking in which resources are conceptualized as finite: an increase in women’s wages will necessarily mean decreases for other groups. Finally, the field’s framing of gender disparities risks distorting public understandings of the wage gap. The wage gap is not simply about the paucity of women employed in STEM fields — even women with jobs in STEM fields earn less than their male counterparts. As a result, addressing the wage gap requires not just ensuring that STEM careers are equally accessible to women and men, but also promoting gender equality throughout these fields.

**The integrated relationship between formal and informal STEM learning environments holds promise in broadening public perception of the value of multiple learning contexts.** Advocacy organizations represent a vibrant partnership between formal and informal STEM learning environments. They consistently explain how each context supports the other and how public support for *both* contexts will improve STEM educational outcomes. This is a critically important framing strategy, as it addresses the public's inability to think productively about the relationship between formal and informal learning contexts.<sup>30</sup> This strategy will help lift support for expanding informal STEM learning opportunities *and* for strengthening STEM teaching in formal contexts.

## Recommendations

FrameWorks recommends that organizations seeking to promote STEM education reform, particularly in informal contexts, integrate additional components into the existing narratives on this topic. *Put simply, organizations should seek to tell a complete story that diagnoses the problems impacting the current state of STEM education, explains why reform is important, and lays out concrete steps for improving learning outcomes.* This approach requires that STEM advocacy organizations promote complete narratives in their public-facing materials and interactions. Specific strategies to expand and strengthen organizational narratives include the following.

**Use the *Pollination Points* Explanatory Metaphor to leverage existing explanations of the relationships between formal and informal STEM learning.** STEM advocates are presenting an integrated, collaborative and mutually supporting relationship between formal and informal settings for STEM learning. *This message, however, has not found its way into the media.*<sup>31</sup> *Pollination Points* provides this relationship with a metaphor, and it can be used to create messages that are likely to stick in the media and help the public think more productively about the relationships between formal and informal learning contexts. Below is a sample iteration of *Pollination Points*, adapted for STEM.

*Learners need multiple pollination points to engage their attention and grow their motivation for learning. Multiple pollination points are especially important when children are learning science, technology, engineering or math skills — what some people call STEM skills. When schools are pollination points, they help children develop ideas and skills that help them in the classroom and beyond. Other important pollination points are in communities in places like libraries, science centers, museums and after-school programs. To really grow learning, we need to develop these community pollination points. Children learn most effectively when they can access pollination points in their schools and in their communities and use the skills they develop in all places.*

**Use the *Weaving Skill Ropes* Explanatory Metaphor to explain how STEM learning occurs.** None of the narratives currently employed by STEM organizations consistently explain how learning occurs. *Weaving Skill Ropes* was designed to explain the learning process — it provides the public with tools to understand skill transfer, as well as deepens its sense of the importance of hands-on learning. Below is an iteration of the metaphor adapted for STEM.

*Developing STEM skills is a part of weaving skill ropes. As we learn new skills, our brains weave them together into ropes, which we use to do all the things that we need to be able to do — solve problems, work with others, formulate and express our ideas and learn new things. No single strand can do all the work of the rope. Instead, for a rope to be strong and useable, each strand needs to be woven tightly together. STEM skills are vital strands in all different kinds of skill ropes. Students need chances to learn how to weave and reweave them into different ropes, and to get practice using the resulting ropes. When kids have strong STEM strands, they can use them for all kinds of things that they will need to be able to do — in school, but also more generally in life.*

**Connect discussions of civic engagement directly to both formal and informal settings.** Experts and advocates are clear that STEM education is a critical part of twenty-first century democratic citizenship.<sup>32</sup> Yet, STEM organizations are not explaining *how* learning in specific educational contexts contributes to the development of an engaged citizenry. Providing this information will allow the public to better engage with how STEM skills can be transferred and applied in other domains of social life. Causal chains, a framing technique, can be used to advantage here.<sup>33</sup>

**Use the *Charging Stations* Explanatory Metaphor to provide a systems-level explanation of disparities.** Experts and advocates agree that disparities in STEM learning outcomes by gender, race and socio-economic status are heavily determined by context. However, STEM organizations tend to focus on disparities in education and career outcomes among single groups (i.e., women, Latinos) in isolation. The *Charging Stations* metaphor can be used to shift public attention from characteristics of particular groups to the educational contexts that create educational inequality. Communicators should explain the contexts that cause educational inequality and the policy-level solutions that will address disparities. These kinds of programs and policies can then be described as creating a system of *Charging Stations* designed to address differences in STEM learning outcomes. Furthermore, *Charging Stations* allows communicators to speak to the *common* sources of inequality in STEM education and will set the stage for discussions about how individual groups are impacted. Below is an iteration of the *Charging Stations* metaphor.

*STEM learning opportunities are like Charging Stations that power up kids' learning. Some students are in charging stations with lots of opportunities to charge up learning about STEM subjects. Everywhere they go there are powerful charging stations like great libraries, museums, science centers and after-school programs. But other students are in charging dead zones — places*

*where there just aren't many high-quality learning opportunities. The current system is patchy — it's built so that some of our nation's children are provided fewer charging opportunities than others. This is especially true of STEM learning, where trained teachers and hands-on opportunities are required in multiple places to scaffold up the learning. We should build an effective charging system across the country so that all students, no matter where they are, have high-quality STEM learning opportunities to charge up their learning.*

**Employ the *Workforce Preparation Value* to frame the collective benefits of addressing gender disparities in STEM education.** Currently, STEM organizations' initiatives to include more women in STEM careers are framed primarily in terms of the economic benefits that would accrue to individual women. However, previous FrameWorks research has shown that the *Workforce Development* value is effective in lifting support for education policies.<sup>34</sup> The shift from individual economic benefit to workforce development defines STEM as a public issue of importance to the country as a whole, not merely to those affected; this reframing strategy will result in greater support for programs and policies designed to improve STEM education for young girls.

## Conclusion

It is clear from this analysis that STEM organizations are trying to change the public conversation about STEM learning in the United States. However, FrameWorks analysis of media coverage of STEM issues shows that the field's communications attempts are up against a narrow media conversation that often runs contrary to the goals of STEM organizations. For example, while supportive of STEM education initiatives, the media trains its attention on singular individuals and events to explain the need for education reform or to demonstrate successful STEM learning. In addition, the media fails to engage in issues — like the lack of teacher training in STEM and inequality in STEM learning outcomes — that would expand the public's understanding of the scope of the problems facing STEM education in the United States. Finally, the media reinforces the public's sense of division between formal and informal learning contexts by presenting these domains as distinct.<sup>35</sup>

The analysis presented in this report shows that the communications materials of organizations working to improve STEM learning contain several of the necessary elements to fill out this media narrative. However, for these elements to “stick” in the media discourse they must be organized into a coherent *narrative*. Several vital narrative elements — most important, explanations of *how* STEM learning happens — are missing from the field's existing messages. By telling complete explanatory stories, STEM organizations can become a stronger presence in the public sphere and more effectively move public understanding on their issues. Using tested Values and Explanatory Metaphors and ensuring that these elements are used as part of a coherent narrative will be key to these efforts.

## Appendix: Methods

### **Stage 1. Identifying Influential Organizations Using Link Analysis**

In collaboration with program staff at the Noyce Foundation, FrameWorks researchers created a list of over 90 organizations currently involved in STEM advocacy. These organizations spanned the full ideological and political spectrum, and included governmental agencies, non-profit organizations, foundations, research organizations and member associations. This list of organizations was entered into Issue Crawler, a Web-based application that “crawls” an identified set of organizational sites and compiles all the shared links among organizations (including both those in the original set and those identified during the crawl).<sup>36</sup> Issue Crawler then uses a method called link analysis to determine the “network” of organizations for a given issue area and the degree of prominence or influence of each organization within that network.

This method is based on the premise that “modern communication is increasingly organized around computer-mediated technologies,” and that the Internet serves as a public repository for information about organizations and their goals, activities, networks and relative influence. On the Web, an organization’s influence is “strongly correlated with the organization’s reputation for providing reliable and credible information.”<sup>37</sup> Thus the density of links between organizational sites can be used as a proxy for the reliability and credibility of that information and by extension, the influence of the organization.

We then consulted with program staff at the Noyce Foundation to confirm the Issue Crawler results. From this process, we selected the following 22 influential organizations to include in the analysis.

#### *Non-Profit Organizations:*

- Partnership for Children and Youth (PCY)
- The National Summer Learning Association (NSLA)
- The Afterschool Corporation (TASC)
- National Science Teachers Association (NSTA)
- The Council of Chief State School Officers (CCSSO)
- Association of Science Technology Centers (ASTC)
- American Association for the Advancement of Science (AAAS)
- STEM Education Coalition (SEC)



- Harvard Family Research Project (HFRP)
- Afterschool Alliance (AA)
- American Society of Mechanical Engineers (ASME)
- Southwest Educational Development Laboratory (SEDL)
- Change the Equation (CTE)
- Society of Women Engineers (SWE)

*Non-profit Direct Service Provision:*

- Girl Scouts (GS)
- Girls Inc. (GI)
- 4-H
- First

*Government Agencies:*

- Department of Education (ED)
- Department of Energy (DOE)

*Private Industry:*

- The Boeing Company (BC)
- Time Warner Cable (TWC)

## **Stage 2: Content Selection and Coding**

We then sampled approximately eight communication materials from each of these organizations. These materials included press releases, reports, mission statements and “About Us” Web pages. They were selected because they contain content about how each organization describes its mission, as well as the specific STEM policies that each organization promotes. In total, the sample consisted of 176 materials drawn from these 22 organizations.

Each document was coded using a coding scheme designed to track all the narrative components present in organizational materials. Each narrative component comprises a distinct category that contains a number of possible codes. Together, these narrative components map the stories that influential STEM organizations are telling about STEM education reform (see Table 1).

Table 1: Variables Included in Analysis

Narrative Component	Description	Examples of Codes
<b>Topic or Plotline</b>	What is the document about? What is the primary issue or topic being discussed?	<ul style="list-style-type: none"> <li>• STEM and racial or gender disparities</li> <li>• Shortage of qualified STEM teachers</li> <li>• STEM teaching methods</li> </ul>
<b>Presences or Absence of a Causal Story</b>	Does the material provide a clear cause for the issue under consideration?	
<b>Value</b>	Why is reform important? Why is it necessary to reform STEM education in the U.S.?	<ul style="list-style-type: none"> <li>• Workforce development</li> <li>• Innovation</li> <li>• Civic engagement</li> </ul>
<b>Solution</b>	What should be done to fix the immigration system?	<ul style="list-style-type: none"> <li>• Recruit/retain qualified STEM teachers</li> <li>• Programs to address racial disparities</li> <li>• Increase the number of visas available to high-skilled immigrants</li> </ul>
<b>Character</b>	Who are the responsible actors in the narrative?	<ul style="list-style-type: none"> <li>• Teachers</li> <li>• Students</li> <li>• Program administrators</li> </ul>
<b>Messenger</b>	Who are the quoted experts on STEM education reform?	<ul style="list-style-type: none"> <li>• Politicians</li> <li>• Researchers/academics</li> <li>• Advocates</li> </ul>
<b>Target of STEM education reform</b>	What groups should be the target of STEM education reform?	<ul style="list-style-type: none"> <li>• Women</li> <li>• Students of color</li> <li>• Adults</li> </ul>
<b>Grade level of Target students</b>	What specific ages of students are mentioned?	<ul style="list-style-type: none"> <li>• K-12</li> <li>• High school</li> <li>• College/University</li> </ul>

We first coded the set of approximately eight documents belonging to an individual organization then summed the number of times that each code was applied across the full set of that organization’s materials. This approach yielded a frequency count of codes *per organization*. Consider, for example, the frequency of codes in the *topic or plotline* category for Girls Inc. Looking across all materials belonging to Girls Inc., the code “STEM and the gender gap” was applied nine times.

### Stage 3: Cluster Analysis

We analyzed this raw frequency data using a technique called cluster analysis.<sup>38</sup> The goal of cluster analysis is to identify patterns in a set of data. It uses a statistical algorithm to group objects together on the basis of similarity. In the present analysis, the “objects” are the narrative elements that appear in organizations’ mission statements, press releases and reports, and “similarity” refers to the extent to which those objects co-occur in materials. The goal of cluster analysis is to identify clusters, or groups, in which objects within the same group are more similar to each other than to those in other groups (clusters). In other words, objects in the same cluster should co-occur more frequently with each other than they do with objects in other clusters.

Figure 1 summarizes the results of this analysis. Based on the cluster analysis results, we determined that three narratives account for all the variance in organizations’ use of narrative components. We then used a statistical algorithm to assign coordinates to each object on this one-dimensional grid, called a dendrogram, such that the distances between them reflect the extent to which they co-occur across all organizational materials. Objects that are closer together are more likely to appear together in organizational materials than objects that are farther apart.

#### **Stage 4: Cognitive Implications**

Finally, these findings were compared with results from FrameWorks’ research on how experts and the public think about STEM education reform.<sup>39</sup> This comparison allowed researchers to detect ways in which existing communications will impact public understanding of, and support for, STEM education reform.

## About The FrameWorks Institute

The FrameWorks Institute is an independent nonprofit organization founded in 1999 to advance science-based communications research and practice. The Institute conducts original, multi-method research to identify the communications strategies that will advance public understanding of social problems and improve public support for remedial policies.

The Institute's work also includes teaching the nonprofit sector how to apply these science-based communications strategies in their work for social change. The Institute publishes its research and recommendations, as well as toolkits and other products for the nonprofit sector, at [www.frameworksinstitute.org](http://www.frameworksinstitute.org).

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## Endnotes

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- <sup>1</sup> O'Neil, M., Simon, A., & Haydon, A. (2014). Missing matter: Holes in the media narrative about informal and formal STEM learning. Washington, DC: FrameWorks Institute.
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- <sup>8</sup> Kendall-Taylor, N., Lindland, E., & Baran, M. (2012). Mapping the gaps on where and when learning takes place: A core story of education report. Washington, DC: FrameWorks Institute.
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- <sup>14</sup> O'Neil, M., Simon, A., & Haydon, A. (2014). Missing matter: Holes in the media narrative about informal and formal STEM learning. Washington, DC: FrameWorks Institute.
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- <sup>16</sup> Harris, D. *Creating educational opportunities for minorities in STEM*. Posted on September 17, 2012 on the Web site of the Department of Energy.
- <sup>17</sup> Brenchley, C. *2014 Education Budget: What's the bottom line?* Posted on April 10, 2013 on the Web site of the Department of Education.
- <sup>18</sup> Wren, K. *Online networks are key to student achievement in the STEM fields*. Posted on September 13, 2013 on the Web site of the American Association for the Advancement of Science.
- <sup>19</sup> Change the Equation. *Why STEM?*
- <sup>20</sup> Girls Inc. *A Message from Judy Vredenburg on the Gender Wage Gap*.
- <sup>21</sup> See for example, Peterson, T., & Morgan, L.A. (1995). "Separate and unequal: Occupation-establishment segregation and the gender wage gap. *American Journal of Sociology* 101(2): 329-65.

- <sup>22</sup> Volmert, A., et. al. (2014). "You have to have the basics down really well": Mapping the gaps between expert and public understandings of STEM education. FrameWorks Institute: Washington, D.C.
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