Discourse, Gender, and the Meaning of Work

Rearticulating Science, Technology, and Engineering Careers through Communicative Lenses

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ABSTRACT

In this chapter, we offer communicative perspectives and challenges related to gender representation and the gendered organizing and career processes in science, technology, engineering, and math (STEM) areas. We focus on the meaning of work in STEM and how these meanings are (re)created and communicated through discourses. Using a discursive approach, new perspectives on the issue of the underrepresentation of women in STEM careers derive from the constructed nature of STEM work itself and its meaningfulness to different groups, particularly women. Engagement in STEM careers also provides a context to evaluate and expand theory, research, and practice in communication. We use multidisciplinary lenses to examine developmental, educational, media, technological, sociocultural, and organizational perspectives on STEM work and careers. In summary, this chapter examines the discursive roots of contemporary constructions and images of STEM work, careers, education, and organizations, offering an opportunity to address a socially relevant issue and context for further examination and explication of communication research, theories, and practices across specialties.

DISCOURSE, GENDER, AND THE MEANING OF WORK: REARTICULATING SCIENCE, TECHNOLOGY, AND ENGINEERING CAREERS THROUGH COMMUNICATIVE LENSES

Introduction

In 2006, the President of the International Communication Association (ICA), Jon Nussbaum, called for communication scholars to address socially relevant quality of life concerns placing communication at the “very heart of these discussions” (Nussbaum, 2007, p. 5; see also Craig, 2005). For adults, work and careers, and the opportunities perceived as accessible and meaningful to particular individuals and groups, comprise a central aspect of quality of life. At the simplest level, careers give form and meaning to paid labor and relevant unpaid work experiences (Buzzanell & Lucas, 2006). The nature, accessibility, and meaningfulness of work and careers, broadly conceptualized1 (see Arthur, Inkson, & Pringle, 1999; Cheney, Zorn, Planalp, & Lair, 2008; Medved, this volume), have material considerations embedded in their very conduct and context. The ways in which stakeholders socially construct these issues are communicative in nature. These constructions center on the discourses, or everyday talk, interactions, media depictions, and linguistic choices surrounding work and careers, as well as on the Discourses, or “standardized ways of referring to/constituting a certain type of phenomenon” (Alvesson & Kärreman, 2000, p. 1134), such as gender, economics, globalization, and managerialism that people invoke to determine whether or how they might participate in work and careers (Alvesson & Kärreman, 2000; Fairhurst, 2007; Kuhn et al., 2008). As Kuhn and colleagues noted, D/discourses can act as resources or tools, serving as linguistic devices that explain past actions, affect future practices, and guide our interpretations and constructions of experience, persons, and institutions (see also Fairclough, 1992; Kuhn & Nelson, 2002).
The work of science, technology, engineering, and math (STEM) and associated careers offer a site in which the d/Discourses of work and careers are complexly manifested and contested. National and international calls for innovative theory, research, assessment, and practices seek to draw in a new generation of participants, especially women, and rearticulate what work in these areas contributes to society within the context of a contemporary and globalized information economy (Congressional Commission on the Advancement of Women and Minorities in Science, Engineering and Technology Development [CAWMSET], 2000; Domestic Policy Council, 2006; National Academy of Sciences [NAS], 2007; National Science Foundation [NSF], 2004, 2005). Because communication constitutes the heart of needed scholarship and practice within STEM, our goals in this chapter are twofold: We strive, first, to set research agendas with communication at the center of STEM work and career initiatives, and second, to propose STEM as a site in which innovative communication theory, research, and practice can be undertaken. We believe communication perspectives and research can bring new insights to the continuing underrepresentation of women in STEM while simultaneously providing a rich and influential site in which to test and evaluate communication theories from organizational, family, instructional/educational, cultural, media, technology, and other communication perspectives.

We focus on STEM because these disciplines do and will continue to play important roles in 21st century society, particularly given the ubiquity of technology in everyday lives and work. STEM work offers technical solutions to the world’s most urgent problems—from health issues and global warming to drought-resistant foods and advance warning systems for tsunamis—and to the world’s seemingly more mundane activities—productivity, domestic work, and education. Solutions require multidisciplinary and diverse insights, including those from communication, women, and multicultural populations, to define, evaluate, and identify solutions that hold social as well as technical influences and implications. Moreover, because of the tremendous workforce demand and monetary rewards of this work, STEM careers can provide opportunities for countries, groups, and individuals to benefit economically and socially.

Given global demands for recruitment and retention of individuals in STEM careers and the underrepresentation of women in these careers, many initiatives are directed toward women and girls (CAWMSET, 2000; Etzkowitz, Kemelgor, & Uzzi, 2000; NAE, 2002, 2008; NSF, 2004, 2005, 2006; Phipps, 2008; Rosser, 2008). Yet, despite decades of effort, women remain underrepresented in most STEM fields even as the demand for a highly skilled and educated workforce grows (U.S. Department of Labor, Bureau of Labor Statistics, 2006–2007; International Labour Organization, 2003; Judy, D’Amico, & Geipel, 1997). Although enrollment rates have risen in certain STEM disciplines, such as the life sciences and biomedical engineering (NSF, 2006), the underrepresentation of women continues (Snyder, Tan, & Hoffman, 2006), particularly in engineering and computer science (Rosser, 2004; Spertus, 1993). In computer science academic programs in the United States, according to Snyder et al., the number of females enrolled has actually declined, and graduation rates have fallen below 25%, the lowest since 1977 (Snyder et al., 2006). For this reason, although we situate our review and discussion within the broad framework of STEM, we focus specifically on engineering and computer science, given the intransigence of growth in those two areas. Underrepresented in the global STEM labor force, both individual women as well as their nations do not receive the economic and social benefits that arise from more equal participation in the research, design, and engineering of systems, technologies, and processes that are ubiquitous in everyday life.

We frame our review around the meaning of work, seeking to understand the messages that influence how members of society, particularly girls and women, perceive and construct these
meanings; how people talk about work matters. Thus, examining work as a discursive construction helps uncover “the very nature and goals of work” within different historical contexts and how these meanings are shaped by Discourses and demographics of race, nationality, gender, and class (Cheney et al., 2008, p. 140). Because doing the work—both the craft and intellectual aspects—is of utmost importance, the language that accompanies STEM work also deserves examination. Employing a discursive approach helps to make sense of, consider the linguistic choices and occupational frames employed by, and locate the ways in which STEM members discursively position themselves and others within macrodiscourses surrounding STEM. In other words, we explore the intersections of d/Discourse, gender, technology, and meaningful work, with the intent of bringing new perspectives to the issue of women’s underrepresentation in STEM careers while simultaneously seeing the context of STEM careers as a setting that presents challenges that can lead to new Understandings of communication theories and processes.

Rearticulation of STEM Careers from Cross-Disciplinary Perspectives

We begin with the development/lifespan perspectives and then consider educational, media, technological, sociocultural, and organizational lenses on the discursive constructions of meaningful work in science, engineering, and technology. In so doing, we provide new and multiple lenses in which to examine both the communicative perspectives of the representation of women in STEM careers, as well as the multiple factors that influence and contribute to the meaningfulness of science and engineering work.

DEVELOPMENTAL (LIFESPAN) PERSPECTIVES

From a lifespan perspective (Nussbaum, 2007; Pecchioni, Wright, & Nussbaum, 2005), STEM provides a context in which memorable messages (Stohl, 1986/2006) attributed to multiple socialization agents can be considered more or less salient depending on the developmental phase of individuals within particular contexts. Stohl defined messages as memorable if an individual “remembers the message for a long period of time and perceives the message had a major influence on the course of his or her life” (p. 146). With known influences of early parental aspirations and socialization processes, STEM provides an opening for enhancing research in family communication that explores how families talk (or do not talk) about work with their children—both boys and girls (Golden, 2000; see also Lucas, 2006). Children are not simply socialized in the how of a particular career but whether a particular career or type of work is acceptable through indirect, direct, absent, and ambient messages. For example, a study of Chinese immigrant parents in Canada illustrated that participants considered different types of careers or work to be appropriate for girls and boys (Liu, 2006), and most of the parents in the study associated engineering, science, and computers with boys. As Liu detailed, one mother stated that:

In terms of occupation for a girl, it ought to be something steady and peaceful, decent and clean, and not very challenging and risky. I hope my son will go out as far as he likes to explore the wide world as much as he likes. But with a girl, I would not have held such high expectations. The most important thing for a girl is to be steady and safe. (p. 496)

Evidence suggests that boys and girls are differently socialized in career views. As early as age 2, girls receive differential reinforcement to engage in play, academic subjects, and occupations that are gender appropriate, subsequently resulting in different educational exposure...
and perceived expectations (Etzkowitz et al., 2000; Fels, 2004; Lytton & Romney, 1991). As Etzkowitz et al. explained, in the United States, many teachers and parents encourage STEM-valued behavioral traits (such as risk-taking, innovation, and independence) in boys and urge boys to pursue math and science for fiscally rewarding careers while persuading girls to consider careers that allow family commitments to be prioritized over or balanced with work. These socialization processes circumscribe occupational choice considerations (Gottfredson, 1981, 2002) and can intersect with sociopolitical and cultural factors. In China, for example, many parents indicate that the “sciences, engineering, construction, computer, politics, military affairs, [and] management” are the most suitable occupations for boys (Liu, 2006, p. 496). However, in response to national agendas, such as the one-child policy, parents now also encourage girls into traditionally masculine careers because such careers can bring prestige, economic value, and honor to families and the country (Liu, 2006; Lucas, Liu, & Buzzanell, 2006). Thus, national Discourses and messages intersect and sometimes contradict traditional economic, culture, and gender Discourses, and reframe and reshape messages and socialization patterns.

Although they may not be able to articulate, from the earliest ages children conceptualize adult labor as separation from family life and recognize adults’ attitudes toward work and nonwork (e.g., Jablin, 1985, 2001; Van Maanen & Schein, 1979). As children age, they consider and role-play familiar occupations and receive reinforcement for their performances. Boys become firefighters, doctors, and policemen; girls play the parts of teachers, cooperative game players, and nurses (Thorne, 1993). Furthermore, children develop skills and talents by participating in sports, taking lessons, and excelling in subjects that might prove appropriate for desirable careers. Intergenerational research indicates that children may learn the details of particular work through regular interaction with and observations of occupational members (Gibson & Papa, 2000; Lucas, 2006). Through this occupational osmosis process, families, friends, and neighbors function as important socialization agents, and the home and local community serve as sites for learning and refining meanings of work (Jablin, 2001).

Parental conversations about work and career continue through adolescence and often eclipse other socializing agents, until youth begin to learn about work, jobs, and careers through part-time employment (Levine & Hoffner, 2006). When parental work and careers and the messages associated with them do not align with the work that their children choose (e.g., in the move from an industrialized to an information economy), children must contend with mixed or contradictory messages that complicate success and perceptions of the meaningfulness of their work or career (Lucas, 2006). Lucas noted that contradictory messages may occur when parents alternate between wanting their children to make use of talents, get an education, find a fulfilling career, remain in their communities, and do work that is not dangerous or marked by instabilities caused by strikes and layoffs. Complicating these messages are conditions of deindustrialization (Lucas, 2006), changes in cultural norms through outsourced work in developing nations (Pal & Buzzanell, 2008), or shifting national social policies (Liu, 2006; Zachmann, 2000).

With regard to socializing agents in Western nations, vocational and career counseling centers in educational institutions frequently impart advice and messages about following one’s passions, abilities, and interests, emphasizing the “know thyself” approach (e.g., Butler & Waldrop, 1999; Buzzanell & Lucas, 2006; Collingwood, 2001). In other nations and cultures, such as China (Liu, 2006) and the Chinese Canadian immigrant culture (Li, 2001), family members explicitly state career aspirations for children. According to Li, families encourage participation in science and engineering, and explicitly discourage participation in law, the arts, or politics. Although the political–economic ideologies are dissimilar in many ways in China and
the United States, Lucas et al. (2006) demonstrated how both exert control through systematically distorted career and work discourses that appear benevolent but encourage individuals to extend themselves indefinitely and in particular types of work. From desires for jobs that enable individuals to be self-sustaining in the inner city (Newman, 2000) to “real jobs” (Clair, 1996) with advancement and prestige potential, influential adults affirm the nature, perceived accessibility, and meanings of work to children early in life.

The recognition of gender and cultural differences in influences on meaningful work resonates through these cross-cultural and class-based descriptions. Gender differences in work and career start early and are influenced by Western developmental and lifespan processes that emphasize independence for boys and relational development for girls (Gallos, 1989). For example, Helwig (2004) asked elementary school-aged children to identify desirable occupations and found that in the second grade both boys and girls tended to select occupations dominated by members of their own gender. However, these aspirations changed with age. In the sixth grade, boys were more likely to select a “male” occupation (93%, vs. 83% in second grade), but girls were less likely to select a “female” occupation (30%, vs. 56% in second grade) as they matured. The fifth to sixth grade period, then, may represent a time in which girls (though not boys) are less likely to hold gender-role stereotypes about occupations. This occupational orientation changes again in adolescence when identity and peer identification begin to exert stronger influences in occupational choice (Faber, Brown, & McLeod, 1979; National Academy of Engineering [NAE], 2008).

While there may not be strict boundaries, girls may find that their ambitions are either encouraged or curtailed through sanctions and memorable messages (see Fels, 2004) as well as memorable absences (Arendt, Buzzanell, Dohrman, & Litera, 2008). Furthermore, even when girls select male-dominated university majors and careers, they may be discouraged by an unsupportive climate, little integration of family and community aspects, and instructional styles that perpetuate notions of STEM occupational members as isolated, obsessed with work, and intolerant of those who do not adapt rapidly to the work and material conditions (e.g., Arendt et al., 2008; Grant, Knight, & Steinbach, 2007; Hewlett, Luce, & Servon, 2008; Margolis & Fisher, 2002). They also may learn that organizations discourage or prohibit leave-taking for familial reasons or discuss the implications of technical or scientific skill decay and its material consequences (Allen, Armstrong, Riemenschneider, & Reid, 2006; Galtry & Callister, 2005; Kirby, 2000; Kirby & Krone, 2002; Remke, 2008).

The developmental perspective, then, illustrates that multiple socialization agents (particularly the family, school, and culture) communicate the meaning of STEM work, generating memorable messages throughout the lifespan of an individual. The discursive construction of STEM work (as masculine and isolated, prestigious and academic, and segregated from and often incompatible with other social roles or commitments such as family) provides early and sometimes lasting Discourses with which individuals determine the appropriateness or desirability of pursuing STEM careers.

**Educational Perspectives**

In his book, *A Short History of Nearly Everything*, journalist Bill Bryson (2003) detailed his first exposure to science in school. Excited, he rushes home, opens his textbook, ready with “real wonder” to uncover the answers to important questions. Unfortunately, the textbook “wasn’t exciting at all…it didn’t answer any of the questions…stirred up in a normal inquiring mind….
So I grew up convinced science was supremely dull, but suspecting that it needn’t be, and not really thinking about it at all if I could help it” (p. 5).

In contrast to developmental/lifespan perspectives, an educational perspective on STEM from kindergarten through college, at both broad and discipline-specific levels, can help communication researchers to understand the institutionalized messages and discourse that influence the enactment of meaning regarding work and career choice within educational institutions. These influences include curricular materials and programs, occupational counseling, academic role models and advisors as well as institutional discourses and policies that influence the perception of meaningful work. STEM and communication researchers as well as STEM practitioners should examine the ambient and indirect messages and strategic absences provided by educational institutions preparing future engineers, scientists, and technologists—the direct and discrete messages evidenced in textbooks, curriculum, teacher language choices, and marketing through organizational documents and Web sites.

Jablin (2001; see also Levine & Hoffner, 2006) regarded schools and school-related activities as significant sources of work, vocational, and career information for children, noting that “school is typically the first socializing institution in a child’s life that institutionalizes status differentiation and hierarchical division of labor” (p. 737). These early influences of school continue through adolescence. According to Phillips’s (2005) study of 200 youth, “[t]hrough eighth grade, there is no significant difference between boys’ and girls’ performance in math and science, but by twelfth grade boys tend to outperform girls in both subjects. Girls are more likely than boys to attribute difficulty in math and science to personal ability” (p. 1). However, recent research has demonstrated that these minor differences in academic achievement generally disappear with curricular changes that encourage girls to take advanced level math courses during high school (Hyde, Lindberg, Linn, Ellis, & Williams, 2008; Lubinksi & Benbow, 2006).

In addition to aptitude tests, training opportunities and curricular context also reflect educational influences on the meaning of STEM work. Blue collar, masculine constructions of engineering in the United States (Oldenziel, 2000) historically contributed to women being denied entry to certain areas of hands-on factory training that was essential to industrial engineering careers, in effect excluding them from graduation or future career promotions. Further, Eriksson-Zetterquist (2007) asserted that science education has been “constructed in ways that are not attractive to women in the same degree as to men…. This construction affects women as students, teachers and researchers, as well as the content of the textbook” (p. 306; see also Faulkner, 2000, 2007; Wajcman, 1991). In critiquing the ostensibly inclusive “science for all” U.S. curriculum initiative, Calabrese Barton and Osbourne (2001) argued that critical, postmodern, and feminist discourses remain marginalized, such that traditional renderings of technology, science, and engineering remain dominant and generally do not appeal to marginalized groups, including minorities and women.

The cultural environment of academic programs also influences the desirability and hospitability of climates for female students. Margolis and Fisher (2003) studied women in the premiere computer science program at Carnegie Mellon University and noted the strong masculine culture. According to Margolis and Fisher, “the male norms of who can do computer science exert their influence at many points throughout a student’s college career. Curriculum, culture, peer relations, and faculty expectations reflect the traditional male claims on computing” (p. 17). Margolis and Fisher’s findings (2002, 2003; see also Sahr, 2008) suggest that the meaning or broader implications of work may be more influential in career choice for women in computer science than for men. While the enjoyment of computing is a primary factor for both
female and male students, women also prioritize the versatility offered by the career, its relationship to their interests, the excitement offered by the rapidly changing nature of the field, and encouragement (or lack thereof) from teachers and parents. Male students, in contrast, envision a computing career as “a natural extension of their lifelong passion for computers” (Margolis & Fisher, 2002, p. 50). Thus, for women, enjoyment and passion for computers and computing constitutes a necessary but not sufficient condition for deciding to enter the computer science profession; broader considerations factor into this decision as well.

Eccles (2006) reached similar conclusions, based upon 35 years of research on gender underrepresentation in the physical sciences and engineering. Her research indicates that the main source of gender differences does not come from aptitude or self-efficacy differentials but, rather, from differences in the value that men and women place on certain occupational types. However, inaccurate stereotypes about STEM careers persist that “lead some young women and men to reject these careers for the wrong reasons” (p. 209); the messages and information about such careers result in better informed occupational choices. For example, Metz (2007) analyzed popular Web sites about college majors and found that Web sites for fields such as mechanical engineering continue to emphasize “the least interesting aspect of the field” with limited and stereotypical descriptions that emphasize a “love of math and science,” enjoyment of “computer games, mazes and jigsaw puzzles”—thus characterizing the field as hard work and lots of math (pp. 196 -197). According to Metz, professionals reviewing these Web sites noticed the absence of particular messages. For example, one reviewer suggested that messages about “[h]ard, math, and makes you a nerd but NOTHING that describes what mechanical engineers do—nothing about serving society or building products,” will “drum all women out of the field” (p. 198).

Furthermore, while attempting to demonstrate the diversity of engineers in a list of 21 well-known artists, astronauts, musicians, leaders, CEOs, and personalities who had earned engineering degrees, Metz only identified one woman, one African American man, and one Hispanic man. Thus, narrow and inaccurate messages and images of STEM careers do not represent work attributes that women value.

Educational perspectives must also address the cultural context(s) and the educational system(s) within which the students reside. Unlike in nations such as India and China, where educational assessment determines future education and career paths, in the United States, teenagers face at least two important decision points—deciding whether to pursue a college education and then settling on an academic major. Engineering and science majors present an exception to these educational rhythms, however, because more stringent curricular requirements require an early commitment to the major during the freshman year, as well as substantial prerequisite courses in math and science. Individuals who are discouraged (or not encouraged) from taking prerequisite courses perceive themselves to be at a disadvantage and are dissuaded from considering such programs. Flexible curricular programs can encourage diversity and entry to STEM fields. In addition certain types of educational institutions are able to counter broader social patterns (Giguette, Lopez, & Schulte, 2006; Lopez & Schulte, 2002) and enact influences that affect enrollment and the completion of academic degrees. For instance, women are more equally represented in STEM programs in historically Black U.S. colleges and universities, than other institution types (Giguette et al., 2006; Lopez & Schulte, 2002).

Educational influences can be both institutionally and culturally specific. In contrast to the more individualist choice within U.S. culture, Gupta and Sharma (2002) argued that women in Indian culture experience patrifocality (Mukhopadhyay & Seymour, 1994; Subrahmanyan, 1998), a system that gives precedence to men in the family and expects women to subordinate
their goals. According to Mukhopadhyay and Seymour, within this system of patrifocality, educational decisions arise from family, not individual choices, and, as Subrahmanyan explained, the mother-in-law (on behalf of the husband’s family) exercises substantial influence over the educational decisions of the daughter-in-law, who is considered an economic liability. Subrahmanyan noted that women in India (in most classes) historically had very limited access to higher education because of the economic burdens imposed on the family. However, the trend has shifted in contemporary times to recognize the “earning wives” benefit of women with STEM degrees, making these careers palatable and in demand for Indian women. By appealing to economic Discourses as a basis for career meaningfulness, the construct of economically viable wives has been created.

In sum, educational perspectives on the meanings and meaningfulness of STEM work do not rely simply on the everyday discourses of teachers and coaches of extracurricular activities but also upon broader societal and cultural Discourses that reveal how social policies, historical periods, cultural norms, economic pressures, and other factors create contexts in which STEM interests are gendered, privileged, curtailed, and reconfigured. Rather than looking solely at educational reforms and governmental policies that correspond with STEM initiatives and outcomes (e.g., Phipps, 2008), communication researchers can ascertain how the d/Discourses portray shifts in educational thinking and practices that encourage or discourage participation of girls and minorities in STEM and examine whose interests these shifts sustain.

MEDIA PERSPECTIVES

STEM work generates a plethora of slogans and portrayals of scientists, engineers, mathematicians, and technologists as mechanistic, nerdy, or geeky. From the infamous Barbie chant “Math is hard” to the more recent suggestions that “engineering is elementary” (Museum of Science, 2007) and “[m]ath is cool for girls,” proponents increasingly strive to expand the discourse (NAE, 2002, 2008) and portray engineering as a way to individual and national prosperity (Gupta & Sharma, 2002). At national policy levels in the United States, the NSF (2005) discussed the importance of changing the ways in which media sources represent fields such as engineering and the talk and interactions that surround and shape its Discourse (NAE, 2008). Examining the metaphors, images, and media perceptions of STEM in the context of broader discourses of scientific rationality gives insight into the perceptions of meaningful work. Media portrayals of STEM work include dominant archetypes that are constructed and communicated through multiple media—movies, television, music, the Internet, and others—with the intent of engaging a global media perspective. Rhetorical and popular cultural scholars pursue these portrayals with examinations of the myths and stereotypes that infuse television, movies, and cyberspace (Steinke, 2004, 2005; Van den Bulck & Van den Bergh, 2005).

The myths and stereotypes associated with both STEM work and gender roles permeate cultural portrayals (Steinke, 2004; see also Leonardi, 2003; NAE, 2008). In both engineering and computer science careers, considerable research indicates stereotyped views of STEM work influence subsequent career choices (see Clarke & Teague, 1996; NAE, 2008; Whyte, 1984). Clarke and Teague reported that both male and female high school and college students believed that women were not enrolling in computer science programs because of the “images of computing as technical, male sex-typed, and mathematical” (p. 242). According to Clarke and Teague, when asked about the desirability of careers, high-school girls generally panned the idea of computing careers, characterizing such work as boring to be “sitting in front a computer all day” (p. 243), in spite of their enthusiastic use of computers at school and home. The girls failed
to see the relevance of such careers to factors that they deemed meaningful in work (NAE, 2008; Whyte, 1984). Similarly, despite a decrease in the media portrayal of scientists as “mad,” dangerous, and anti-social, Turkish middle school students tended to characterize scientists as elderly Caucasian males who work alone on chemistry experiments (Türkmen, 2007). These stereotypes are not globally consistent, however. In Mauritius, negative stereotypes for computing careers are absent; “instead, computing is seen as fresh, new, modern, and challenging” (Adams, Bauer, & Baichoo, 2003, p. 62).

As children age, peers and media become more prominent socialization agents. Television viewing begins for many around 2 to 3 years old, and it comprises a prominent socializing medium that increases in importance as children reach adolescence. According to Steinke (2005, p. 28), “during this time, adolescents are more likely to look to the media for information on specific ‘life tasks’ that have the greatest salience to them: developing a gender-role identity, learning how to interact with members of the opposite sex, and selecting an occupation and other future life roles.”

During preadolescence and adolescence, the media offer images of possible selves and ways of thinking about and managing femininity and work–life issues. Hylmö (2006) analyzed the messages presented about gender and vocational roles in films for teenage girls, and she noted that films deliver messages that minimize the importance of careers for women and suggest that men (fathers and boyfriends) will be available for “protection, guidance, and financial support” (p. 167). Consistent with this research, Conaway (2007) analyzed television portrayals of teenage girls in programming noting mixed messages when brainy girls “learned to perform more normatively” (p. 242) by neglecting schoolwork for relational benefits (popularity or romance).

Even though female scientists and engineers in film appear as competent professionals with high status, Steinke (2005) found that only 20% of the films analyzed in her study depicted scientists as mothers, and only one (of 23) depicted a dual-career family that shared childcare responsibilities. Steinke concluded that films emphasized the femininity of the scientists and engineers—all were or became attractive and were typically romantically involved during the course of the film.

In short, popular depictions of females on television and other media continue to display women as passive, dependent, emotional, social, and more interested in romance and appearance than in work and careers (Signorelli, 1997; Steinke, 2005). Steinke (2005) detailed the implications of these portrayals for women in science and engineering:

The focus on female scientists and engineers as single and the lack of images of working mothers...represents an important direction for future research. The impact, if any, of the message conveyed by some of the female scientist and engineer primary characters about the difficulties of balancing work and family and the scarcity of characters presented as successfully balancing work and family needs to be examined given recent research on women’s perceptions of SET [science, engineering, and technology] careers. (p. 54)

Narrow portrayals of STEM careers have significant implications for girls and adolescents who are beginning to consider how to integrate and balance work and family in future careers. As Hanson (2000) argued, “A critical element in the culture of science occupations involves ideas about having to be wedded to one’s work—making it difficult for women with families (spouses and/or children), but not men with families, to succeed” (p. 170).

Representations do not merely occur in traditional mass media. The Internet, new media, and even virtual worlds, such as Second Life, have broadened the avenues through which social actors perform and portray occupations and gender roles (Bortree, 2005; Mazzarella, 2005; Stern, 2004), providing an additional source of potentially influential information and portrayals.
given the number of teens who use the Internet on a daily basis (Lenhard, Madden, Macgill, & Smith, 2007). Steinke (2004) analyzed Web sites targeted toward girls seeking information about science and engineering careers. While a number provided positive portrayals about careers, Steinke observed the many mixed messages conveyed—countering struggles against discrimination and work—life challenges with positive achievements in work that was meaningful and socially important. Furthermore, some of these Web sites are too narrowly focused, neglecting to emphasize elements and opportunities of the profession that are attractive to women, such as civic and global responsibility (Raphael, Bachen, Lynn, Baldwin-Philippi, & McKee, 2006).

The absence of media portrayals of women in STEM professions continues to communicate volumes. Signorelli (1997) analyzed the messages to which girls are exposed through film, television, music videos, and teen magazines, and she found that most women were not portrayed in occupational contexts. Furthermore, few media portrayals of engineers and scientists exist that one would consider cool, fun, and sexy, despite notable exceptions. The Nickelodeon network consistently portrays girls as capable, strong, and empowered individuals, who can save others, boys included (Banet-Weiser, 2004). Additionally, PBS launched a new television series aimed at middle- and high-school students to illustrate engineering work. Design Squad (WGBH Educational Foundation, 2007; see also Sahr, 2008) follows a multicultural and gender diverse team of students who accept engineering challenges and use the processes of brainstorming, designing, building, and testing to illustrate that engineering can be fun, challenging, and performed with teams of people who look like “you and me.”

In addition, numerous social groups—online and off-line—have formed to offer counternarratives to the stereotypical STEM professional as a male nerd or geek. For example, at Tufts University, the Nerd Girls group embraces the nerd label, challenging the notion that geek pursuits are incompatible with feminine interests in fashion and reframing such activities (and the members who enjoy them) as geek chic (Bennett & Yabroff, 2008). Members perform these counternarratives by modeling themselves after popular media figures such as Tina Fey, writer and star of 30 Rock whose character loves Star Wars; by hosting Girl Geek dinners; or even participating in, and winning, Sexiest Geek Alive contests typically geared toward men (Bennett & Yabroff, 2008; Newitz & Anders, 2006).

These stories and performances recognize and subvert the familiar stereotypes of STEM work (Tucker, Pawley, Riley, & Catalano, 2008) and offer counternarratives to the existing cultural portrayals of engineers as nerdy, boring, and nonsocial. In fact, alternative discourses expand and reframe the discourse of engineering work and its members to one of coolness—a bit like the Apple Get a Mac television commercials that contrast the nerdy, overweight, institutional PC guy with the cool, independent, healthy Mac guy (see http://www.apple.com/getamac/ads/). These discourses also reframe the meaningfulness of STEM work and its careers, when media sources connect the value of innovation and imagination to serving social needs and importance in our future world. Specifically, alternative discourses reframe the meaning of being smart and choosing STEM careers as an opportunity to empower girls. However, critics have warned that the counterdiscourses can themselves be problematic as evident in debates over the culturally dominant stereotypes of attractiveness employed by the nerd girls, which some argue demand women to fill traditionally hegemonic ideals of feminine sexuality while simultaneously demonstrating intellectual prowess (Pawley, 2008).

The biases inherent in the news media compound this problem of mixed messages in media portrayals. For example, promoting itself as a progressive company in gender equality (Styhre, 2006).
Backman, & Börjesson, 2005), Volvo created an all-female engineering and design team to develop a new concept car and illustrate the possibilities and products that result when more women participate in engineering design. Through critical discourse analysis of 272 news articles, Styhre et al. found that the media coverage drew upon gendered stereotypes and produced a form of *double articulation*—emphasizing the unique qualifications of the female team, while refusing to admit differences between female and male engineers.

As engineering groups, most notably the NAE (2008), work toward branding engineering in more attractive and accurate fashions, new media campaigns can draw more youth, particularly girls, into STEM majors and careers (see also NAE, 2002). Based upon interviews and surveys of children, youth, and parents, the NAE identified phrases and messages about engineering that have strong appeal to youth of particular age, gender, and racial/ethnic groups. However, these message campaigns can also have opposite, mixed, and contradictory effects. In particular, messages strategically designed to increase interest and participation in STEM areas by women and members of underrepresented groups may have unintended, and opposite effects (i.e., a *boomerang effect*; see Byrne & Hart, this volume) if the targeted audience is already predisposed toward certain behaviors or values. Factors such as gender, age, prior knowledge or behavioral involvement, and media usage can impact potential boomerang effects. In addition to unintended consequences, media campaign efforts might have little effect if they are not aligned with and adapted to cultural values (see Hornikx & O’Keefe, this volume). Furthermore, health campaign message research can provide useful strategies for the development of persuasive STEM message campaigns using both tailored rather than targeted message strategies (see Noar, Harrington, & Aldrich, this volume).

In short, many media portrayals of gender and STEM perpetuate stereotypes about occupational members’ appearance, values, behaviors, and work–life intersections in ways that are unappealing to girls, women, and many males. Current and upcoming campaigns to create more inspiring messages and accurate occupational portrayals about the meanings and meaningfulness of STEM work and careers would benefit greatly from critique and research by communication scholars well versed in message construction, unintended consequences, and long-term campaigns.

**TECHNOLOGICAL PERSPECTIVES**

Careers in STEM disciplines hold distinct and direct relationships with the technologies believed to be germane to those occupations. In the case of computer science and engineering, intimate relationships exist between the technologies and the occupational members’ interests, self-efficacy, feelings of belonging, and retention that have both discursive and material consequences. The tools of the trade carry particular connotations about the nature of work which, in turn, frames occupational members’ expression and experience. Even when not stated explicitly, such machine–occupation correspondences underlie gendered orientations to STEM work and careers (Faulkner, 2000, 2007; Frehill, 2004). For example, “working with computers,” “building bridges,” “fixing engines,” or “using Bunsen burners” constitute iconic symbols reinforcing the mechanistic and manual nature of such work in a way that backgrounds the intellectual, creative, and interactive dimensions of these disciplines. Technologies influence individual perceptions and constructions of the meaning of STEM work as well as the experience and skill that people bring to such careers.

Activities in school and play shape interest in technologies. Clarke and Teague (1996) demonstrated that boys participated more in computing activities such as clubs and camps than
girls and spent more time in programming and gaming activities, experiences that build both intellectual and physical fluency with the tools that one uses in computer science and engineering. Consistent with this research, Margolis and Fisher (2002, 2003) found that girls in the Carnegie Mellon computer science program did not have the same degree of programming experience, or even gaming skill, as their male counterparts, despite similar academic preparation. This lack of technical fluency influenced female confidence as participants in the program as well as their comfort with the culture of play that pervaded and typified these academic environments (Margolis & Fisher, 2003). Enhancing the fluency of young girls can lead to better comfort and self-efficacy (Bertozzi & Lee, 2007) and shift attitudes toward valuing such work (and play) in occupational and organizational cultures.

Changes in the nature of technologies themselves can also change interest and engagement with the tools and related environments as well as their associated careers. For example, the gap between technology use in girls and boys in the United States has narrowed, primarily due to the increasingly social nature of technologies. In 2000, the number of teenaged girls using the Internet approached that of the boys in most activities and exceeded them in others (Fallows, 2005). Furthermore, young women were actually more likely than young men to be online but participate in different activities: Women were more likely to engage in socially interactive activities underscoring human connections, while men engaged more in instrumental and recreational activities (Fallows, 2005; Kennedy, Wellman, & Klement, 2003). Furthermore, teenage girls were more likely than their male peers to be content creators on the Internet (Lenhard et al., 2007). Thus, as Lenhard et al. detailed, the prevalence of social technologies appears to have increased interest and participation in the Internet and Web-based technologies among teenage girls and young women, which could change the landscape of users and creators of such technologies.

Researchers recognize, however, that the digital divide—a gap between those with access to and fluency with technologies—continues to persist in nations outside of the United States, particularly in nonindustrialized countries without digital infrastructures (DiMaggio, Hargittai, Neuman, & Robinson, 2001). The presence of digital infrastructures is a necessary but not sufficient condition for technical efficacy. In a survey of 700 people in Singapore, a country with an extremely high penetration rate of communication technologies, Cheong (2007) found that efficacy rates among women remained quite low, demonstrating the interaction of social and cultural factors in influencing access to and use of technology.

A growing area of research involves how play and gaming technologies can be used to broaden occupational choice, development (Klawe, 2006; Shaffer, 2006a, 2007), and learning (Prensky, 2007). For example, a new genre of gaming and virtual environments called serious games (Gee, 2003; Prensky, 2007) employs gaming for nonentertainment goals such as learning, skill training, and decision-making simulations. These approaches tap into the notion that the use of creativity, imagination, and innovative technologies engages the interest of new millennial students (also called digital natives, Palfrey & Gasser, 2008) and holds the potential to attract a broader audience to the STEM disciplines and prime their interest in addressing global societal needs. For example, Shaffer uses epistemic games in the development of professional skills, values, and identities in children (Shaffer, 2006b; Svarovsky & Shaffer, 2006) as they role-play the work of particular professions. In the course of simulations requiring problem solving, students learn the skills, knowledge, and values required in certain professions, that is, the epistemology of a profession. In the Alternate Routes to Technology and Science (ARTS) program, Shaffer (2005, 2006b) created engaging learning environments that are relevant to
students’ interests. In the *Digital Zoo* project, students utilize practices of biomechanical engineering to design virtual creatures and learn physics and biology; in *Ecology 2020*, students use geographic information systems to create urban plans, learning about sustainability and urban growth. These processes convey the value, identity, and meaning of such work.

The integration of creativity, art, design, and fun with engineering processes and technological design environments for learning and doing STEM shift the meaning of STEM work away from existing perceptions of such professions as hard, boring, and mechanistic. Such alternate articulations of STEM can communicate and reinforce ties to work and careers that coincide with what young girls value and find meaningful. In parallel with this increase in the design and production of new games-based learning environments, colleges and universities are developing new academic programs in game design and game studies to address growing industry needs and attract broader interest to the computer sciences (Jackson, 2007).

Determining whether such new learning environments influence gender participation and interest in STEM careers, improve fluency, and affect the perceived meaningfulness of such work constitutes an important area for communication research. For example, the influence of these new learning environments as an extension of play, and the structures that underlie the design of such technologies, calls for more extensive research. Opportunities also exist to integrate such efforts with emerging knowledge on media portrayals and message campaigns in order to reframe the portrayal of STEM work, in collaboration with STEM educators, professionals, and branding experts. These tools pose exciting possibilities for learning. However, while gaming can also expand occupational interest, technical fluency, and skill competency, designers should also ensure that the structure of such games, traditionally gendered and biased toward activities that are attractive to boys and men—competition, war, violence, and misogynist treatments and portrayals of women—do not serve as tools to further hinder participation by girls and women. A considerable body of research has examined the content of games (Sherry, 2001; Lucas & Sherry, 2004), particularly their trends toward violence and gender-related play preferences (Bertozzi & Lee, 2007), but few have examined the context and structure of games (with the notable exception of Shaffer (see 2005, 2006a, 2006b) or the ambient and discrete career messages (and absences) inherent in such technology designs.

Taylor (2003) found that gender comprises a significant contributor to understanding how gamers approach play and the creation and use of avatars in online gaming, and Consalvo (2004, 2006) described the continuing gendered assumptions that drive the development of new technologies in the games industry7 (see also Cassell & Jenkins, 2000). Furthermore, Soukup (2007) noted that many digital games are gendered at the structural level of game design, with their assumptions of what elements of play are attractive. The gendered structures of game design suggest the presence of gendered Discourses and messages as well, and additional examination of the messages present and absent in games is necessary to avoid further disadvantaging women considering STEM careers (Kafai, Heeter, Denner, & Sun, 2008). As Jackson (2007) observed, researchers must “consider and critique not only the content of games (which are often violent and sometimes misogynistic), but also the gendered qualities of those things that might be taken for granted (and therefore invisible) in the deeper structure underlying game play” (p. 151).

Social constructionists of technology remind researchers that technologies stem from the societies and members who create them (see Flanagan & Waldeck, 2004; Jackson, Poole, & Kuhn, 2002; Pinch & Bijkert, 1984). Technologies are gendered (Wajcman, 1991), and the creation of technologies has generally been considered to be a masculine job, while the
consumption of technologies has been rendered either feminine or masculine (Consalvo, 2006; Wajcman, 1991). One of the most powerful reasons to be concerned with fewer women in the fields of engineering and computer science involves realizing the implications of their absence as designers of the ubiquitous technologies that pervade our everyday lives (Eriksson-Zetterquist, 2007; Latour & Woolgar, 1979; Margolis & Fisher, 2002). When, as Margolis and Fisher asserted, “boys invent things and girls use the things boys invent” (p. 5), the consequences extend not only to the technologies being designed but also to the messages created and implied by those technologies.

The construction of technologies and their associated STEM professions intersects with the resulting artifacts, products, and the knowledge as well as the identities of those creators and producers. Scholars have suggested that decoupling the identities of computer science and engineering professionals from the knowledge that is created and produced in such programs and careers holds promise for changing the value and meaning of such work for young women (Leonardi, Jackson, & Diwan, in press; Putnam et al., in press). Because some young women hesitate to adopt the identities typically associated with STEM professionals, yet embrace the knowledge and preparation, decoupling one from the other holds promise as another form of rearticulating STEM careers. Putnam et al. (in press) suggested alternative educational paths toward STEM careers, such as through industrial and architectural design, in which the artifacts and knowledge are similar, but the identities differ.

Furthermore, technology intersects not only with gender identities but also sociocultural and economic factors. Kennedy et al. (2003) acknowledged that, as industrialized societies moved from the production of things to the production of knowledge and discourse, gender roles (on the Internet and beyond) were also affected, with both material and discursive consequences. For example, the globalization of technological product manufacturing and the outsourcing of customer service industries have changed the locus of work so that women in developing countries now possess breadwinning status and power that previously resided with men in industrialized countries (Eriksson-Zetterquist, 2007). Coupled with this shift comes a revaluing of meaningful work in these societies as work that empowers women in material and discursive ways.

In a fascinating account of how technology empowers women in STEM careers in other cultural contexts, M. Anderson and Shrum (2007) interviewed female scientists in India. While women in India have been encouraged to pursue STEM careers (Subrahmanyan, 1998), the social and cultural norms of their country continue to limit their mobility in terms of social interaction with men outside of their family. The introduction of communication technologies (such as cell phones and the Internet) provide a way for women to circumvent cultural restrictions, empowering them with greater access to knowledge and professional networks while still respecting the norms of their culture. Thus, participation in workforce economies and societies changes the sociopolitical and socioeconomic elements in which STEM work is embedded.

Similarly, the factors that allow women to participate through virtual or distance work may provide both challenges and opportunities in STEM work. Organizations tend to privilege physical proximity in terms of influence and promotions (Hylmö, 2004); virtual or distance employees receive fewer promotions and pay increases than comparable physically colocated employees, and may face challenges in organizational assimilation and socialization (Gibbs, Nekrassova, Grushina, & Wahab, 2008; Picherit-Duthler, Long, & Kohut, 2004; Waldeck & Myers, 2007). However, distributed and distance work (Hinds & Kiesler, 2002) can facilitate
work–family balance (Hylmö, 2004) as well as foster relations among virtual team members (Gibbs et al., 2008; Leonardi, Jackson, & Marsh, 2004). The strategic use of distance work and virtual organizing may change the value and meaning that such work holds for women and provide opportunities to reexamine assumptions and ideas held about work and organizing in fixed contexts (Marsh, 2006).

Thus, engineering’s prominence in shaping the artifacts and technologies of the industrial age, and both engineering and computer science’s prominence in shaping the artifacts and technologies of the information age, suggest underlying meanings and messages within the tools and technologies themselves. These meanings hold implications for understanding valued and meaningful STEM work and careers as well as grasping the underlying assumptions of the systems, products, and tools designed (or, pointedly, not designed) in our 21st century society.

**Sociocultural Perspectives**

The examination of STEM careers from class and cultural perspectives provides insights into how careers are constructed differently by classes and cultures (Lucas, 2006; Weinger, 1998; Willis, 1977). Class may constrain STEM career opportunities through omissions. According to Lucas, the absence of specific message types and content may be as significant as the presence of others. Additionally, ambient messages may influence as much as discrete ones. For example, Lucas explained that intergenerational Discourses and discourses in a blue-collar community undergoing deindustrialization are complicated and ambiguous as the children of working-class mining families are forced to transition to careers in an information economy. According to Lucas, with transition periods and “no footsteps to follow” (p. 6), difficulties occur in legacy careers, but opportunities arise for STEM membership. These multiple and intersecting social and cultural discourses produce discursive and material opportunities and constraints on individuals’ and group members’ consideration and pursuit of careers in STEM fields.

Research on African American socialization practices indicate that parents and members of extended kin relationships promote autonomy and close familial relationships at early ages (Bell & Nkomo, 2001; Suizzo, Robinson, & Pahlke, 2008), socializing young children into expectations of educational achievement within the context of ancestral struggles. As Suizzo et al. argued, these messages reflect a “broader cultural value among African Americans, regardless of class” (p. 308). Parents in middle-class African American families recall direct messages as children of working-class parents that emphasized the value of educational achievement. Early and continued socialization into hard work, development of human capital, and attainment may be more manifest in certain groups, but it remains part of continuities across time and location of American work ethics (Bernstein, 1997).

Economic Discourses play a prominent role in sociocultural perspectives of class. As corporations become the dominant organizations in contemporary society, embedded values regarding meaningful work align with money, accountability, return on investment, financial sustainability, efficiency, and cost/benefit analyses. Some may question the economic imperatives which appear to change institutional structures and processes (Herrmann, 2007). Herrmann argues that Economic Discourses pay insufficient attention to the specific contexts in which discourses can assist in (re)defining meaningful actions. In terms of meaningful work, individuals reference Economic Discourses in their everyday negotiations, such as: when parents decide who engages in paid labor and who becomes a stay-at-home parent, or when individuals decide to engage in wage work to give their offspring the benefits of travel, private education, and extracurricular training that can foreshadow their adult work or enable them to move from
one occupational category to another in insecure economic times. For example, individuals frequently select STEM careers for the economic benefits provided by such professions and that parents identify as sources of future economic security for their children (NAE, 2008).

Economic Discourses, as well as models of social and human capital, still play into discursive equations that education, hard work, and networking yield “good” jobs and entitlements to the good life. In other words, investment into economic indicators equates with positive career outcomes and meaningful work. Such investment constitutes a motivating force, a hope for the future, a hedge against insecurity, and a powerful Discourse that joins with survival of the fittest and individualistic values. Economic Discourses do not simply communicate that work is meaningful because it pays for life’s necessities or the extra things that make life enjoyable (Ciulla, 2000); instead, they pervade everyday conversations in subtle ways, negotiated with an eye toward material realities. Today, the Discourse of career passion can supersede money, status, and even class. Those in elite classes prioritize “following your bliss” more than money, which is simply assumed to follow from passion-driven work (Collingwood, 2001).

In addition to classed constructions of work, the cultural environment exerts a significant influence on the construction of meaningful work and occupational choice. International research indicates significant differences in how families, schools, educational institutions, and national sociopolitical climates portray work in science and engineering which shapes the meaning and value placed on educational and occupational choices (Galpin, 2002; Lagesen, 2005). For example, in the country of Mauritius, girls are just as likely as boys to select academic majors in computer science careers (Adams et al., 2003); and, compared to those in Norway, girls in Malaysia consider computing to be cool and a desirable career choice (Jumnongjit, 2007; Lagesen, 2005).

These cultural influences affect academic aptitude as well. Guiso, Monte, Sapienza, and Zingales (2008) analyzed test scores in mathematics and reading for 15-year-old students across 40 countries. Categorizing the countries according to their gender equality using economic, political, educational, and general well-being indices, they found that the gap in mathematics ability was higher in countries with a low gender equality index and disappeared in those countries considered to be gender-equal, suggesting that the gender gap in math ability is culturally influenced.

Across countries and cultures, research on gendered disparity in science, technology, and engineering careers includes substantial discussion about the impact of culture on perceptions of and involvement in these fields (Crump, Logan, & McIlroy, 2007; Gupta & Sharma, 2002). The assumption that individuals have the ability to choose careers may not be prevalent in non-Western cultures where responsibility to one’s family, community, and culture are more dominant factors of influence. For example, like women in India, Jorgenson (Jorgenson & Wang, 2008) asserted that women in China may not have the same presumption of individual agency in occupational choice. At the same time, paradoxically, Pinker (2008) demonstrated that, in cultures where choice is more prevalent, the gender gap among STEM professionals may actually be more pronounced. Assessing the prevalence of women in physics professions, Pinker found that, in countries (such as the United States, Norway, Switzerland, Canada, and the United Kingdom) with better financial stability and legal support for job choice, the gender split is higher than in countries (such as the Philippines, Thailand, and Russia) with less support for occupational choice. For example, roughly 30 to 35% of physicists are women in these less supportive countries, compared to 5% in more supportive countries (Canada, Japan, Germany). This research highlights the complexity of intersections of sociopolitical, economic, and cultural
influences in occupational choice of STEM careers and the continuing opportunities to examine the discourses that influence such choice. In ongoing research, we are analyzing the work and career socialization messages received by children in kindergarten through fourth grade in three countries, comparing the United States, Belgium, and China. In this project, we are examining potential differences in both micro- and macro-level discourses received by very young children in diverse cultures (Kisselburgh, Berkelaar, & Buzzanell, 2008).

These cultural discourses of meaningful work deserve greater research attention. Cultural perspectives also yield important insights as the practice of engineering and other STEM careers becomes increasingly global and multicultural, and internationalization essential to economic success (Kumar, Ochieng, & Oyango, 2004). Evetts and Buchner-Jeziorska (2001) argued that professional knowledge (i.e., transmitted through language) is moving beyond national borders as professional associations discuss standards with growing international professional bodies. The internationalization of all professions, not simply science, technology, and engineering professions, makes discourse about these professions relevant to a broad, interconnected community.

**Organizational Perspectives**

In this section, we focus on organizational (and occupational) culture literature and career discourses. First, in offering a communicative view of organizational culture, Eisenberg and Riley (2001) defined it as a process that “consists solely of patterns of human action and its recursive behaviors (including talk and its symbolic residues) and meaning” (p. 292). While they encouraged a focus on organizing rather than organizations, given the boundarylessness of organizations (Arthur & Rousseau, 1996), in this chapter, we focus on the culture of specific organizations as well as organizing processes of STEM organizations and occupations. First, we provide an overview of engineering culture, and then, we share a critique of its premises and findings with regard to the meanings and gendering of STEM work.

Classic work on engineering culture (Kondo, 1990; Kunda, 1993; Kvaande, 1999; see also Collins, 2003; Kuhn & Nelson, 2002; Leonardi, 2003), suggests that engineering cultures are often organizational manifestations of the stereotypes and typified professional identities of engineers and engineering, implying underlying and broader values of what it means to be a successful engineer. Margolis and Fisher (2003) assessed the culture of CMU’s computer science program where students described peers as someone who is “in love with computers, myopically focused on them to the neglect of all else, living and breathing the world of computing” (p. 17). While many of the females in the program denied fitting this profile, the discrepancy between self-identity and the perceived identity of their (mostly male) peers contributed most to their questioning whether they belonged in the field: “I don’t seem to love it as much as the men, and therefore I don’t belong” (p. 18). Male-dominated cultures persist into organizations as well, and Hewlett and colleagues (2008) identified the pervasiveness of such cultures as the primary reason that 50% of women leave STEM careers after 10 or 15 years. According to Belkin (2008),

Engineers have their “hard hat culture,” while biological and chemical scientists find themselves in the “lab coat culture” and computer experts inhabit a “geek culture.” What they all have in common is that they are at best “unsupportive and at worst downright hostile to women.” (p. 1; see also Hewlett et al., 2008)

The discourses within an organization help shape the culture in ways that reinforce or (re)construct the gendered notions of careers. Ruiz Ben’s (2007) research on employees in the software industry in Germany suggests that women talk differently about technology than men.
and are less arbitrary in their use of technological terminology. Similarly, Peterson (2007) examined the talk of male versus female workers in a Swedish IT firm and found that “male colleagues ‘talk more about how competent they are’ while [females] preferred to ‘tone [their] competence down’” (p. 344). Further examinations of the discourse—or *talk-in-practice*—could provide insight into how different framing strategies and discursive resources shape career meanings and opportunities for different groups (see related work by Drew & Heritage, 1992).

Peterson (2007) also noted the “feminization of IT work” (p. 334), discussing how the meaning of valuable work within the Swedish IT sector has been reconstructed in the past decade to revalue and redefine social competence as a masculine quality of “aggression, instrumental, rationalized, competitive” more typically found in men (p. 345). As a result, the roles of women in the firm were (re)constructed according to new norms of value and prestige. Peterson determined clear gendering in the discursive labeling of work. According to Peterson, “Senior developers, systems analysts and systems architects...are male dominated. It is technology. The rest: design, interface profiling and application architects.... In these softer kinds of work, such as design, the majority are women” (p. 339). Thus, the meaning of valuable work was gendered even within the IT firm, depreciating the “softer” fields of work and contrasting them with “real” technology work. Interestingly, the male-dominated areas, such as systems architecture, involve working closer to the machine, while the female-dominated areas (such as design, user interface, and higher-level applications work) involve working closer to the people. In other words, the greater the interface with people rather than machine, the greater the emphasis on the aesthetic versus the manual, the “softer” (less valuable, and less masculine) or more feminized the work, participants tend to more readily perceive and configure the occupation (even STEM occupations) as sex segregated (see also Blackburn & Jarman, 2006).

These gendered dualisms of different aspects of STEM practice are evident in notions of teamwork and collaboration as well. Although organizations herald teamwork and collaboration as valuable for contemporary STEM practices, particularly in engineering (see Accreditation Board for Engineering and Technology [ABET], 2007), Discourses of individualism and individual achievement or skill persist. When incorporated into everyday discourses, an imbalanced dualistic tension emerges—they contrast teamwork with more valued technical skill as a necessary but less important component of professional practice (Faulkner, 2000).

Thus, an organizational lens presents either a singular organizational culture centered on engineering values, or a culture that is adversarial in nature, where members delineate subcultures by gender or some other point of difference (e.g., creators or users of technologies or particular computer systems, or soft versus real work; see W. Anderson & Buzzanell, 2007). Studies rarely reveal the complex and fragmented nature of organizational and occupational cultures in STEM (Martin, 1992). Without exposing the nuances and contradictions inherent in the discourses about and the tasks and tools of STEM work, predominant images and Discourses of masculinity and exclusion persist.

An organizational perspective also encourages researchers to examine not only how STEM work and careers might better be portrayed, but also how the meaning and organization of STEM (and other fields) might be changed to better accommodate the values of women. For example, Rosser (2004) told the story of a female computer scientist who discovered that her desires for broad life experiences conflicted with the views of her male peers, who perceived computing as both work and a “relaxing hobby” and where “respect is conferred upon those who possess knowledge obtained primarily through countless hours investigating the nuances of hardware and operating systems” (p. xxiii).
At its core, this restructuring of organizations and organizational values fundamentally involves discursive practices and incorporation of alternative values and work accomplishment strategies (Buzzanell, 1995). According to Buzzanell, numerical goals for enhancing equity of representation may be necessary, but they are not sufficient. Broader awareness and appreciation of the different values and patterns of thinking embedded in Discourses and interaction (discourse) that affect the construction, validation, gendered composition, and meaning of certain professions is required. For example, research suggests that in countries where the representation of women within STEM careers is more balanced, members link the value of STEM careers more to cultural values and gender roles and identities (e.g., being a good wife and daughter) (M. Anderson & Shrum, 2007; Gupta & Sharma, 2002; Subrahmanyan, 1998), and the fulfillment of traditional gender roles (e.g., wife and mother) as well as career roles is enabled by social policies and structures (Oldenziel, Canel, & Zachmann, 2000; Zachmann, 2000). These values, however, can conflict with one another as in the case of Chinese American mothers in IT fields who must adopt assertive interpersonal styles in order to defend their work flexibility, which contrasts with their cultural norms (Jorgenson & Wang, 2008).

Young women are less likely to study and choose such careers, but, perhaps even more striking, a significant number of women leave STEM careers early. Hewlett et al. (2008) completed a large-scale study of women in STEM careers, finding that, although 41% of entry-level STEM professionals are women, nearly 55% of these women leave their careers roughly 10 years after beginning, what the researchers called a “key moment” (p. 23). As reasons for this exodus, the women mentioned (a) hostile work climates amidst heavily macho cultures; (b) feelings of isolation; and (c) a disconnect between preferred work rhythms and those rewarded in high-risk, fast turnaround occupations. These results coincide with other research in information technology (IT) work (Major, Davis, Sanchez-Hucles, Downey, & Germano, 2007), where the perceived incompatibility of occupational cultural aspects (e.g., long hours, continual need to stay current with technologies, late nights, and on-call duty) and women’s responsibilities as mothers result in turnover (Allen et al., 2006), regardless of whether official policies of flexible or nonstandard work arrangements existed (Armstrong, Riemenschneider, Allen, & Reid, 2007). These findings are not organization or culture specific. Indeed, in countries that experience underrepresentation of women, engineering and technology careers are perceived as entailing long, unrelenting hours, with no time for a personal or family life (Sumner, 2008), countering the values that many women hold or that Discourses assert.

An organizational or occupational cultural lens aligned with fragmentation, ambiguities, and multiple realities (see Martin, 1992) offers opportunities to explore how particular discourses about career, meaningfulness of work, and quality of life intersect. For example, because women place a higher value on having a multifaceted life (Eccles, 1994; Mainiero & Sullivan, 2005), they are more concerned about selecting occupations that demand the whole of their life. Thus, the perception of the single-minded absorption of computing careers may be less attractive to women and to people of different racial, ethnic, religious, or national backgrounds who desire participation in community (Bell & Nkomo, 2001; Buzzanell & Lucas, 2006). Ironically, computing and other STEM careers may also be perceived as attractive because some women value flexibility and mobility, where work can be done in multiple sites, through virtual and distributed work (Crider & Ganesh, 2004; Gibbs et al., 2008; Hinds & Kiesler, 2002; Hylmö, 2004; Leonardi et al., 2004; Marsh, 2006; Picherit-Duthler et al., 2004), and at different temporal rhythms (Ballard & Gossett, 2006).
The organizational/occupational approach in an organizational perspective opens up discussions about specific organizational practices, occupational cultures, and work–life issues that other lenses consider but do not see as central to the meaning and meaningfulness of STEM work and careers. Understanding how to discursively reframe STEM careers and their associated environments to accommodate work–family and work–life demands offers a challenge to current organizational and family communication studies (Golden, Kirby, & Jorgenson, 2006). Current research on work–life Discourse suggests that the presence of policies is not sufficient for accomplishment of work–life goals, since discursive constructions discouraging their use tend to maintain the status quo even as the presence of official texts suggest their possibilities for work–life balance (Buzzanell & Liu, 2005; Fogg, 2003; Kirby, 2000; Kirby, Golden, Medved, Jorgenson, & Buzzanell, 2003; Kirby & Krone, 2002). Empowering women to take advantage of these work–life policies requires occupational and cultural change as well as acknowledgment of the varied structures and discursive positionings in which careers take place (Buzzanell & Lucas, 2006; Jorgenson, 2002).

Second, the Discourses of career and their association with the meaning and meaningfulness of STEM work deserves note. When status, power, compensation and benefits, and perceived competence are defined by a linear career track with few, if any, interruptions, and when the work requires continual monitoring for technological changes, members establish expectations and Discourses for appropriate forms of occupational membership and work. As such, the rapid change of technological and knowledge skills inherent in STEM careers complicates the issue of work–family balance, where taking a midcareer break makes reentry into the field problematic because of potential skill decay. The most common metaphor used in discussing STEM careers is the pipeline (or even the “leaky pipeline”), which suggests and constrains career trajectories as linear and hierarchical, a pattern typical for traditional middle-class White males but not for lower income, minority, or female members (Buzzanell & Goldzwig, 1991). Alternative career movement metaphors such as “slow burn/apprenticeship,” “multifaceted life-stage responsive,” “Web,” and multichannel careers in which women and men enter full-fledged career commitments later in life or alternate technical or managerial and family work according to life phases. These metaphors promote nonlinear career forms that emphasize personal choice, knowledge, and development (Bailyn, 1989, 2004; Buzzanell & Goldzwig, 1991; Buzzanell & Lucas, 2006; Helgeson, 1990). Reconceptualizing the metaphor of the ideal STEM career to allow for nonlinear and other alternative career models could permit potential employees to align careers with more realistic gendered career experiences and facilitate reentry and skill maintenance even with sabbaticals or parental leaves. Looking at issues of work–family or work–life through the lens of STEM careers encourages communication scholars to recognize even greater complexities in proposed problems and solutions.

Reimagining Science, Technology, and Engineering Work and Careers

A discursive lens on the meaning of work in science, technology, and engineering and associated messages provides insights to the nature, portrayal, and material aspects of college majors, work, and careers in these areas across the globe. Throughout this chapter, we have drawn from communication scholarship including family, lifespan, instructional, media, communication technologies, cultural, feminist, rhetorical, and organizational as well as relevant literature from interdisciplinary scholars to address the underrepresentation of women in STEM careers. We sought to provide a comprehensive review of the multidisciplinary literature on gender and STEM careers and to rearticulate this literature from communicative perspectives on meaningful
work. Thus, this chapter establishes a foundation that intersects work, gender, and technology, providing a springboard for further collaborations between scholars in the communication and STEM disciplines, as well as STEM practitioners.

In framing this piece around d/Discourse, gender, and career, we implicitly acknowledge the underlying tensions of power implicit in this orientation and embrace the transformative opportunities for rearticulating both the meaning and dynamics of STEM work in global contexts (Mumby, 2005). Specifically, in uncovering and acknowledging the incongruities and ambiguities in the d/Discourses of STEM careers, we envision power as discursive, relational, institutionalized, and embedded in the very core of institutions and careers.

By acknowledging d/Discourse and power, we affirm opportunities for resistance. In this chapter, we have discussed both meaningful work as well as occupational identities as sites of resistance (Ashcraft, 2005, 2006)—contesting the nature of work and the meaning of STEM work, challenging it and opening it up for alternative discourses and images, practices in collaboration and culture, and values of meaningful work (e.g., work that is meaningful to community, environment, and global enterprises; see Waugh, 2001). In addition to examining women who leave such occupations as forms of resistance (Allen et al., 2006; Hewlett et al., 2008), we can explore the everyday resistance that women perform during the course of STEM work, including the mundane processes and dialectics (Fleming & Spicer, 2008; Mumby 2005), and the covert and overt practices (Gabriel, 2008) that members perform within specific cultural and sociopolitical contexts and as they negotiate identities (Jorgenson, 2002) within such careers.

Furthermore, by framing this chapter around d/Discourse, we argue that the capacities to understand and acknowledge the power relations and struggles, and transform everyday life and institutions are embedded within communication. Specifically, by focusing on the layers and interdependencies embedded within talk-in-interaction, linguistic choices, and cultural Discourses or formations, we gain understanding not only about how power is used in productive ways, but also how it can be used to transform micropractices and macrostructures through attention to the unfolding of talk—whether in developmental, educational, media, technological, sociocultural, or organizational perspectives—providing a holistic and communication-centered view of gender in STEM work. As such, this chapter goes beyond reviewing related literature to advance an argument for how literature from multiple disciplines can be rearticulated through communicative lenses in a way that foregrounds the distinctive contributions that the field of Communication can bring to the conversation about STEM careers.

In summary, then, research on STEM careers offers broad potential for future communication research. We challenge theorists and researchers in communication to become more fully engaged in communication scholarship that can advance understandings of work and related issues in the STEM disciplines. Communication scholars can contribute to an issue highlighted both nationally and internationally, demonstrating theoretical and practical benefits of a communicative approach as well as potential for programmatic funding. For example, NSF has granted significant funding in the past five years under the ADVANCE program for multidisciplinary research that serves to increase the participation of women in academic STEM careers. Additional programs, such as the Broadening Participation in the STEM initiative, provide funding and incentives for including a more representative population in academic research. Other funding agencies, including the National Institute of Health (NIH), support research addressing issues of underrepresentation not only in work but in the knowledge and research that is produced about and for underrepresented populations.
IMPLICATIONS

This chapter engages broad societal imperatives including technological, gender, organizational, and globalization imperatives. First, both local and global societies are becoming more technological. Individuals, organizations, and countries without access to technology, engineering, and scientific discoveries experience clear disadvantages in access to information but also fail to benefit from the economic, social, educational and other opportunities afforded to those with access. At national and international levels the resources of the STEM disciplines, including an educated workforce, serve as critical drivers for economic and social development in the new knowledge economy.

Second, although this chapter examines gender specifically, research suggests that insights gleaned from patterns of difference among one group may be transferable to others. For example, Carnegie Mellon University investigators found that addressing issues that undermined the retention and graduation of women improved the retention and graduation of cultural minority groups and international students as well (Margolis & Fisher, 2002). Third, technology organizations entail the largest growing sector of many economies and some of the fastest growing professions. The continuing development of STEM disciplines depends on individuals’ abilities to understand collaboration and teamwork, processes for which communication is inherent and critical. Finally, ongoing development of global and multicultural economies rests in large part on communication and technological innovation intersections. Frankel’s (1993) book, *In Pursuit of Technological Excellence: Engineering Leadership, Technological Change, and Economic Development*, provides one foundation for understanding these imperatives. Jorgenson’s (2002) examination of gender and identity negotiations in engineering work shares a communication-oriented view into broader discourses, such as gender, that underlie these societal imperatives.

Generating research that helps us to understand and address the underrepresentation of women in STEM careers constitutes a societal imperative that requires knowledge, inspiration, and collaboration from multiple disciplines both within and outside of communication. These research issues will appeal to communication scholars from a number of disciplines, including family, lifespan, instructional/educational, cultural, media, communication technology, and organizational, as well as the communication of science. The interest in STEM career issues has already launched new research in the communication discipline that considers these questions from the multidisciplinary communicative perspectives underlying this social issue. This research includes examinations of cross-cultural career stories, media representations, the new educational approaches of game studies, collaborative work experiences of nanotechnology scientists, and transnational work–family issues (Jackson, 2008; Jorgenson & Wang, 2008; Kisselburgh et al., 2008; Mastronardi, 2008; Putnam et al., in press; Stoltzfus, 2008). These works exemplify the new articulations possible when communication scholars examine the issue of women in STEM careers and illustrate new avenues of research and interventions that can make an important difference in girls’ interests and choices about education and careers.

Conclusion

In the 20th century, our society was framed by scientific discourse and the orientation of rational, industrialized work. The discourse of this era continues to influence significant sectors of our 21st century society including our court systems, academic institutions, and particularly technological organizations. The 21st century society, however, while still linked to scientific–
rational discourse, is evolving beyond the mechanistic industrial frameworks that characterized work and organizations in the previous century. Innovation, knowledge, connectivity, and global perspectives are the new discourses of this century. Yet, meaningful work continues to be driven by the discursive formations of the past. Specifically, work in STEM careers is still framed by science and technology discourses that are linked to masculine, mechanistic, and rational understandings of what is valued and meaningful to members of our society.

As communication scholars progress in the new millennium, it is essential that researchers examine other rationalities and cultural formations, particularly the d/Discourses of work that are meaningful and valued for members of our global society. In addition to the d/Discourses of efficiency, production, and construction, d/Discourses of design, creativity, and innovation provide new meanings and appeal to broader segments of our populations. These alternative d/Discourses can coexist with existing d/Discourses, create and sustain dialectic tensions that are absent from current d/Discourses, and provide opportunities for transformation. Through this discursive lens, we both rearticulate and reimagine the work and careers of science, technology, and engineering, and broaden the meaning of such work to appeal to both men and women across multiple cultures.

Acknowledgments

The authors express thanks to Christie Beck and to the anonymous reviewers for their many helpful suggestions regarding this chapter. We also thank Rebecca Dohrman for her research assistance during this project.

NOTES

1. Although work is traditionally defined in terms of paid employment, Cheney and colleagues (Cheney et al., 2008; see also Clair, 1996; Medved, this volume) argue for a reconceptualization of work beyond economic contracts to incorporate unpaid employment such as housework, volunteer work, and other forms of hidden labor.
2. Some of the richest reports on institutional level policy and discourse have focused on U.S. STEM concerns (e.g., The Task Force of the Future of American Innovation, 2005; Council on Competitiveness: Innovate America, 2004; Tapping America’s Potential: The Education for Innovation Initiative, 2005). Furthermore, a plethora of summits and conferences, including the 1999 UNESCO World Conference on Science, and the 2003 World Summit on the Information Society, encouraged the development and refinement of STEM policies or initiatives at many educational institutions.
3. Traditionally situated within sociological and psychological perspectives, the study of meaningful work is emerging as an area of interest for communication scholars because of the centrality of meaning to organizational communication specifically and communication more broadly (Cheney et al., 2008; Kuhn et al., 2008; see also recent set of essays in Management Communication Quarterly, 2008, volume 22).
4. There are a growing number of exceptions to these television and film narratives, including The Suite Life of Zach and Cody, High School Musical, and the gender neutral portrayals of females in Hackers and The Matrix, that suggest a potential shift in portraying and heralding female characters for their intelligence, work ethic, and ambition. Additional research from media scholars is needed to assess whether such counter narratives are exceptions or reflect cultural shifts, and the effect these messages have on occupational identification and identity construction of teenage girls.
5. The term sexy is used in this context to denote something that is trendy, attractive, and exciting, rather than something with sexual connotations (Merriam-Webster Online Dictionary, 2008).
6. Notice the construction of an acronym decidedly different from what one would expect of a science and technology program. This strategic use conveys an image that attracts new learners to an unexpected environment.
7. There are exceptions, and the work of Sheri Graner Ray (2003) and the NSF-funded Project IT Girl (http://wiki.laptop.org/go/Project_IT_Girl) in Austin, Texas are exemplars.
8. Although there are multiple definitions of class, in this work we define class according to economic delineations, distinct from cultural delineations of class used in India (Subrahmanyan, 1998).
9. Tests were designed to be free of cultural bias, by the Organisation for Economic Co-operation and Development (OECD).
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