Using the Lens of Social Capital to Understand Diversity in the Earth System Sciences Workforce

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ABSTRACT

In this commentary, we argue that social capital theory, the idea that membership in a group creates opportunities to acquire valuable information and resources from other group members, is a useful framework in which to consider ways to increase diversity in the Earth System Sciences (ESS) and in the science, technology, engineering, and mathematics fields more broadly. Existing literature documents numerous barriers to underrepresented groups' participation in the sciences. These include a sense of isolation, a lack of visible role models, and a lack of trust in mentors or teachers. We discuss how these challenges impact acquisition of social capital and how lack of social capital affects career success and satisfaction. We conclude with recommendations for increasing diversity in the ESS through careful attention to building trustworthy professional relationships. In particular, the community should (1) recognize that trust must be built in order for students to feel connected to the larger community; (2) provide explicit guidance to students on different types of ties, how to build each type, and the value of each type in career development; and (3) train professionals to recognize their own social capital and best practices for imparting capital to students. © *2015 National Association of Geoscience Teachers*. [DOI: 10.5408/15-083.1]

Key words: social capital, diversity, STEM workforce

INTRODUCTION

The Earth System Sciences (ESS) fields in the United States face a workforce shortage (Wilson, 2014). While an 11% increase in career opportunities in general is expected over the next decade, the ESS is likely to see an even greater increase of 16% (Bureau of Labor Statistics [BLS], 2014). Although other sciences are beginning to equalize the number of workers available to fill critical openings in science, technology, engineering, and mathematics (STEM), the ESS continues to lag in recruitment, retention, and advancement of skilled workers from diverse populations (Olson and Riordan, 2012; Mosher et al., 2014; Wilson, 2014). This persistent workforce shortage is a significant problem recognized by the geoscience community (Wilson, 2014) and is one for which solutions are actively being sought. For example, the National Science Foundation (NSF, 2015) has just announced a new solicitation for proposals that seek to increase enrollment in geoscience degree programs.

Discussions of the workforce shortage in the ESS, and in STEM disciplines more generally, often focus on recruitment and retention of undergraduate students (Velasco and de Valasco, 2010), as well as training of K–12 science teachers (Mosher et al., 2014). In the past, these strategies have included programs that provide students with opportunities to conduct research while earning their undergraduate degrees (Seymour et al., 2004; Hunter et al., 2007; Judge et al., 2012); programs that pair undergraduates, graduate students, and early-career professionals from underrepresented groups with mentors (Callahan et al., 2001; Muller et al., 2012); and programs that focus on the transition from high school to college (Gonzales and Keane, 2010; Dunn et al., 2012). Participating students frequently report that these experiences provide insight into what it is like to be a scientist and encourage future enrollment in science programs (Seymour et al., 2004; Hunter et al., 2007). We suggest that a common underpinning of research experiences for undergraduates (REUs) and mentoring programs is the model of cognitive apprenticeship in a community of practice (Brown et al., 1989; Lave and Wenger, 1991).

Scientific communities are structured by the paradigms under which they operate (Kuhn, 1962). A paradigm guides the methodologies used, as well as the problems studied, in a given discipline (e.g., Lukes et al., 2015). Cognitive apprenticeship conceives that students acquire knowledge of practices of a science through learning by direct example from a mentor (Brown et al., 1989; Farmer et al., 1992). The cognitive apprenticeship model, consequently, focuses on the socialization of students into an existing community with its own traditions and vocabulary (Lave and Wenger, 1991). Research that explores career satisfaction once students enter the STEM workforce is less extensive (Wachs and Nemiro, 2007; Callister et al., 2009; Ucol-Ganiron and Malvecino-Ganiron, 2012). For example, in the recent Summit on the Future of Undergraduate Geoscience Education (Mosher et al., 2014), recommendations related to meeting workforce needs and broadening participation in the discipline largely highlight programmatic efforts consistent with cognitive apprenticeship in a community of practice (e.g., REU programs for students at 2-y colleges and mentoring programs for underrepresented minorities).

The recommendations in the summit report also mention the importance of educating faculty on issues of diversity in the discipline (Mosher et al., 2014) and explicitly

Received 26 January 2015; revised 25 March 2015; accepted 26 March 2015; published online 13 May 2015.
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refer to problems such as "stereotype threat" (i.e., believing oneself to confirm negative stereotypes about a group of which one is a member) and "imposter syndrome" (i.e., believing oneself not to be competent despite past success or accomplishments). These issues are significant because they bring to the fore a limitation of the cognitive apprenticeship model: membership hinges on possessing knowledge of the norms within the community, but for some that knowledge is not an easy commodity to obtain or sustain.

We suggest that the workforce-shortage problem in the ESS might be more fully understood through the lens of social capital and through an analysis of the role that relationships play in career development and success in the ESS. Social capital theory, the idea that membership in a group creates opportunities to acquire valuable information and resources from other group members, is a useful theoretical framework for workforce analysis, because social capital asks how individuals benefit from different types of social ties and networks in their professional lives. Social capital theory has been applied to fields such as business (Tharenou, 1999) and less commonly to STEM (Ucol-Ganiron and Malvecino-Ganiron, 2012). It has also been used to study different populations of interest within STEM, including underrepresented groups (Foor et al., 2007; Whitney et al., 2011). Various researchers in the United States have found that underrepresented populations are less likely than others to benefit from relationships that impart significant amounts of social capital (Etzkowitz et al., 2000; Potts, 2005; Foor et al., 2007), potentially contributing to the lack of diversity in some STEM fields. Scholars across the globe have made similar claims (Gray et al., 2007; Broadbridge, 2010). For example, Broadbridge (2010) found that women senior-level managers in the United Kingdom and Ireland are less likely than men to accumulate social capital for career development purposes.

In the literature, the persistent lack of diversity in any of the STEM disciplines is commonly coupled with concern over workforce needs (National Academy of Sciences [NAS], 2011; Fealing and Myers, 2012; Daily and Eugene, 2014). Most often, the underrepresented groups of interest are women and minorities; less frequently, consideration is also given to socioeconomic status, disability status, or sexual/gender orientation (NAS, 2011; National Research Council [NRC], 2013; Patridge et al., 2014). Each of these groups is underrepresented in the sciences and particularly in the ESS. We argue that social capital theory can (1) help us recognize barriers these groups face to entering the ESS and the STEM disciplines more broadly and (2) provide a useful construct for motivating future research efforts.

SOCIAL CAPITAL THEORY AND CAREER SUCCESS

Social capital has been recognized for more than 40 y as an important construct in understanding what influences career success and satisfaction, collaborations among workers, employment opportunities, and compensation (Adler and Kwon, 2002). Although scholars may differ slightly in their perspectives on social capital, they agree that this resource can be acquired through relationships (Bourdieu, 1986; Coleman, 1988; Putnam, 1993). Individuals within a group—members of a family or even a community—are expected to share privileged information and resources in order to better the lives of all members. Through the sharing of this knowledge, group members exchange social capital.

However, social capital theory is not absent of critique. Dika and Singh (2002), Grenfell and James (1998), and other authors argue that the concept of social capital is often not clearly defined in research studies, leaving a gap in our understanding of what social capital is and how it should be measured (Halpern, 2005). In the context of this paper, we favor Coleman's (1988) conceptualization of social capital, which focuses on sharing of resources between individuals (Putnam, 1993). Unlike earlier advocates of the concept (e.g., Bourdieu, 1986), Coleman (1988) also argues that social capital exists in all communities, regardless of wealth or privilege; indeed, social capital has been identified in the context of poor and marginalized groups across disciplines (Coleman, 1988).

The amount of information shared and received by individuals in a group is often regulated by the amount of trust inherent to relationships between individuals, as well as the expectations, obligations, and social norms that are observed and maintained by group members (Coleman, 1988). Relationships with family, friends, and close coworkers are referred to as "strong" ties or "bonding" networks (Granovetter, 1973). Strong ties tend to provide individuals with frequent and intense personal and professional support from people with whom they share commonalities (Granovetter, 1973; Levin and Cross, 2004). Individuals within bonding networks commonly share trust that is benevolence based (where individuals believe others care about their general well-being), as well as trust that is competence based (where individuals believe others hold positions for which they are qualified; Levin and Cross, 2004). By comparison, relationships with acquaintances, associates, and higher-level managerial staff are often referred to as "weak" ties or "bridging" relationships (Granovetter, 1973). These relationships are less intense than strong ties but are frequently considered more valuable because they provide access to information, people, and resources that would otherwise be inaccessible (Levin and Cross, 2004). Weak ties also include benevolence-based trust, but competence-based trust is essential for weak ties to be beneficial (Levin and Cross, 2004). All ties, however, require some amount of trust, and trust requires a willingness to be vulnerable (Fig. 1; Mayer et al., 1995; Hezlett and Gibson, 2007).

The concept of social capital is being adopted more widely as scholars across a variety of fields attempt to understand the value of social ties. This is especially true for scholars interested in the role of social capital in career success, where both strong and weak ties are recognized as important for career-related outcomes (Bridges and Villemez, 1986; McPherson et al., 1992; Seibert et al., 2001; Adler and Kwon, 2002; Zhang et al., 2010). Seibert et al. (2001) integrated conceptualizations of social capital theory with research on career-related outcomes and determined that the number of weak ties that an individual has correlates positively with the number of career-related resources available to that individual. While both strong and weak ties are necessary for career success, weak ties

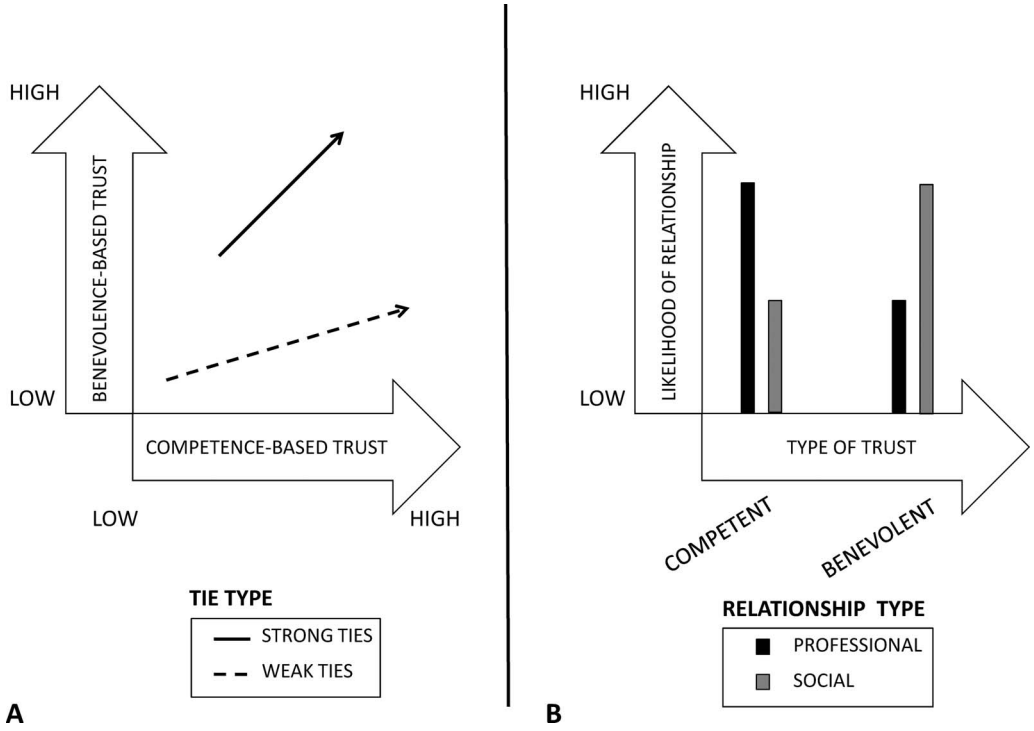

FIGURE 1: Characteristics of social capital. (a) Relationship between tie type and trust. While both benevolence- and competence-based trust can be present for strong and weak ties, strong ties require significant benevolence. (b) Relationship between trust and relationships. Competence-based trust is mostly found in professional relationships, while benevolence-based trust is mostly found in social relationships.

are more closely associated with career-relevant information that is difficult to obtain, such as strategies for obtaining promotions or salary increases (Seibert et al., 2001; Levin and Cross, 2004).

In the book *Lean In,* Sheryl Sandberg (2013) devotes a chapter to her thoughts on different kinds of mentoring relationships, and although it was not Sandberg's explicit intent, her discussion provides us with concrete examples of network ties. She recounts the number of times that women who are just starting in their careers have asked her to be their mentor, often mere minutes after being introduced. She bemoans the question. In part, she sees it as a reflection that too often women are focused on finding a mentor who will adopt a guardian-like role in their careers. The characteristics ascribed to these mentors align well with benevolence-based, strong ties. Sandberg contrasts such instances of unrealistic expectations placed upon her with times when she has willingly provided discrete pieces of information when asked specific questions. In those cases, often involving junior male colleagues or acquaintances, she did not feel encumbered with a duty to be a benevolent resource or confidant. Rather, she was acting primarily as a competent weak tie.

In general, then, social capital is understood to have an important influence on employment, resource exchange, entrepreneurship, and overall career success (Seibert et al., 2001; Adler and Kwon, 2002; Levin and Cross, 2004). Weak ties provide access to resources and information, while strong ties provide social support needed during times of change or stress. Notably, the relative importance of weak versus strong ties for career success is still unclear (Bridges and Villemez, 1986; McPherson et al., 1992), and the debate among scholars is prevalent in the United States and across the globe (Anticliff et al., 2007; Gray et al., 2007).

DIVERSITY IN STEM AND BARRIERS TO ACQUIRING SOCIAL CAPITAL

STEM disciplines are widely recognized as relatively nondiverse (NAS, 2011; NSF, 2013). Within the ESS, organizations in the United States, such as the Geological Society of America (GSA, 2013) and the American Geophysical Union (AGU, 2002), as well as organizations abroad, such as the Geological Society of London (GSL, 2014), have published position statements articulating their concerns about the lack of diversity in the discipline and their interest in expending more effort on the issue. A common refrain running through these statements and other studies is that recruiting and retaining members of underrepresented groups will help address anticipated workforce needs in the years ahead (Foor et al., 2007; Perna et al., 2009; NAS, 2011; NRC, 2013; White and Mitchell, 2013; Daily and Eugene, 2014). The argument supposes that in order to meet labor demands, the community needs to draw from a larger pool of potential employees (Atkinson and Mayo, 2010; Gonzales and Keane, 2010; Velasco and de Velasco, 2010). Attention to increasing diversity in the ESS arises also from a concern that the diversity of its workforce should more closely reflect the diversity of the larger population (AGU, 2002; Velasco and de Velasco, 2010; GSA, 2013; GSL, 2014). To

this end, several decades of effort intent on recruiting and retaining women and underrepresented groups into the ESS have had some success, albeit generally on a small scale (Velasco and de Velasco, 2010).

For women in STEM careers, a foremost challenge and source of dissatisfaction is a sense of professional isolation (Olsen et al., 1995; Wachs and Nemiro, 2007; Xu, 2008; Callister et al., 2009). In academic science, female faculty members labor under disproportionate workloads as they are commonly tasked with service duties that male colleagues are unwilling to do or are uninterested in doing; these tasks are sometimes equated with a kind of "mothering" role that women are expected to take on within departments (Wachs and Nemiro, 2007; Blackwell et al., 2009; Callister et al., 2009). Male faculty members who manage to be unencumbered with extra responsibilities at work have the time to develop social and professional networks that contribute to their careers (Callister et al., 2009; Holleran et al., 2010). With added time constraints, women struggle to acquire valuable social capital ties that would help support and move their careers forward.

A different kind of isolation imposed on underrepresented groups in STEM disciplines leads to experiences that undermine a sense of belonging (Etzkowitz et al., 2000; Noonan et al., 2004; Foor et al., 2007; Hurtado et al., 2007; Blackwell et al., 2009; Dunn et al., 2012). One example of this is the oft-noted lack of visible role models for women, minorities, and individuals with disabilities in STEM organizations or academic departments (Noonan et al., 2004; Foor et al., 2007; Zeldin et al., 2008; Dunn et al., 2012). This absence has the potential to raise doubts among young scientists and engineers in those underrepresented groups about their ability to succeed: Why would they succeed if others like them have not? Negative racial stereotypes encountered by underrepresented minority students majoring in STEM disciplines can be a significant deterrent to their persistence (Ream et al., 2014). For these students, such experiences perpetuate a sense of their otherness relative to the majority. In the parlance of social capital, we argue that instances that foster a perceived lack of belonging have implications for trust in relationships. Without confidence that others care about their success or see them as capable, members of underrepresented groups seem in danger of accruing deeper distrust in the community; instead, they should be acquiring social capital as members of the community.

The value of social capital as a theoretical framework for understanding the impact of exclusion or inclusion of diverse groups in STEM is particularly well exemplified in two case studies. First, Foor et al. (2007) reported the experiences of a first-generation, economically disadvantaged, multiminority, female undergraduate engineering student. Given the pseudonym Inez, the student recounted how one of her professors, in response to her struggling in her course and asking for help, explicitly discouraged her from proceeding with her plan to be an engineer. When asked during her interview if she had any advice for faculty members, Inez replied, "Try to make people feel more welcome. I never felt like I was welcome" (Foor et al., 2007, 113). Second, Ream et al. (2014) focused on a program titled, Minority Access to Research Careers, Undergraduate Student Training in Academic Research (MARC-U*STAR), in which minority students majoring in biological or physical sciences worked with mentors during their junior and senior years of college. The purpose of the study was to investigate the impact of students' trust in their mentors on students' motivation and career expectations. Notably, students enrolled in the MARC-U*STAR program had significantly higher levels of trust in their mentors, both at the outset of the mentoring relationship and at the end, than did mentored students (most of whom were not minorities) who had not gone through the program. Ream et al. (2014) suggested that one implication of this finding is that mentored students not in the program did not have a history of feeling uneasy in the STEM community; consequently, not being in the program made little difference to them in terms trust in academic mentors. We propose that perhaps the faculty members in the MARC-U*STAR program were able to do what Inez's physics professor was not: "make people feel more welcome."

In summary, a sense of isolation, lack of role models, and lack of trusting relationships are only examples of the kinds of barriers members of underrepresented groups face in obtaining social capital. Our intent was not to be comprehensive. Rather, we used these examples because they emphasize the ways in which career success hinges substantially on different kinds of trustworthy connections. If someone is missing these relationships, it seems to be that much harder to enter a career and become a valuable member of the community.

SUMMARY AND RECOMMENDATIONS

Past initiatives to diversify the ESS workforce have been aimed largely at increasing graduation rates across genders (Holmes et al., 2008) and races or ethnicities (Callahan et al., 2001; Velasco and de Velasco, 2010; O'Connell and Holmes, 2011). Recent efforts have also expanded awareness about including more students with disabilities in the ESS (Locke, 2005; Atchison and Martinez-Frias, 2012; Atchison and Libarkin, 2013). This collective attention to diversity in the ESS suggests that the community may be ready for more focused efforts to challenge structures that may inadvertently inhibit participation and to introduce mechanisms that could be put in place to allow greater access. Drawing upon social capital as a theoretical framework, we make the following suggestions for efforts to diversify the ESS workforce:

1. Pay attention to trust and the vulnerability it implies. A relationship between two individuals where there is competence-based trust means that each person considers the other capable; a relationship between two individuals where there is benevolence-based trust means that each person cares about the other person's well being. For some members of underrepresented groups, past experiences may mean that they hesitate to make themselves vulnerable through trusting others. Mentors especially must build trusting relationships in order to ensure students feel connected to the STEM community.
2. Provide explicit guidance to students on different types of ties and how to build them. Weak ties can be valuable resources for obtaining discrete pieces of information. Strong ties may prove beneficial for

career development and satisfaction in the long term. Appreciating the differences that exist between these two types of ties can help focus students' career development efforts.

3. Provide guidance to professionals in the ESS community about the social capital they can offer to students and colleagues. Mentors may not recognize that access to networks, opportunities for information exchange, and trust development can be as important for student development as research or career mentoring.

In conclusion, we note an analogy invoked by Foor et al. (2007) in their discussion of the case study of Inez. The authors proposed that efforts intent on increasing diversity could benefit from thinking about the computer-programming term "bootstrapping." The term refers to the fact that computers cannot simply go from being turned off to being on and ready to use. Computers are programmed to initiate internal processes before becoming ready for use:

> *"[Computers] take a simple set of instructions (or, in human terms, resources or capital) and repeatedly use these to locate more numerous, powerful, and useful instructions.... We need to help disadvantaged students effectively utilize their meager capital resources to locate and acquire the additional social, cultural, and symbolic capital resources needed to excel."* (Foor et al., 2007, 113)

In essence, Foor et al. (2007) argued that even small amounts of social capital are valuable; what matters is how it is put to use. If we want to meet the current and forthcoming workforce demands in the ESS, we need increased communitywide sensitivity to the power of relationships and an appreciation of the potential social capital that comes with diverse experiences and views.

REFERENCES

Adler, P.S., and Kwon, S. 2002. Social capital: Prospects for a new concept. *Academy of Management Review,* 27(1):17–40.

American Geophysical Union (AGU). 2002. AGU diversity plan. Available at http://education.agu.org/diversity-programs/agu-diversity-plan/ (accessed 23 March 2015).

Antcliff, V., Saundry, R., and Stuart, M. 2007. Networks and social capital in the UK television industry: The weakness of weak ties. *Human Relations,* 60(2):371–393.

Atchison, C.L., and Libarkin, J.C. 2013. Fostering accessibility in geoscience training programs. *EOS, Transactions American Geophysical Union,* 94(44):400–401.

Atchison, C.L., and Martinez-Frias, J. 2012. Inclusive geoscience instruction. *Nature Geoscience,* 5:366. doi:10.1038/ngeo1487.

Atkinson, R.D., and Mayo, M. 2010. Refueling the U.S. innovation economy: Fresh approaches to science, technology, engineering and mathematics (STEM) education. Washington, DC: Information Technology and Innovation Foundation.

Blackwell, L.V., Snyder, L.A., and Mavriplis, C. 2009. Diverse faculty in STEM fields: Attitudes, performance, and fair treatment. *Journal of Diversity in Higher Education,* 2(4):195–205. doi:10.1037/a0016974.

Bourdieu, P. 1986. Forms of capital. *In* Richardson, J.G., eds., Handbook of theory in research for the sociology of education. New York: Greenwood Press, p. 241–258.

Bridges, W.P., and Villemez, W.J. 1986. Informal hiring and income in the labor market. *American Sociological Review,* 51:574–582.

Broadbridge, A. 2010. Social capital, gender and careers: Evidence from retail senior managers. *Equity, Diversity and Inclusion: An International Journal,* 29(8):815–834.

Brown, J.S., Collins, A., and Duguid, P. 1989. Situated cognition and the culture of learning. *Educational Researcher,* 18(1):32–42.

Bureau of Labor Statistics (BLS), U.S. Department of Labor. 2015. Occupational outlook handbook, 2014–15 edition: Geoscientists. Available at http://www.bls.gov/ooh/life-physical-and-social-science/geoscientists.htm (accessed 29 January 2014).

Callahan, C.N., Byerly, G., and Smith, M. 2001. The American Geological Institute Minority Participation Program (MPP): Thirty years of improving access to opportunities in the geosciences through undergraduate and graduate scholarships for under-represented minorities. *In* Paper presented at the American Geophysical Union Spring Meeting, Boston, MA, abstract ED21D-04.

Callister, R.R., Minnotte, K.L., and Sullivan, K.A. 2009. Understanding gender differences in job dissatisfaction among science and engineering faculty. *Journal of Women and Minorities in Science and Engineering,* 15:223–243.

Coleman, J. 1988. Social capital in the creation of human capital. *American Journal of Sociology,* 94:S95–S120.

Daily, S.B., and Eugene, W. 2014. Preparing the future STEM workforce for diverse environments. *Urban Education,* 48(5):682–704. doi:10.1177/0042085913490554.

Dika, S.L., and Singh, K. 2002. Applications of social capital in educational literature: A critical synthesis. *Review of Educational Research,* 72(1):31–60.

Dunn, C., Rabren, K.S., Taylor, S.L., and Dotson, C.K. 2012. Assisting students with high-incidence disabilities to pursue careers in science, technology, engineering, and mathematics. *Intervention in School and Clinic,* 48(1):47–54. doi:10.1177/1053451212443151.

Etzkowitz, H., Kemelgor, C., and Uzzi, B. 2000. Athena unbound: The advance of women in science and technology. Cambridge, UK: Cambridge University Press.

Farmer, J.A., Buckmaster, A., and LeGrand, B. 1992. Cognitive apprenticeship: Implications for continuing professional development. *New Directions for Adult and Continuing Education,* 55:41–49.

Fealing, K.H., and Myers, S.L.J. 2012. Pathways pipelines to broadening participation in the STEM workforce. Paper presented at the Southern Economic Association Meeting, Washington, DC. Available at http://papers.ssrn.com/sol3/papers.cfm?abstract_id=2020504 (accessed 29 January 2014).

Foor, C.E., Walden, S.E., and Trytten, D.A. 2007. "I wish that I belonged more in this whole engineering group:" Achieving individual diversity. *Journal of Engineering Education,* 96(2):103–115.

Geological Society of America (GSA). 2013. Diversity in the geosciences community. Available at http://www.geosociety.org/positions/position15.htm (accessed 23 March 2015).

Geological Society of London (GSL). 2014. Science council declaration on diversity, equality and inclusion. Available at http://www.geolsoc.org.uk/About/Diversity/Declaration-on-Diversity-Equality-and-Inclusion (accessed 23 March 2015).

Gonzales, L.M., and Keane, C.M. 2010. Who will fill the geoscience workforce supply gap? *Environmental Science and Technology,* 44(2):550–555. doi:10.1021/es902234g.

Granovetter, M.S. 1973. The strength of weak ties. *American Journal of Sociology,* 78(6):1360–1380.

Gray, M., Kurihara, T., Hommen, L., and Feldman, J. 2007. Networks of inclusion: Job segmentation and social networks in the knowledge economy. *Equal Opportunities International,* 26(2):144–161.

Grenfell, M., and James, D. 1998. Bourdieu and education: Acts of practical reason. London, UK: Farmer Press.

Halpern, D. 2005. Social capital. Malden, MA: Polity Press.

Hezlett, S.A., and Gibson, S.K. 2007. Linking mentoring and social

capital: Implications for career and organization development. *Advances in Developing Human Resources,* 9(3):384–411. doi:10.1177/1523422307304102.

Holleran, S.E., Whitehead, J., Schmader, T., and Mehl, M.R. 2010. Talking shop and shooting the breeze: A study of workplace conversation and job disengagement among STEM faculty. *Social Psychological and Personality Science,* 2Z:65–71. doi:10.1177/1948550610379921.

Holmes, M.A., O'Connell, S., Frey, C., and Ongley, L. 2008. Gender imbalance in U.S. geoscience academia. *Nature Geoscience,* 1:79–82. doi:10.1038/ngeo113.

Hunter, A., Laursen, S.L., and Seymour, E. 2007. Becoming a scientist: The role of undergraduate research in students' cognitive, personal, and professional development. *Science Education,* 91:36–74. doi:10.1002/sce.

Hurtado, S., Han, J.C., Sáenz, V.B., Espinosa, L.L., Cabrera, N.L., and Cerna, O.S. 2007. Predicting transition and adjustment to college: biomedical and behavioral science aspirants' and minority students' first year of college. *Research in Higher Education,* 48(7):841–887. doi:10.1007/s11162-007-9051-x.

Judge, S., Pollock, M., Wiles, G., and Wilson, M. 2012. Mentored undergraduate research in the geosciences. *EOS, Transactions American Geophysical Union,* 93(36):345–347.

Kuhn, T. 1962. The structure of scientific revolutions. Chicago, IL: University of Chicago Press.

Lave, J., and Wenger, E. 1991. Situated learning: Legitimate peripheral participation. Cambridge, MA: Cambridge University Press.

Levin, D.Z., and Cross, R. 2004. The strength of weak ties you can trust: The mediating role of trust in effective knowledge transfer. *Management Science,* 50(11):1477–1490. doi:10.1287/mnsc.1030.0136.

Locke, S. 2005. The status of persons with disabilities in the geosciences. Paper presented at the Regional Alliance for Science, Engineering, and Mathematics Squared ($RASEM^2$) Symposium. Las Cruces, NM: New Mexico State University.

Lukes, L.A., LaDue, N.D., Cheek, K.A., Ryker, K., and St. John, K. 2015. Creating a community of practice around geoscience education research: NAGT-GER. *Journal of Geoscience Education,* 63:1–6.

Mayer, R.C., Davis, J.H., and Schoorman, F.D. 1995. An integrative model of organizational trust. *Academy of Management Review,* 20(3):709–734.

McPherson, J.M., Popielarz, P.A., and Drobnic, S. 1992. Social networks and organizational dynamics. *American Sociological Review,* 57:153–170.

Mosher, S., Bralower, T., Huntoon, J., Lea, P., McConnell, D., Miller, K., Ryan, J., Summa, L., and Villalobos, J. 2014. Summary report for summit on future of undergraduate geoscience education. Available at http://www.jsg.utexas.edu/events/files/Future_Undergrad_Geoscience_Summit_report.pdf (accessed 23 March 2015).

Muller, C., Blake-Beard, S., Barsion, S.J., and Wotipka, C.M. 2012. Learning from the experiences of women of color in MENTORNET's one-on-one program. *Journal of Women and Minorities in Science and Engineering,* 18(4):315–335.

National Academy of Sciences (NAS). 2011. Expanding underrepresented minority participation: America's science and technology talent at the crossroads, Committee on Underrepresented Groups and the Expansion of the Science. Washington, DC: National Academies Press.

National Research Council (NRC). 2013. Preparing the next generation of earth scientists: An examination of federal education and training programs. Washington, DC: National Academies Press.

National Science Foundation (NSF). (2013). Women, minorities, and persons with disabilities in science and engineering: 2013. Special Report NSF 13–304. Arlington, VA: National Center for Science and Engineering Statistics. Available at http://www.nsf.gov/statistics/wmpd/ (accessed 29 January 2014).

National Science Foundation (NSF). (2015). Improving undergraduate STEM education: pathways into geoscience. Program NSF 15–526. Available at http://www.nsf.gov/pubs/2015/nsf15526/nsf15526.htm (accessed 25 March 2015).

Noonan, B.M., Gallor, S.M., Hensler-McGinnis, N.F., Fassinger, R.E., Wang, S., and Goodman, J. 2004. Challenge and success: A qualitative study of the career development of highly achieving women with physical and sensory disabilities. *Journal of Counseling Psychology,* 51(1):68–80. doi:10.1037/0022–0167.51.1.68.

O'Connell, S., and Holmes, M.A. 2011. Obstacles to recruitment of minorities into geosciences: A call to action. *GSA Today,* 21(6):52–54.

Olsen, D., Maple, S.A., and Stage, F.K. 1995. Women and minority faculty job satisfaction. *Journal of Higher Education,* 66(3):267–293.

Olson, S., and Riordan, D.G. 2012. Engage to excel: Producing one million additional college graduates with degrees in science, technology, engineering, and mathematics. Report to the President. Washington, DC: Executive Office of the President.

Patridge, E.V., Barthelemy, R.S., and Rankin, S.R. 2014. Factors impacting the academic climate for LGBQ STEM faculty. *Journal of Women and Minorities in Science and Engineering,* 20(1):75–98. doi:10.1615/JWomenMinorScienEng.2014007429.

Perna, L., Lundy-Wagner, V., Drezner, N.D., Gasman, M., Yoon, S., Bose, E., and Gary, S. 2009. The contribution of HBCUS to the preparation of African American women for stem careers: A case study. *Research in Higher Education,* 50:1–23. doi:10.1007/s11162-008-9110-y.

Potts, B. 2005. Disability and employment: Considering the importance of social capital. *Journal of Rehabilitation,* 71(3):20–25.

Putnam, R.D. 1993. The prosperous community: Social capital and public life. *American Prospect,* 13:35–42.

Ream, R.K., Lewis, J.L., Echeverria, B., and Page, R.N. 2014. Trust matters : Distinction and diversity in undergraduate science education. *Teachers College Record,* 116(May):1–50.

Sandberg, S. 2013. Lean in: Women, work, and the will to lead. New York: Alfred A. Knopf.

Seibert, S.E., Kraimer, M.L., and Liden, R.C. 2001. A social capital theory of career success. *Academy of Management Review,* 44(2):219–237.

Seymour, E., Hunter, A.-B., Laursen, S.L., and DeAntoni, T. 2004. Establishing the benefits of research experiences for undergraduates in the sciences: First findings from a three-year study. *Science Education,* 88(4):493–534. doi:10.1002/sce.10131.

Tharenou, P. 1999. Gender differences in advancing to the top. *International Journal of Management Reviews,* 1(2):111–132.

Ucol-Ganiron, T., and Malvecino-Ganiron, T. 2012. Social capital on civil engineer career success. *International Journal of Innovation, Management, and Technology,* 3(6):718–724. doi:10.7763/IJIMT.2012.V3.326.

Velasco, A.A., and de Velasco, E.J. 2010. Striving to diversify the geosciences workforce. *EOS, Transactions American Geophysical Union,* 91(33):289–291.

Wachs, F.L., and Nemiro, J. 2007. Speaking out on gender: Reflections on women's advancement in the STEM disciplines. *Journal of Women and Minorities in Science and Engineering,* 13(1):77–94. doi:10.1615/JWomenMinorScienEng.v13.i1.40.

White, J.L., and Mitchell, S.K. 2013. Career certainty and persisting interest in STEM: An analysis of underrepresented groups. *Journal of Women and Minorities in Science and Engineering,* 19(1):47–66.

Whitney, J., Langley-Turnbaugh, S., Lovewell, L., and Moeller, B. 2011. Building relationships, sharing resources, and opening opportunities: A STEM learning community builds social

capital for students with disabilities. *Journal of Postsecondary Education and Disability,* 25(2):131–144.

Wilson, C. 2014. Status of geoscience workforce. Alexandria, VA: American Geosciences Institute.

Xu, Y.J. 2008. Gender disparity in STEM disciplines: A study of faculty attrition and turnover intentions. *Research in Higher Education,* 49(7):607–624.

Zeldin, A.L., Britner, S.L., and Pajares, F. 2008. A comparative study of the self-efficacy beliefs of successful men and women in mathematics, science, and technology careers. *Journal of Research in Science Teaching,* 45(9):1036–1058. doi:10.1002/tea.20195.

Zhang, L., Liu, J., Loi, R., Lau, V.P., and Ngo, H. 2010. Social capital and career outcomes: A study of Chinese employees. *International Journal of Human Resource Management,* 21(8):1323–1336.