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# Trust Matters: Distinction and Diversity in Undergraduate Science Education

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**Background:** *How do we account for the persistent difficulty the U.S. community of science has in educating larger numbers of talented and diverse undergraduates? We posit that the problem lies in the community's unrelenting focus on scientific subject matter knowledge and students' ability to learn, to the neglect of interpersonal social relations—particularly trust. Our study focuses on trust in academic mentoring. This topic is particularly relevant in studies of the undergraduate segment of the pipeline into science that typically occurs in large, impersonal settings that often generate student alienation. Our study hypothesizes that trustworthy relations may be both a significant condition for academic mentoring as well as an important outcome.*

**Purpose:** *The study we report explores the promise of a new research direction in undergraduate science education, one focused on trust in academic mentoring. A focus on interpersonal trust is unusual, if not entirely overlooked, in most studies of undergraduate science education, and stands in sharp contrast to the situation in K–12 education where an emergent body of survey and field research measures trust and documents its educational importance. Our framework derives from social capital theory and cautions that a science curriculum that informs and motivates entails attention not only to cognition, as indicated by subject matter knowledge, but also to the educational significance of other complex forms of cognition that undergird social skill, relational awareness, and the development and maintenance of trust.*

**Research Design:** *Because the MARC-U\*STAR training program funded by the National Institutes of Health sponsors only a select number of talented upper division science major students on each host campus, our correlational analyses were based on a unique and relatively small sample of data collected from undergraduate science major students (N=161) in 16 colleges and universities in the Pacific Southwest. We analyzed the data in two linked parts: (a) an analysis of the association between trust and motivation; and (b) an evaluation*

*of whether the Program affects trust. We link the two parts by using the same longitudinal dataset in each and, further, by building the evaluation on the findings from models that compare trust and motivation among upper division science major students enrolled in the Program (n=49) with trust and motivation among upper division science major students not in the Program (n=112). Given the study's exploratory purpose and design limits, we situate the results near the front end of the continuum from preliminary studies designed to suggest further research directions to the kinds of precise predictions we can expect from truly randomized controlled experiments.*

**Findings:** *Despite its necessarily preliminary findings regarding trust, this study contributes to the literature on academic mentoring in undergraduate science education in several ways. First, our study develops a novel conceptual perspective on the measure and utility of trust as a crucial form of social capital. Second, we used this perspective to develop a set of structural models that suggest interpersonal trust is producible in undergraduate science education; is pedagogically powerful, not a mere nicety; and is particularly important for students who are members of groups historically underrepresented in the sciences. Third, and surprising because the literature on trust does not prepare for them, are results suggesting that trust may work differently for different groups of students in different contexts.*

**Conclusions/Recommendations:** *Our findings are unusual and encouraging, and they bring several issues to light regarding (a) the utility of theory in research and practice in undergraduate science education, (b) inequitable representation in the sciences, and (c) contextual complexities that condition the development and maintenance of trust within institutional settings. First, our framework on trust derives from social capital theory and cautions that a science curriculum that informs and motivates entails attention not only to cognition but also to the educational significance of other complex forms of cognition that undergird social skill, relational awareness, and the development and maintenance of trust. In cognitively and socially consequential exchanges in undergraduate science education, trust and mistrust are important. Next, our most unusual finding—that trust in a mentor seems to matter more for the motivation and career expectations of the MARC-U\*STAR Program students than for non-Program students—raises the question: How does trust in a university mentor matter for equitable undergraduate education in science? With our data, we cannot fully account for this unexpected finding. Drawing from studies that disentangle the concept of interpersonal trust from more generalized notions of trust in the social environment, we have worked at a tentative interpretation: Perhaps interpersonal trust is especially impactful in situations where the more general social environment poses perceptible threats. Last, when the literature on trust is examined concurrently with our findings, trust emerges not as an invariant entity, but as supremely contextualized. We conclude by calling for a more expansive, multidisciplinary, and multimethod research agenda focused on trust, which may contribute to a reorientation of undergraduate science education.*

For more than half a century, federal attention in the United States has been directed at strengthening the scientific and technological labor force using reforms in STEM (science, technology, engineering, and mathematics) education. Despite significant infusions of public resources, however, efforts to increase the number, competitiveness, and diversity of

undergraduates who major in STEM disciplines and pursue a career in science have continued to fall well short of stated goals (National Research Council, 2011a; National Science Foundation, 2009). Recent reports indicate that the science community continues to have difficulty fulfilling a “Science for All” agenda designed to recruit and educate talented and interested undergraduates from African American, Latina/o, and Native American groups historically marginalized in the sciences (Anderson & Kim, 2006; Carter, Mandell, & Maton, 2009; Lee, 1997; Malcom, Dowd, & Yu, 2010; Mutegei, 2011; NSF, 2006; Summers & Hrabowski, 2006).

One common explanation for this continuing difficulty is that many programs in undergraduate science education are poorly designed (Crisp, Nora, & Taggart, 2009). They are said to be based on unexamined assumptions about best practices rather than basic research grounded in theory (DePass & Chubin, 2009; Lewis, 2003; Mervis, 2006; U.S. Department of Education, 2007).

A different explanation, however, points to limits in the basic research itself (NRC, 2012). One limitation is that research about undergraduate science education has reproduced the commonplace that success in science depends principally on cognition, as indicated by mastery of time-honored subject matter knowledge (Nespor, 1987; Seymour & Hewitt, 1997), to the neglect of other forms of thinking, persuading, and decision making in meaningful interpersonal relations that can result in a student’s improved ability to learn (Heckman, 2008; NRC, 2010; Rose, 2013). A second and related limitation is that the basic research has often polarized social versus psychological accounts, with each position underemphasizing that, when college students contemplate and work toward careers in science, both social and psychological processes are entwined.<sup>1</sup>

The traditional standoff is shifting, however. Sociologists and scholars of higher education are increasingly interested in studying the interpersonal dynamics that influence undergraduate expectations and paths into science (Chang, Eagan, Lin, & Hurtado, 2011; Hurtado, Cabrera, Arellano, & Espinosa, 2009; Melguizo, 2011; Perna, 2006). The trend is toward putting a human face on broad social forces such as the authoritative science curricula, campus racial climate, stereotypes, and racial microaggressions (Chang, Denson, Saenz, & Misa, 2006; Cole, 2007; Locks, Hurtado, Bowman, & Oseguera, 2008; Pettigrew, 1998; Seymour & Hewitt, 1997; Solórzano, Ceja, & Yosso, 2000). At the same time, psychologists and social psychologists are increasingly skilled at measuring the socialization of dispositions, including science major students’ attitudes and expectations acquired in university settings (Elliot & Dweck, 2005; Enman & Lupart, 2000; Harackiewicz, Barron, & Elliot, 1998; Lent et al., 2003; Steele, 2010; Steele & Aronson, 1995). These moves toward a more comprehensive,

interdisciplinary model of research bode well for the necessarily practical endeavor of science education, in which events do not come labeled “sociological” or “psychological” or, for that matter, “academic.” Moreover, while initiatives in undergraduate education typically include a mix of social and psychological components—reflective perhaps of a commonsensical notion that pedagogy that includes a little of everything will “work”—they seldom make explicit a *sociocognitive rationale* that can give the assorted components coherence, direction, and purpose (Bandura, 1986; Jones & Nisbett, 1972; Steele, 1997).

### THE CURRENT STUDY

Our study explores the promise of a new research direction in undergraduate science education, one focused on trust. Although the study employs longitudinal survey data, it differs in purpose and design from the strictly randomized experimental analyses that seek to furnish precise predictions and causal interpretations (Schneider, Carnoy, Kilpatrick, Schmidt, & Shavelson, 2007). We reason that an exploratory study that pays more attention to descriptive evidence than definitive proof is warranted insofar as it encourages the discovery of new social phenomena (Rozin, 2001) and promises to inform and, perhaps, help mitigate the persistent, limited success in the United States in achieving both an excellent and equitable community of science.

We design our study with four considerations in mind. First, we bring the sociological and psychological aspects together in the concept of trust. We investigate the effect of trust—specifically, trust between science major students and the mentors they designate as being most helpful in college life—on the motivation and career expectations of juniors and seniors majoring in the biomedical sciences. A focus on interpersonal trust is unusual if not entirely overlooked in most studies of undergraduate science education (Ghosh, Whipple, & Bryan, 2001), and stands in sharp contrast to the situation in K–12 education where an emergent body of survey and field research measures trust and documents its educational importance (Adams, Forsyth, & Mitchell, 2009; Bryk & Schneider, 2002; Goddard, 2003; Hoy, Gage, & Tarter, 2006; Louis, 2007).

Second, our study provides a concise definition of interpersonal trust, shows how trust can be operationalized in survey research, and explores its association with motivation and science outcomes. This design feature is important if trust is neglected in studies of undergraduate science because it seems impossible to define or measure objectively, much less produce in practice, particularly in contrast to more familiar curricular interventions such as remedial tutoring or “hard” criteria such as grade point average

(Glaeser, Laibson, Scheinkman, & Soutter, 2000). Limiting research and practice to inputs and outputs that are relatively easy to count can distort the education deemed relevant to becoming a scientist and exacerbate the very difficulties the community of science has in attracting and retaining new recruits, particularly recruits from groups long outside the community of science.

Third, our study focuses on trust in academic mentoring. This topic is particularly relevant in studies of the undergraduate segment of the pipeline into science that, in contrast to graduate programs, typically occurs in large, impersonal settings that often generate student alienation (Hurtado et al., 2009; Lewis, 2003; Seymour & Hewitt, 1997). Moreover, while many policy documents, along with some research, attest to the educational importance of faculty–student mentoring in higher education, particularly in STEM programs (Carter, 2001; Jacobi, 1991; Kuh & Hu, 2001; Maton, Hrabowski, & Schmitt, 2000; Nettles, 1991), little is known about what it takes to make mentoring relationships successful, particularly for students who are members of historically underrepresented groups (DuBois & Karcher, 2005; NRC, 2005; Sánchez & Colón, 2009). At best, we know that the effects of mentoring are variable, and that they depend in part on the *quality* of the relationship between students and faculty (Anaya & Cole, 2001; Milem, 1998; Tinto, 1993). Therefore, our study hypothesizes that trustworthy relations may be both a significant condition for academic mentoring as well as an important outcome (Rhodes, 2002).

Finally, in contrast to cross-sectional studies in undergraduate science education, we use longitudinal survey data collected from science major students in 16 colleges and universities in the Pacific Southwest. Because all 16 campuses host a supplemental training program funded by the National Institutes of Health (NIH)—the *Minority Access to Research Careers - Undergraduate Student Training in Academic Research* (MARC-U\*STAR), hereafter “the Program”—the sample includes a subset of upper division science major students who are members of groups traditionally underrepresented in the sciences.

The aim of the MARC-U\*STAR Program is to increase the number and competitiveness of talented, minority undergraduates who go on to graduate school and careers as research scientists. Although some variation in the Program across campuses is expected, MARC-U\*STAR provides that all the selected students will engage, for a consecutive 24-month period during the final two years of their undergraduate training, in a curriculum focused on academic mentoring under the supervision of science faculty. The mentoring entails supervised laboratory research experience, a year-long seminar devoted to presenting and critiquing research articles, and assistance in applying to graduate school. The curriculum also includes an

annual stipend and travel funds to attend professional conferences (see <http://www.nigms.nih.gov/Training/MARC/USTARAWards.htm>).

We analyze and evaluate the longitudinal survey data in two linked parts: (a) an analysis of the association between trust (seen as a form of social capital) and motivation; and (b) an evaluation of whether the Program affects trust. We link the two parts by using the same longitudinal dataset in each and, further, by building the evaluation on the findings from structural analyses that compare trust and motivation among upper division science major students enrolled in the Program to trust and motivation among upper division science major students not in the Program. Social capital theory guides both parts of the study (Bourdieu, 1986; Coleman, 1990; Portes, 1998).<sup>2</sup>

Thus, we first investigate how trust and motivation are related in the academic mentoring of junior and senior science major students by the institutional agent each student identified as most helpful in college life. Structural models test the hypothesis that trust and motivation are social and psychological factors that work together rather than as discrete, unrelated educational inputs. These models also test the hypothesis that science major students' motivations and behaviors may be different in different social domains, and that program status, i.e., participation in the MARC-U\*STAR Program, moderates sociocognitive processes in undergraduate science education.

The second, evaluative part of our investigation is built on the findings from the first part. Using the same longitudinal, multisite dataset, it develops single-group autoregressive models (Loehlin, 1998) to measure the influence of the Program on trust. We reason that if trust and motivation are educationally important, then knowing whether a science education program can affect trust and motivation also merits consideration. We pursue the following research questions:

1. Do trustworthy mentors affect science major students' motivation and their educational behaviors and expectations?
2. Does motivation mediate the effect of trust on the expectations of science major students?
3. Do links between trust, motivation, and education outcomes differ between science major students who are in the MARC-U\*STAR Program and science major students who are not in the Program?
4. Can we infer the Program's influence by measuring its association with trust?

In what follows, we begin with a brief review of the literature on social capital, trust posed as a form of social capital, and motivation in



postsecondary education. We follow with a more detailed description of our two-part research design. We then turn to the heart of the paper: the structural analyses linking trust, motivation, and science education outcomes, and the evaluation of trust in the MARC-U\*STAR Program designed to supplement the standard undergraduate science curriculum for small cohorts of juniors and seniors who are members of groups long disadvantaged in university science. We conclude with a discussion of the implications and limitations of our findings for future research in undergraduate science education.

## REVIEW OF THEORY AND RESEARCH

An extensive literature demonstrates the varying impact of social relationships on the ability of college students to succeed in higher education and in STEM fields (Deil-Amen & Rosenbaum, 2003; Hurtado et al., 2009; Kuh & Hu, 2001; Maldonado, Rhoads, & Buenavista, 2005; Pascarella & Terenzini, 2005; Patton, Morelon, Whitehead, & Hossler, 2006). Relatively few studies in higher education, however, employ a social capital framework—although a handful utilize social capital theory in investigating transitions to college (O'Connor, Hammack, & Scott, 2009; Perna & Thomas, 2008; Perna & Titus, 2005; Sandefur, Meier, & Campbell, 2006). Fewer still focus on the importance of trust, which is often acknowledged as the most widely recognized form of social capital (Bryk & Schneider, 2002; Coleman, 1990; Putnam, 2000). Instead, the theoretical bases in much research addressing social conditions in postsecondary education are social integration ([Spady, 1971](#); [Tinto, 1993](#)), group involvement (Astin, 1993), social support ([House, 1981](#)), and social cognitive career theory ([Bandura, 1986](#); [Lent et al., 2003](#); [Melguizo, 2011](#)). We orient this study using an explicit sociocognitive framework that draws heavily from social capital theory.

Three features of social capital theory recommend it as a suitable frame for our research and, more broadly, as an important perspective for research in higher education and undergraduate science education. First, it emphasizes the value of trust in the efficient exchange of resources ([Coleman, 1990](#); [Putnam, 2000](#)); second, it calls critical attention to mistrust and its effects on the exchange of information ([Lin, 2001](#); [Ream, 2003](#)); and third, it points to a dialectical relation between the social world as constituted and the interested practices and internalized dispositions of people as social actors ([Bourdieu, 1984](#); [Brubaker, 1985](#)).

## MEASURING TRUST

Elaborating on the first of these three features, trust is working as social capital where there is an objective state of social actors voluntarily opening themselves to and cooperating with the actions of others (Coleman, 1990; Rousseau, Sitkin, Burt, & Camerer, 1998). Trust lubricates the inevitable frictions of social and economic life and facilitates the network exchange of resources (Coleman, 1988; Granovetter, 2002). Indeed, trust encourages risk-taking among interdependent actors who share a belief in keeping promises and in the duty of honoring one's declaration of will (Seligman, 1997). Such risk-taking situations entail an exchange of the vulnerability of one actor and the perceived ability and good will of another (Moorman, Zaltman, & Deshpande, 1992).

Questions about trust and what motivates cooperative behavior are generating increased interest within and across various disciplines, including sociology (Kramer, 2006), psychology (Dunn & Schweitzer, 2005), K-12 education (Bryk & Schneider, 2002), organizational management (Schoorman, Mayer, & Davis, 2007), economics (Glaeser et al., 2000), and political science (Putnam, 2000).<sup>3</sup> Survey research typically assumes that trust entails sweeping judgments, such as whether most people are trustworthy or whether trust is characteristic of human nature in general.<sup>4</sup> Other scholars, however, draw on philosophical and empirical studies to distinguish between generalized trust in the context of the abstract social environment versus interpersonal trust between interdependent actors (Cook, 2001; Schoorman et al. 2007). We posit that trust is more validly measured on a case-by-case basis, depending on what social actors perceive about particular others and the specific stakes involved in a relationship (Russell Sage Foundation, 2000).

Oriented by this view of interpersonal trust, we measure the aggregate of science major students' perceptions of the trustworthiness of institutional agents, specifically the mentors they identify as most helpful. The importance of trust is often acknowledged, but less often examined, in higher education, perhaps because interpersonal trust is quite difficult to model in survey research. Our measure builds upon recurring definitions of trust that assume that students estimate mentor trustworthiness based on three particular qualities in their mentors—competence, benevolence, and integrity—and risk making themselves vulnerable to a mentor on the basis of their perceptions of his or her qualities (Mayer, Davis, & Schoorman, 1995; Tschannen-Moran & Hoy, 2000). Thus, we conceptualize trust as one party's willingness to be vulnerable to another party based on the confidence that the latter party is (a) competent, (b) benevolent, and (c) a reliable person of integrity who acts transparently.

*Competence* concerns the perceived expertise of the trustee to perform actions of importance to those who trust (Oliver & Montgomery, 2001). In appraising a mentor's role-specific competence, for instance, a science major student may judge the mentor's expertise in unpacking a complex mathematical equation or demonstrating an important laboratory technique. *Benevolence*, perhaps the most common facet of trust, concerns the degree to which the trustee is perceived to care about and respect the one who trusts (Hardin, 2002). In appraising benevolence, a science major student may appreciate a mentor's capacity for altruism and for holding the student's best interest in mind because the mentor values the continuation of the relationship with the student. *Integrity* concerns the degree to which the trustee is perceived to act transparently and with fairness and predictability (Tschannen-Moran, 2004). In appraising a mentor's integrity, a science major student may be aware of the mentor's consistency in following through on doing what was promised.<sup>5</sup>

## ACCOUNTING FOR MISTRUST

Mentoring is often assumed to be an irrevocably positive process, and it is widely advocated for STEM education, especially in interventions aimed at recruiting students from underrepresented groups (Cole & Espinoza, 2008; Cronan-Hillix, Gensheimer, Cronan-Hillix, & Davidson, 1986; Nettles & Millett, 2006). However, in relying on social capital theory—specifically the second feature that recommends it—we are turned to a critical awareness of the downside of trust. We examine undergraduates' appraisals of their mentors as reflective of the level and quality of trust in the relationship and assume that the effects of mentoring vary (Anaya & Cole, 2001; DuBois & Karcher, 2005). For example, a recent evaluation of NIH-sponsored minority training programs in science red-flagged mentoring, warning that some students' perceptions of "benign neglect by their mentors or, at best, a lack of encouragement" threatened the "already low numbers of minority trainees at this relatively advanced career stage" (NRC, 2005, p. 8).

Negative relations are rarely integrated into social theory. Yet, critical perspectives on social capital emphasize that interpersonal relations are never free of wider institutional and historical contexts (Kao, 2004; Orr, 1999; Ream, 2003). Although trust often depends on the social class and/or ethnoracial characteristics of social actors (Tschannen-Moran & Hoy, 2000), it may also depend on the competitive structures and institutional playing fields of undergraduate science education where resources and information are exchanged or guarded. People tend to extend trust more readily to others they perceive as being similar to themselves; people also

tend to trust institutions that they perceive as embodying their values (Zucker, 1986). Insofar as heightened awareness of racial microaggressions and stereotypes reinforce a historically embedded skepticism among minorities regarding how welcome they are in institutions of higher education (Allen, Epps, & Haniff, 1991; Ancis, Sedlacek, & Mohr, 2000; Cabrera & Nora, 1994; Solórzano et al., 2000; Steele & Aronson, 1995; Tierney, 1999), mistrust may protect some students from being taken advantage of by science. Mistrust may even enhance the self-preservation of people at risk of being exploited by science (Bogart & Bird, 2003; Gauchat, 2012). Thus, for historically underrepresented minority (URM) students, a willingness to place trust in science faculty may require the voluntary acceptance of a unique vulnerability to institutional authority (Gambetta, 1988; Guiffrida, 2005).

### SOCIALIZING DISPOSITIONS: LINKING TRUST AND MOTIVATION

The third feature recommending social capital theory, apart from its important emphasis on trust and its critical recognition of mistrust, is that it (like social cognitive career theory) rejects siloing sociological versus psychological first principles. Instead, it calls attention to a dialectical relation between the *determinative* power of social groups and the *undetermined* motivations of free agents (Ortner, 2006) and thus preserves insights gained by important viewpoints across disciplines. Given this perspective, we seek to investigate whether and how trust and motivation work in relation to one another, rather than as discrete inputs.

In surveying the literature on motivation (Elliot & Dweck, 2005; Wentzel & Wigfield, 2009), we grappled with what is external to individuals versus what is *in* them. Much work on *intrinsic motivation* attends to the social-contextual conditions that impact cognitive regulation (Connell & Wellborn, 1991; Deci & Ryan, 1985; Weiner, 1991). Although this work does not explicitly link trust and motivation, it suggests that interpersonal relatedness bears mightily upon individual agency and will (Rosenhan, 1973; Rotter, 1980). Both Self-Determination Theory (SDT) and a subtheory of SDT labeled Cognitive Evaluation Theory specify social factors that explain variability in motivation (Deci & Ryan, 2000). By pinpointing competing needs for relatedness and autonomy, this research identified sociological processes (e.g., positive feedback in social settings) that fulfill innate psychological requirements for the development of motivation (Ryan & Deci, 2000).<sup>6</sup>

While we acknowledge that people may be motivated to engage in an activity for reasons that range on a continuum from inherent interests to external surveillance or even coercion (Ryan & Grolnick, 1986), we avoid re-inscribing the notion that motivation is somehow produced *sui generis*. A person may have a unique passion for science, but that passion can be

accelerated (or extinguished) by experiences in the world, including science education. Using the word *intrinsic* implies that motivation is somehow self-produced and belongs to people by their very nature. Yet, initially eager science major students may elect not to pursue a career in science, or they may participate only on a pro forma basis if, for example, they perceive their mentors to be incompetent or unsupportive. Accordingly, social capital theory and SDT scholarship in psychology lead us to couple trust in a mentor with what we term *internalized motivation*. Our results show that making this link is warranted inasmuch as (a) motivation is measurably associated with relatedness to mentors students perceive as trustworthy and (b) science education outcomes depend significantly on internalized motivation.

We have pointed out that social capital theory provides an illuminating sociocognitive framework, one that directs attention to neglected variables such as trust and mistrust, as well as to familiar variables such as motivation, that deserve meaningful and ongoing clarification. We use social capital theory to frame an investigation of the relation between trust and motivation in academic mentoring in undergraduate science education. In the next section, we describe the design of our study, including its use of longitudinal survey data and structural equation models (SEM) that interrogate the relationship that trust in a mentor has to internalized motivation among upper division science major students.

## RESEARCH DESIGN

Our investigation began with the design of a longitudinal survey instrument that integrated views on trust across social science disciplines (Mayer et al., 1995; Schoorman et al., 2007). The survey facilitates the parsimonious measure of trust between upper division college science major students and their mentors. We also used social capital theory to operationalize our analyses in two parts. In the first part, we tested structural models that can account for the hypothesized association between the trust that science major students have in mentors they deem as most helpful and the motivation of such students to succeed in science education. The models further investigate whether trust and motivation correlate with educational outcomes. We also tested whether enrollment in the federally supported MARC-U\*STAR Program moderated associations between trust and motivation. The second part of the study evaluates the overall effect of the Program on trust over time. It is based on findings from the structural models that suggest trust is an important facet of science education, particularly when the students involved are from groups historically underrepresented in the sciences.

## PARTICIPANTS

We collected the longitudinal data at 16 research and comprehensive universities (four-year colleges and universities) in the Pacific Southwest, all of which had the Program on their campuses. The base year sample (fall 2005) included juniors and seniors majoring in biology, chemistry, biochemistry, or related subdisciplines in the biological and physical sciences.<sup>7</sup> Students who participated in the base year survey were re-contacted one year later in fall 2006 and again in spring 2007 to complete follow-up surveys that contained most of the base year items. The resulting panel data contained a total of 161 undergraduate science major students.<sup>8</sup>

Because one of our goals was to explore similarities and differences in thinking and behavior among different student populations and to arrive at comparative program-based analyses, we divided the panel data (N=161) into two groups: upper division science major students participating in the MARC-U\*STAR Program (N=49) and upper division science major students not participating (N=112) in the Program.<sup>9</sup> Although some information was missing for a portion of survey participants—the degree of missing data on observed variables ranged from 1.0% to 6.2%, with an average of less than 4.0%—we were able to retain missing cases by using imputation techniques so as to make the sample more plausibly representative of students who failed to answer all the questions in the survey or who failed to participate in each wave of measurement.<sup>10</sup>

## DEPENDENT, BACKGROUND, AND CONTROL VARIABLES

African American, Latino/a, and Native American minorities are as likely as White and Asian students to begin college expecting to pursue careers in science (NRC, 2011b). Underrepresented minorities are less likely, however, to persist as their science expectations wane over time (Chang et al., 2011). This may partly explain why science educators are increasingly in pursuit of research that measures not only test scores and course performance outcomes but also dispositional outcomes, such as motivation and expectations, that are important in the process of educational attainment (Bohon, Johnson, & Gorman, 2006; Cabrera & LaNasa, 2000; NRC, 2012; Riegle-Crumb, Moore, & Ramos-Wada, 2011). Thus, in this study, we measured two dependent variables to ascertain whether trust and motivation affect science major students' educational expectations: (a) plans to attend graduate school, and (b) plans to pursue a career as a research scientist.

We use expectations as a concrete indicator of an undergraduate's science ambitions. We conceptualize expectations as reflecting not what

science major students hope for, but what they plan for and believe will actually occur (Bohon et al., 2006; Hanson, 1994). Specifically, a single Likert-type survey item asked each student to rate whether he or she “plan(s) to attend graduate school” on a 5-point scale where 1 = “strongly disagree” and 5 = “strongly agree.” Another single Likert-type survey item asked each student to rate whether she or he “plan(s) to become a research scientist” on a 5-point scale where 1 = “strongly disagree” and 5 = “strongly agree.”

We included students’ socioeconomic status (SES), race/ethnicity, and months remaining until graduation as background variables in each of our exploratory models. We also included controls at the base year for motivation and, importantly, for each of the dependent variables. Each student’s prior outcome score is included in each of our models. SES is widely regarded as the most powerful predictor of racial gaps in educational attainment, and a highly disproportionate number of minority students are from lower socioeconomic households (Kao & Thompson, 2003; Roscigno, 2000; Tienda & Jensen, 1988). Thus, we included an SES composite consisting of three observed variables: family income and each parent’s education. An 8-point scale measured family income: \$2,999 or less corresponded to a score of 1, and family income of \$250,000 or more corresponded to a score of 8. Similarly, we acquired data on each student’s mother’s and father’s levels of education: 1 on a 7-point scale measured up to an eighth-grade education, and advanced degrees (MD, PhD, or JD) corresponded to a score of 7. Family income and the two parent education measures were then factor analyzed. Factor loadings were used to create a single composite socioeconomic status score for each participant by summing the product of each loading and its respective item ( $\alpha = .68$ ).

To measure ethnoracial characteristics, we asked students to report their primary racial/ethnic group(s) on the survey. Self-reported race/ethnicity selected participants into two groups: members of a historically under-represented group (African American, Hispanic, and Native American;  $N = 58$ ) or not ( $N = 103$ ). Lastly, because our survey included science major students who were juniors or seniors when the base year survey was administered in fall 2005, at each measurement wave we asked students to report the year and term in which they expected to graduate with a bachelor’s degree. Using this information in conjunction with the date the survey was completed, we calculated, for each student, the months remaining until graduation. This variable was also included as a control in all statistical models to reduce error variability and to equalize participants on a variable with potentially confounding effects.<sup>11</sup>



## MEASURING TRUST AND MOTIVATION

We used the survey data to address our research questions by developing multi-item, latent measures of trust and motivation and employing them in the measurement component of the structural models.

### *Trustworthy Mentor*

Trust tends to be measured inconsistently in survey research (Rousseau et al., 1998). One common problem is the failure of researchers to specify the *trustee*—i.e., the person to whom something of value is entrusted. Anticipating this problem, we tracked science major students' perceptions of the competence, benevolence, and integrity of the mentor whom students identified as being most helpful during their college science careers.

*Trustworthy Mentor* is a three-item construct representing science major students' views of the institutional agent (i.e., the Program mentor, an assigned faculty advisor, or other faculty member) they identified as most helpful to them in college. This latent construct shows strong inter-item consistency ( $= .86$ , fall 2005) and reflects the degree to which students perceive this person as professionally competent, benevolent, and behaving with integrity.

### *Internalized Motivation*

Measuring internalized motivation as a latent construct is also complicated. In characterizing motivation on an extrinsic-to-intrinsic continuum (Deci & Ryan, 2000), we use the term *internalized* motivation rather than *intrinsic* motivation to call attention to the influence of accumulated and often situation-specific experiences on seemingly spontaneous or inherent inclinations toward interest, exploration, and mastery (Elliot & Dweck, 2005; Ryan & Grolnick, 1986; Wentzel & Wigfield, 2009). We constructed a latent measure to quantify students' acquired, rather than inborn, dispositions toward learning and achievement in science.

*Internalized Motivation* is a three-item construct representing the degree to which science major students are motivated to learn and achieve in their field of study, i.e., the degree to which students pursue learning as its own reward, and not primarily for extrinsic rewards such as a job/money, recognition, or a formal diploma. ( $= .61$ , fall 2006).

## STATISTICAL ANALYSES

We began our analyses of the survey data by examining descriptive statistics and mean differences on study variables across groups. Our longitudinal



analyses were conducted within the latent variable modeling framework and relied on the path analytic strengths of structural equation modeling.

We stacked the multiple-group models to test specifically for group differences according to program status (i.e., in the Program versus not in the Program) in the estimated associations among the two latent constructs—trust and motivation—and the educational outcomes. The inferences we drew from the comparisons depended, in part, on cross-group measurement invariance in which items tapped the same latent construct for the Program and non-Program students. To test for invariance, we constrained and then freed factor loadings across groups for items that corresponded to the latent *Trustworthy Mentor* and *Internalized Motivation* variables in 2006. Each construct was invariant across the two groups of science major students ( $\chi^2\Delta(7) = 4.60, p > .15$ ).

The magnitude and significance of each path coefficient was estimated using the expectation maximization (EM) algorithm and a robust full information maximum likelihood estimator (Asparouhov & Muthén, 2005; Yuan & Bentler, 2000). Below, we detail the multigroup process by which we investigated whether internalized motivation represents the *mediator* through which trust influences educational outcomes, and whether program status *moderates* the relationships among these variables (Baron & Kenny, 1986; Kenny, Kashy, & Bolger, 1998).<sup>12</sup>

We were careful to ensure that our multiple-group models were empirically identified, such that the number of estimated parameters in each model were fewer than the sample size of our smallest group (the Program students,  $N=49$ ). Accordingly, we pre-estimated covariances for exogenous variables, factor loadings, and item residuals for our 2006 latent measure of trust (see Figures 6–8 in the Appendix), and we imputed them in subsequent models.<sup>13</sup> We also pre-investigated the tenability of imposing group equality constraints on control paths by examining models wherein dependent variables were regressed on controls only. Where comparisons of formal models were conducted, we used  $\chi^2$  difference testing with correction for the robust maximum likelihood estimator (Satorra, 2000; Satorra & Bentler, 1999). All reported models were positive-definite and converged normally. We used the following indices to test the appropriateness of all statistical models: the Tucker-Lewis index (TLI), comparative-fit index (CFI), Akaike's information criterion (AIC), and root mean square error of approximation (RMSEA).<sup>14</sup> For more detailed information regarding data analyses procedures, see the Appendix.

In the second part of our analyses, we used single-group autoregressive models (Loehlin, 1998) to investigate the Program's association with students' perceptions of the trustworthiness of their mentors as measured in fall of 2006 and in spring of 2007.

Autoregressive models are especially useful for measuring program effects. This is particularly so where, as in our case, mean levels on the dependent variable, mentor trustworthiness, are unequal across levels of the primary independent variable (the Program status) at the initial point of measurement. Because participants in the survey included both juniors, who were relatively new to the Program, and seniors, who were not, some Program effects were already present in the base year data. We sought a statistical model that would allow us to equalize the Program and non-Program students on base year measures. Of course, the success of the Program might derive, in part, from strategic recruiting practices that skimmed off top-performing and perhaps more trusting minority students. That objection—that trust is an important criterion for eligibility rather than outcome of the Program—is why we accounted for differences in trust upon entry into the Program. In sum, we used autoregressive models to control for levels on the dependent variable, trust, at any previous measurement occasion, and to enable time-specific gains associated with the Program to be isolated from the Program students' higher initial propensity to trust.

## RESULTS

The results are presented in three sections. First, we describe and compare study variables across the MARC-U\*STAR Program and non-Program students. Second, we model sociocognitive processes by examining (a) the association between mentor trustworthiness and internalized motivation, (b) whether motivation mediates the effect of trust on the outcome measures, and (c) whether the associations among these variables are moderated by program status. Third, we explore the influence of the Program on trust while accounting for the Program students' higher initial propensity to trust.

### DESCRIPTIVE FINDINGS

Although the Program-sponsored science major students are less advantaged economically than those not in the Program, they report higher levels of motivation, academic expectations, and trust in their mentors in science. These advantages are measurable and appear to persist over time, as we describe below.

In terms of background characteristics, the majority of the Program students self-identify as African American, Latino/a, or Native American—all underrepresented groups in the biomedical sciences (again, the Program targets talented historically underserved minorities). Non-Asian minorities constitute 72% of the Program science major students compared to

21% of non-Program science major students, per Table 1. In relation to socioeconomic status, the Program students average .66 standard deviations (SD) below the mean SES of non-Program science major students (see Mean Difference column). Yet the Program students are a motivated group with levels of motivation, as measured in the 2005 base year, that are higher than non-Program students' motivation (.57 SD above non-Program students). The Program students also report higher grades and science expectations in fall, 2005. For example, on a scale of 1 to 5, their plans to pursue research science careers eclipse non-Program students' plans by 1.47 points. By the second follow-up survey in spring 2007, the base year advantage in plans to pursue research science careers persists—4.31 versus 2.83 for the Program and non-Program students, respectively. These comparisons between science major students in and out of the Program suggest that high levels of motivation among the Program students may offset some of the educational challenges that tend to coincide with economic disadvantage.

**Table 1. Variable Descriptions and Comparisons Across Program Status**

Variable Descriptions	All Science Majors		MARC-U*STAR Program Students		Non-Program Students		Mean Difference
	M	SD	M	SD	M	SD	P-nP
<b>Background Characteristics Fall 2005</b>							
Underrepresented Minority Status <i>Categorical variable (1 = URM, 0 = not URM)</i>	.36	.46	.72	.44	.21	.38	<b>.51**</b>
Socioeconomic Status <i>Standardized three-item composite variable</i>	.00	1.00	-.46	.83	.20	1.00	<b>-.66**</b>
Internalized Motivation <i>Standardized three-item composite variable</i>	.00	1.00	.41	1.04	-.16	.92	<b>.57**</b>
I am genuinely interested in the material I study in college	4.42	.73	4.65	.63	4.31	.75	<b>.43**</b>
I do what I need for the grade without caring about understanding the material (reverse coded)	3.91	1.03	4.18	1.07	3.79	1.00	<b>.39*</b>

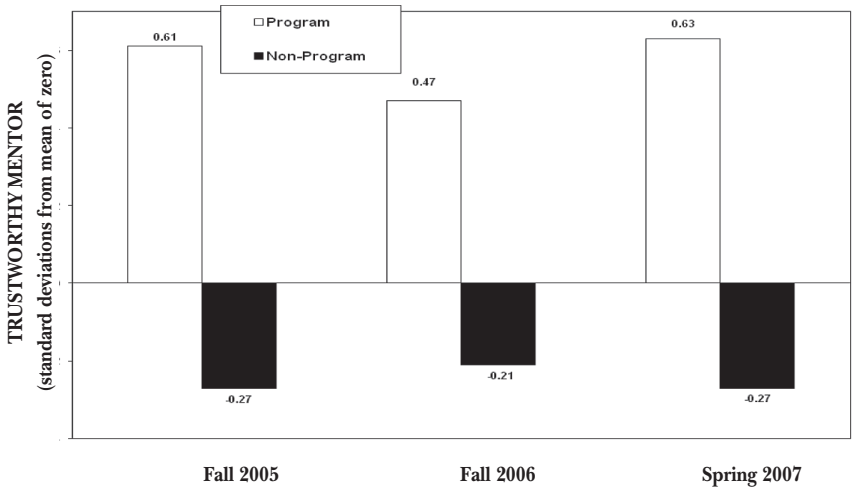
	All Science Majors		MARC- U*STAR Program Students		Non-Program Students		Mean Difference
Variable Descriptions	M	SD	M	SD	M	SD	P-nP
I go to college primarily to get the degree I need for a good job (reverse coded)	3.14	1.33	3.59	1.34	2.93	1.28	<b>.66**</b>
Grades in Science (5 = Mostly A's, 1 = Below D)	4.29	1.41	4.45	.50	4.22	.71	<b>.23*</b>
Plans to Attend Graduate School <i>Likert-Type Item</i> (5 = Strongly Agree, 1 = Strongly Disagree)	4.14	1.17	4.47	1.12	4.00	1.18	<b>.47*</b>
Plans to Become a Research Scientist <i>Likert-Type Item</i> (5 = Strongly Agree, 1 = Strongly Disagree)	3.38	.66	4.33	1.20	2.96	1.29	<b>1.47**</b>
Months Remaining Until Graduation	18.45	6.66	17.20	7.42	18.99	6.26	<b>-1.79</b>
<b>Trustworthy Mentor Fall 2005</b>							
I respect this person as a teacher	4.12	1.17	4.90	.30	3.76	1.26	<b>1.14**</b>
This person respects and appreciates me	4.06	1.00	4.51	.68	3.83	1.06	<b>.68**</b>
This person is fair in his/her dealings with me	4.32	.77	4.59	.61	4.20	.81	<b>.39**</b>
<b>Trustworthy Mentor Fall 2006</b>							
I respect this person as a teacher	4.18	.89	4.56	.74	4.02	.90	<b>.54**</b>
This person respects and appreciates me	4.08	.83	4.38	.78	3.93	.80	<b>.45**</b>
This person is fair in his/her dealings with me	4.25	.69	4.53	.71	4.14	.64	<b>.39**</b>
<b>Trustworthy Mentor Spring 2007</b>							
I respect this person as a teacher	4.12	1.11	4.70	.63	3.83	1.14	<b>.87**</b>
This person respects and appreciates me	4.22	.86	4.68	.55	3.97	.92	<b>.71**</b>

	All Science Majors		MARC- U*STAR Program Students		Non-Program Students		Mean Difference
Variable Descriptions	M	SD	M	SD	M	SD	P-nP
This person is fair in his/ her dealings with me	4.27	.82	4.68	.49	4.03	.86	<b>.65**</b>
<b>Internalized Motivation Fall 2006</b>							
Internalized Motivation							
<i>Standardized three-item composite variable</i>	.00	1.00	.28	.99	-.12	1.06	<b>.40*</b>
I am genuinely interested in the material I study in college	4.48	.57	4.60	.57	4.43	.56	<b>.17</b>
I do what I need for the grade without caring about understanding the material (reverse coded)	4.02	.86	4.26	.68	3.93	.92	<b>.33*</b>
I go to college primarily to get the degree I need for a good job (reverse coded)	2.51	1.14	2.69	1.20	2.43	1.12	<b>.26</b>
<b>Educational Outcomes Spring 2007</b>							
Plans to Attend Graduate School							
<i>Likert Type Item (5 = Strongly Agree, 1 = Strongly Disagree)</i>	4.11	1.29	4.38	1.23	3.96	1.31	<b>.42</b>
Plans to Become a Research Scientist							
<i>Likert Type Item (5 = Strongly Agree, 1 = Strongly Disagree)</i>	3.37	1.35	4.31	.96	2.83	1.25	<b>1.48**</b>

*Note.* For categorical variables, we use Chi-Square Tests of Independence to perform significance tests. For composite variables and Likert-type items, we use Univariate ANOVAs. Fall 2005  $N=161$  (the Program  $n=49$ , non-Program  $n=112$ ); Fall 2006  $N=146$  (the Program  $n=43$ , non-Program  $n=103$ ); Spring 2007  $N=131$  (the Program  $n=47$ , non-Program  $n=84$ ). All means and tests, however, are based on  $N=161$  (the Program  $n=49$ , non-Program  $n=112$ ) after imputing missing data using single imputation via the EM algorithm.  $*p \leq .05$ ,  $**p \leq .01$ .

Furthermore, the Program students across all three survey waves report high levels of trust in the mentor or college professional they identified as being most helpful, as compared to science major students not in the Program.<sup>15</sup> As Figure 1 displays, the Program students' perceptions of mentor trustworthiness in fall 2005 ( $M = .61$  SD) exceeds by nearly one full standard deviation the student average among non-Program students ( $M = -.27$  SD). One year later, the advantage narrows slightly, and then it widens again to .90 SD in spring 2007.<sup>16</sup>

**Figure 1. Science major students' perceptions of mentor trustworthiness by program status**



*Note.* Results of analysis of variance indicate the mean differences in science major students' perceptions of mentor trustworthiness are statistically significant ( $p \leq .01$ ) between the MARC-U\*STAR Program and non-Program students. Fall 2005  $N = 161$  (Program  $n = 49$ , Non-Program  $n =$

112); Fall 2006  $N = 146$  (Program  $n = 43$ , Non-Program  $n = 103$ ); Spring 2007  $N = 131$  (Program  $n = 47$ , Non-Program  $n = 84$ ). All means and tests, however, are based on  $N=161$  (Program  $n = 49$ , Non-Program  $n = 112$ ) after imputing missing data using single imputation via the EM algorithm (Little & Rubin, 2002).

Of course, membership in the Program is associated with several factors (e.g., race/ethnicity, SES, and time until graduation) that may partly account for the ebb and flow of trust and the magnitude of the apparent group-level differences. Later, we control for these factors in autoregressive models designed to gauge the overall influence of the Program on students' perceptions of mentor trustworthiness.

## MODELING SOCIOCOGNITIVE PROCESSES

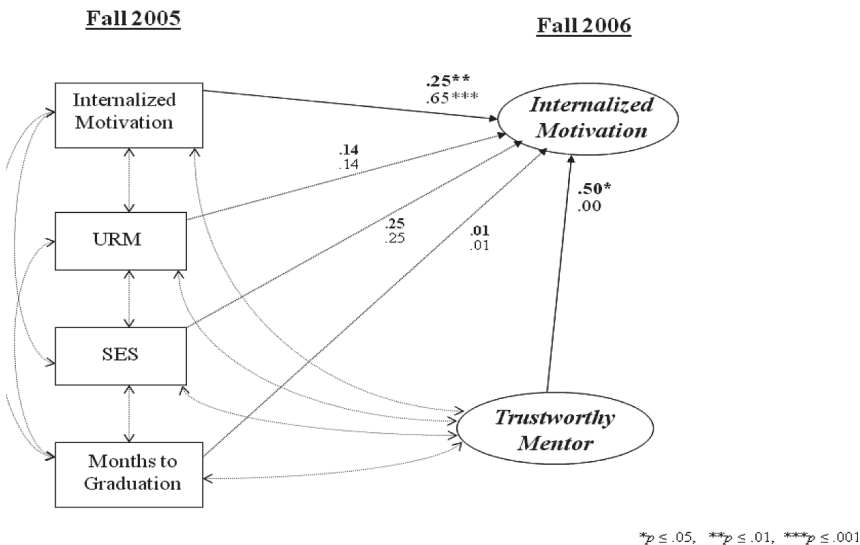
In the exploratory models that follow, we use multiple-groups SEM to systematically compare whether trust and motivation are related over time to the expectations for graduate school and careers in research science as expressed by the Program versus non-Program students. We find that, particularly among the Program students, trust in mentors is associated with motivation to achieve in science.

Our initial attempt at modeling links between trust and motivation examines the effect of mentor trustworthiness on internalized motivation, controlling for background variables—including motivation as measured at the base year in 2005. Based on preliminary analyses (see Figure A1 in the Appendix), all covariances are constrained to equality across groups as are all control paths, except the association between motivation in 2005 and 2006. This model shows a good fit to the data and suggests two important differences between the Program and non-Program students. First, the association between trust and motivation among the Program students is positive and significant ( $t = 2.29, p < .05$ ), while the association for non-Program students approximates zero ( $t = .23, p = .82$ ). Second, although the base year and first follow-up measures of motivation are positively associated, the magnitude of the association is more pronounced for non-Program students, as indicated again by competing models in which this path is freed and constrained across groups ( $\chi^2\Delta(1) = 52.64, p < .001$ ).

Building upon these preliminary analyses, we estimate the model in Figure 2.<sup>17</sup> Results suggest that trust affects motivation among the Program students for whom a 1.0 unit increase in mentor trustworthiness is associated with a .50 unit (.37 SD) boost in internalized motivation ( $t = 2.29, p < .05, b = .50, \beta = .37$ ). Trust is not measurably associated with motivation, however, among non-Program students.

On one hand, non-Program students start out with comparably low levels of motivation at the base year, and their motivation remains relatively stable through the first follow up in 2006. The Program students, on the other hand, demonstrate higher levels of motivation at the base year, and yet the association between base year motivation in 2005 and motivation in 2006 is much less pronounced ( $b = .25$  for Program students versus  $b = .65$  for non-Program students). Thus, even after persevering to the upper division ranks in undergraduate science education, the Program students' motivation still seems amenable to the influence of trustworthy science mentors. The positive association between the Program students' trust in mentors and internalized motivation ( $t = 2.29, p < .05, b = .50, \beta = .37$ ) can be interpreted as a medium association according to the criterion set forth by Cohen (1988).<sup>18</sup> In short, program status appears to moderate links between trust and motivation, per Figure 2.

**Figure 2. Internalized motivation regressed on trustworthy mentor**



*Note.* Top and bottom coefficients are the MARC-U\*STAR Program and non-Program students, respectively. The path weights are presented as unstandardized parameter estimates. All covariances among exogenous variables are constrained to equality across groups (see Figure A1 in the Appendix); whether constrained or freed, the models fit equally well ( $\chi^2\Delta(9) = 9.25, p < .001$ ). Individual items that contribute to the latent constructs (depicted as ellipses) and all error terms and covariances are



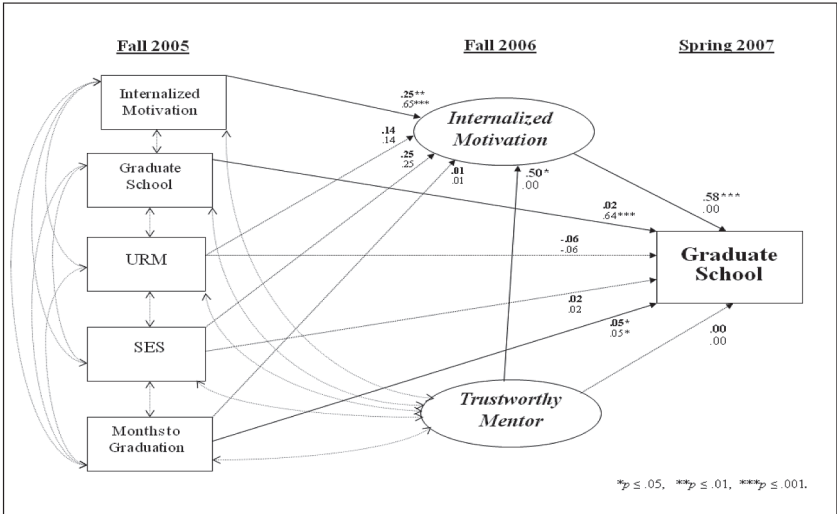
excluded from the figure to improve its readability. Fit Indices: [ $\chi^2$  (91) = 56.54,  $p = .99$ ; CFI = 1.00, TLI = 1.11, RMSEA = .00, AIC = 4192.689]

EXPLORING MOTIVATION AS A MEDIATOR

Next, we explore whether motivation *mediates* students' science expectations as measured at the second follow up in 2007.<sup>19</sup> Specifically, we test mediation against two primary criteria. First, the initial variable, *Trustworthy Mentor*, should demonstrate a measurable association with the mediator, *Internalized Motivation*. Second, the mediator should affect the dependent variable(s). To ascertain whether mediation is complete and consistent, we also examine whether the association between trust and each dependent variable is negligible when motivation (including its impact on the dependent variable) is included as a mediator in the model (Baron & Kenny, 1986; Mackinnon & Fairchild, 2009). We evaluate each dependent variable separately.

In Figure 3, we model as the dependent variable students' plans to attend graduate school. In this model, we constrain all control paths directed at the dependent variable to equality across the two groups with one exception: Preliminary results comparing freed and constrained models ( $\chi^2\Delta$  (1) = 12.93,  $p < .001$ ) show the link between students' plans to attend graduate school as measured in 2005, and then again at the second follow up in 2007, to be strongly dissimilar across groups ( $b = .02$  versus  $b = .64$  for the Program and non-Program students, respectively). This path remains freed.

Figure 3. Graduate school expectations regressed on trust and motivation



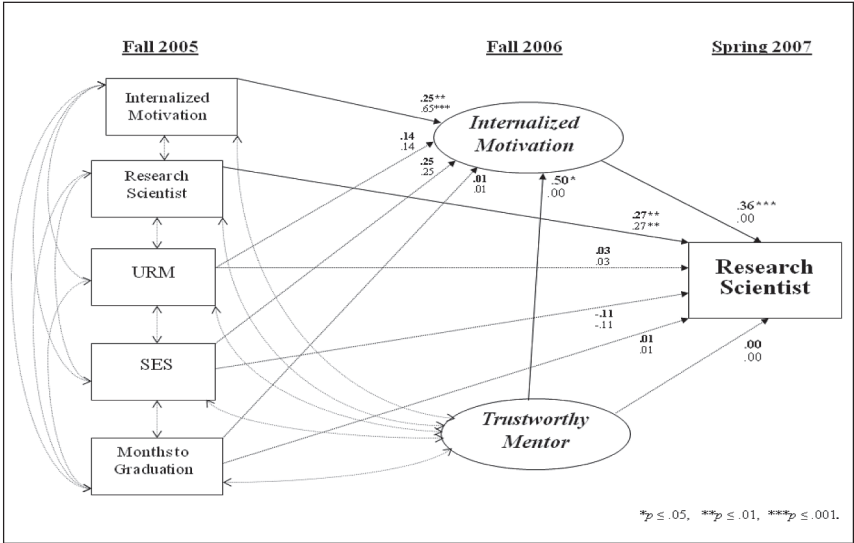
*Note.* Top and bottom coefficients are the MARC-U\*STAR Program and non-Program students, respectively. The path weights are presented as unstandardized parameter estimates. All covariances among exogenous variables are constrained to equality across groups (see Figure A2 in the Appendix); whether constrained or freed, the models fit equally well. Individual items that contribute to the latent constructs (depicted as ellipses) and all error terms and covariances are excluded from the figure to improve its readability. Fit Indices: [ $\chi^2$  (135) = 85.68,  $p$  = .99; CFI = 1.00, TLI = 1.13, RMSEA = .00, AIC = 5082.321]

For non-Program students, neither trust nor motivation is significantly associated with the dependent variable ( $p > .60$  in both cases). The Program students' plans to attend graduate school, however, seem more amenable to the influence of motivation, which is positively associated with the dependent variable ( $t = 3.82$ ,  $p < .001$ ,  $b = .58$ ,  $\beta = .65$ ). This particular association is not subtle, surpassing Cohen's (1988) criteria for qualifying as a large association.

Although the direct link between mentor trustworthiness and the dependent variable in Figure 3 is insignificant for both groups ( $p = .40$ ), here again trust is positively associated with the Program students' motivation ( $b = .50$ ,  $p < .05$ ), which, in turn, is positively associated with their plans to attend graduate school (the mediated effect of trust on the dependent variable is .29 units [.24 SD]). For the larger sample of non-Program students, however, none of these associations meet the threshold of formal statistical significance.

In Figure 4, we examine yet another measure of science major students' expectations, namely, their plans to pursue careers in research science. Once again, for non-Program students, neither trust nor motivation is significantly associated with the outcome variable ( $p > .30$  in both cases). By contrast, among the Program students, motivation affects research science career plans ( $t = 3.10$ ,  $p < .01$ ), although, here again, the direct link between trust and the outcome variable is not significant ( $p = .69$ ). Thus, in Figure 4, we constrain to zero the direct link between trust and the outcome variable for both groups, while freeing the link between motivation and the outcome for the Program students (and constraining it to zero for non-Program students). Again, in this instance, mentor trustworthiness seems to bolster the Program students' motivation, which is positively associated with the outcome variable ( $t = 3.20$ ,  $p < .01$ ,  $b = .36$ ,  $\beta = .50$ ). The mediated association between trust and the outcome (.18 SD) is complete and consistent. Thus, for the Program students, trust in a mentor is positively associated with expectations for a career in research science via the link between trust and motivation. There is no measurable association between trust and motivation for non-Program students, however, nor does trust appear to influence their plans to pursue a career in research.

**Figure 4. Expectations to become a research scientist regressed on trust and motivation**



*Note.* Top and bottom coefficients are the MARC-U\*STAR Program and non-Program students, respectively. The path weights are presented as unstandardized parameter estimates. All covariances among exogenous variables are constrained to equality across groups; all control paths directed at the dependent variable are constrained equal across groups (see Figure A3 in the Appendix). Whether constrained or freed, the models fit equally well. Individual items that contribute to the latent constructs (depicted as ellipses) and all error terms and covariances are excluded from the figure to improve its readability. Fit Indices: [ $\chi^2$  (136) = 94.59,  $p$  = .99; CFI = 1.00, TLI = 1.14, RMSEA = .00, AIC = 5089.947]

To this point, our results suggest that for the MARC-U\*STAR Program students, trust in a mentor is positively correlated with internalized motivation, which appears to *mediate* students' expectations to pursue graduate school and careers in research science. By contrast, these associations turn out to be statistically inconsequential among the larger group of non-Program science major students. Thus, program status apparently *moderates* associations among trust, motivation, and science outcomes.

#### THE EFFECT OF THE PROGRAM ON TRUST

Lastly, we build upon the results in the previous sections by using autoregressive models to explore the hypothesized association between the

Program and our focal variable, trust. Insofar as trust affects the Program students' expectations via motivation, then investigating whether the Program is associated with science major students' perceptions of mentor trustworthiness is also important.

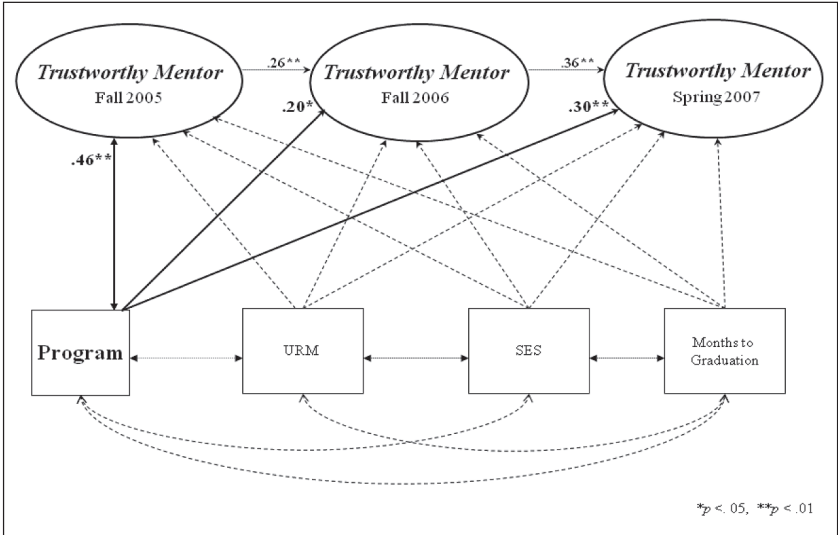
Exploring the Program is also important because it is plausible that MARC-U\*STAR does not produce the desired effects, but simply selects for them. After all, upon entry into the Program, the students in our sample are already motivated to achieve at a high level in science education and generally view their mentors as trustworthy. Apart from this ability to attract gifted science major students who have overcome extraordinary challenges, what is the value of the Program if the students can already make it on their own?

Anticipating these concerns, we explore whether the MARC-U\*STAR Program affects the trajectory of trust in mentors over time, controlling for the Program students' background characteristics and, in particular, students' initial perceptions of mentor trustworthiness, per the single-group autoregressive model depicted in Figure 5.<sup>20</sup>

This model associates the Program with our latent measure of trust at three points in time. At the first data wave in 2005, we correlate trust and each exogenous variable, including Program status, underrepresented minority status (URM), SES, and Months to Graduation. The association is clearly present in 2005 ( $r = .46$ ,  $p < .001$ ), which is unsurprising since we have already established that science major students enter the Program with higher proclivities to trust institutional agents. However, one year later and controlling for base year perceptions of mentor trustworthiness, the Program students again show scores on trust that significantly exceed non-Program students' scores ( $t = 2.27$ ,  $p < .05$ ,  $\beta = .20$ ). Importantly, these scores are modeled as a function of the Program when accounting for the temporally previous score on trust, plus the impact of the control variables, plus error. Thus, above and beyond their initial advantage in trust, the Program students' perceptions of the trustworthiness of their most helpful mentor again exceeds non-Program students' by .20 SD in fall 2006 and increase even more rapidly vis-à-vis non-Program students between fall 2006 and spring 2007 (a difference of .30 SD [ $t = 2.99$ ,  $p < .01$ ,  $\beta = .30$ ]).

By exploring trust and motivation in science education and then evaluating the MARC-U\*STAR Program based on the results of our preliminary models, our findings suggest that the value of the Program is predicated on more than stringent selection and eligibility criteria and a supplementary curriculum aimed at strengthening and/or remediating cognitive gains. It appears also to entail the Program's capacity to bolster its upper division minority enrollees' already optimistic perceptions of the trustworthiness of mentors in university settings.

**Figure 5. Associating the program with trust**



*Note.* The path weights are presented as standardized parameter estimates. Individual items that contribute to the latent constructs (depicted as ellipses) and all error terms are excluded from the figure. Interyear factor loadings for corresponding items were constrained to equality and correlations between interyear error variances for corresponding items were estimated. *Source:* Longitudinal panel data containing 161 undergraduate science major students, including undergraduate biomedical science major students who participated in the MARC-U\*STAR Program (N=49) and those science major students who did not participate in the Program (N=112). Fit indices:  $\chi^2$  (46) = 65.90,  $p$  = .03; CFI = .96, TLI = .95, RMSEA = .05, AIC = 4813.049

### LIMITATIONS

This investigation presents several methodological challenges. As previously discussed, the study uses a unique and relatively small sample of longitudinal, multisite survey data to explore trust as a little-used construct in undergraduate science education. Given the study's purpose and design limits, we situate the results near the front end of the continuum from preliminary studies; it is designed to suggest further research directions to the kinds of precise predictions we can expect from truly randomized controlled experiments (Gutting, 2012; Rozin, 2001; Schneider et al., 2007). Before we discuss the results in more detail, we elaborate upon the methodological

challenges posed by our study and how we dealt with them. In general, we regard design as a series of trade-offs. Researchers must weigh design decisions in light of the purpose(s) they pursue in a study.

One methodological challenge entailed striking a balance between costly data collection versus securing sufficient statistical power. We decided to collect a smaller sample that included multiple survey items measured at three points in time, rather than a larger sample with more stable parameter estimates but fewer waves of assessment. We reasoned that (a) few longitudinal survey research projects explore college populations of minority students in contemporary science education; (b) fewer still employ data in which the same undergraduate science major students are surveyed about the quality of their relationships with mentors over time; and (c) in a demanding, two-year curriculum in upper division science or specifically in MARC-U\*STAR, interpersonal trust might well fluctuate over time rather than being a once-and-for-all achievement.

At the same time, however, we acknowledge that the larger the sample, the more stable the parameter estimates. Yet, quantitative researchers do not agree on what constitutes large; instead, they often operate according to rules of thumb. By contrast, the field of structural equation modeling (SEM) has established some guidelines, and most researchers agree that parameter estimates in SEM become stable beginning at five cases per estimated parameter (Bentler, 1995; Westland, 2010). When the parameter estimates in our study did not meet this guideline, we double-checked our results using a multiple regression framework. We examined all of our study hypotheses in the regression framework in which our latent variables were replaced with summed composites, and analyses were again conducted separately for Program and non-Program students. With this check, the pattern of significant and non-significant findings did not change and the general magnitude of effects remained quite similar. These results supported all of the inferences put forth in this paper.

A second methodological challenge is that variables omitted from the structural models may bias the results. For example, undergraduates may gravitate toward or be assigned to faculty mentors on the basis of unmeasured characteristics that condition the educational impact of trust. We sought to address this challenge by controlling for various background factors—in particular, each student's prior scores on each dependent variable (Cooper, Robinson, & Patall, 2006; Kane, Rockoff, & Staiger, 2008). Without randomized assignment, we cannot know whether we assessed all possible sources of initial differences between individual science major students. But, we *can* claim that the findings are intriguing and robust enough to warrant further studies of trust, especially insofar as few empirical studies, whether with large or small samples, have documented that

trust sparks motivation and that educational programs can make a difference regarding undergraduate distrust of university science, most particularly among minority students (Bogart & Bird, 2003; Gauchat, 2012).

A third methodological challenge entails the strain between examining each feature of an intervention for its impact on trust versus evaluating the overall impact of an intervention. Given the exploratory purpose of our research, we evaluated the impact of the MARC-U\*STAR Program as a whole, and, accordingly, we used autoregressive models that are not designed to tease apart particular aspects of the Program that may be associated with increased trust. Thus, our study does not examine the differential impact of specific curricular components, such as laboratory research or an annual stipend, on students' trust and science priorities. Nor does it consider whether these or other curricular components are robust when matched on additional covariates such as institutional selectivity, campus diversity, or types of financial aid (Brewer, Eide, & Ehrenberg, 1999; Malcom et al., 2010; Melguizo, 2010). Given important concerns such as these, which our study cannot address as well as its promising results, we recommend an agenda for additional research.

## DISCUSSION

Despite its limitations, this study contributes to the literature on academic mentoring in undergraduate science education in several ways. First, our study develops a novel conceptual perspective on the measure and utility of trust as a crucial form of social capital. Second, we used this perspective to develop a set of structural models that suggest interpersonal trust is producible in undergraduate science education; is pedagogically powerful, not a mere nicety; and is particularly important for students who are members of groups historically underrepresented in the sciences. Third, and surprising because the literature on trust does not prepare for them, are results suggesting that trust may work differently for different groups of students in different contexts. For instance, while we know that, in general, being non-White is negatively associated with trust in people and institutions in the United States (Brehm & Rahn, 1997; Weaver, 2006), we found that improving the perceptions of the MARC-U\*STAR Program students, most of whom were minorities, regarding the trustworthiness of their mentors is positively associated with Program students' motivation, which in turn mediates their expectations for graduate study and a career as a research scientist. Yet, for the larger group of non-Program science major students in our sample, most of whom were not minorities, none of these links were measurably significant. We discuss these three research contributions regarding the utility of theory, inequitable representation,

and contextual complexities in turn, and conclude with a recommendation for a more expansive research agenda focused on trust, which may contribute to a reorientation of undergraduate science education.

## THEORY MATTERS

With its focus on trust, our study demonstrates the value of theory development for undergraduate science education (Braxton, 2000; Crisp et al., 2009).<sup>21</sup> For instance, it suggests that it is not surprising that science educators are unaware of trust, including its implications for motivation, if they lack a framework such as the one we introduce, which directs them to consciously look for and develop trust. Our framework is derived from social capital theory and cautions that a science curriculum that informs and motivates entails attention, not only to cognition as indicated by subject matter knowledge, but also to the educational significance of other complex forms of cognition that undergird social skill, relational awareness, and the development and maintenance of trust. Adherence to pedagogical theory focused on subject matter cognition is necessary, yet insufficient for increasing the number, competitiveness, and diversity of undergraduates who major in STEM and pursue research careers in the sciences (Handelsman et al., 2004). The sociocognitive framework we develop using social capital theory emphasizes that exchanges of information and resources entail both trust *and* mistrust, hypothesizes the association between trust and motivation, and posits that sociological and psychological factors work together rather than separately in mentor–student relations. From this perspective, undergraduates in science education are not only learning about science but, simultaneously, are coming to know themselves and others and their places in particular school and social orders (Page, 1991). In such cognitively and socially consequential exchanges, trust and mistrust are important.

## TRUST AND EQUITY

Our most unusual finding—that trust in a mentor seems to matter more for the motivation and career expectations of the MARC-U\*STAR Program students than for non-Program students—raises the question, how does trust in a university mentor matter for equitable undergraduate education in science? The question is important because, with limited empirical evidence about science mentoring’s inputs, quality, or effects (Jacobi, 1991; Nettles & Millett, 2006; NRC, 2009), it is nevertheless touted as among the most efficient means of tempering the alienating effects of off-putting faculty members and large, impersonal, undergraduate courses in the sciences (Lewis, 2003; Seymour & Hewitt, 1997).



With our data, we cannot fully account for this unexpected finding. Yet, drawing from studies that disentangle the concept of interpersonal trust from more generalized notions of trust in the social environment (Cook, 2001; Schoorman et al., 2007), we have worked at a tentative interpretation, which we hope other scholars may penetrate in future research: Perhaps interpersonal trust is especially impactful in situations where the more general social environment poses perceptible threats. Especially within *institutions* that threaten failure, does the trust that develops in meaningful interactions *between individuals* matter more than it might otherwise within institutions that are perceived to encourage success? And, does interpersonal trust matter in ways that can mitigate institutional shortcomings?

For instance, consider that *all* students who declare a science major may have reason to mistrust just how genuinely welcoming the community of science is, insofar as science faculty “wink” about “weeding out students” (Seymour & Hewitt, 1997) and roughly half of the freshmen who declare a science major upon entering are gone by the end of their sophomore year (Center for Institutional Data Exchange Analysis, 2000). However, note too that trust in mentors proved *less* measurably consequential for the non-Program undergraduates in science than for the Program students.

This surprising difference may be partly understandable given that the non-Program students, the great majority of whom are members of groups well-represented in the university and science, are likely to enter the university with fewer prior experiences that would lead them to mistrust the university or science, whereas the MARC-U\*STAR Program students, almost all of whom are members of groups underrepresented in the university and science, may have more tangible reasons to maintain mistrust of the university and the community of science. The latter group may continue to wrestle with heightened awareness of racial stereotypes and micro-aggressions perpetuated within the university environment (Solórzano et al., 2000; Steele, 2010). They may also have specific reasons to perceive their interests as being at odds with those of the community of science (Chang et al., 2011; Major & O’Brien, 2005). For example, studies surveying the recent history of American science, most infamously, the 40-year Tuskegee Institute/U.S. Public Health Service experiment with untreated syphilis in Black males, document why historically disadvantaged groups might mistrust the community of science (Bogart & Bird, 2003; Gamble, 1997; Gauchat, 2008).

However, for the MARC-U\*STAR students—from whom we might expect deep and lingering mistrust—trust in mentors appears to have deepened during the Program, affecting students’ motivation and subsequent aspirations for graduate school and careers as research scientists. Hence, our speculation that for the Program students, the interpersonal trust fostered in the Program moderates the students’ more generalized institutional mistrust.

To be clear, our study did not measure generalized trust in the institution of science or undergraduates' overall perceptions of "the culture of science" (Brint, Cantwell, & Hanneman, 2008; Hurtado et al., 2009), nor did it establish whether trust in the general social environment of the university varied across our two groups of science major students. Therefore, further research with a much larger sample than ours is needed to probe the differential impact of trust on different groups of students across institutional settings, and the research will require a design and multiple forms of data able to account for trust at two levels simultaneously—the individual level *and* the structural level.<sup>22</sup>

### THE INFLUENCE OF CONTEXT

This study was designed to form a bridge between a conceptualization of trust and empirical studies of college science education. However, as previously mentioned, the study sheds little light on the particular components of the Program to ascertain their differential impact on trust. We know little about the shifting conditions of practice in which protégés and mentors in the community of science struggle over relations of trust. In relation to both points, trust emerges, not as an invariant entity, but as supremely contextualized. Accordingly, our call for a wideranging, multidisciplinary, and multimethod research agenda reflects our reasoning that comparative considerations of trust in diverse contexts are an excellent means of recognizing the complexity of interpersonal and generalized trust in schools, including universities.

For purposes of illustration, we note three contextual issues that arose in our study whose delineation requires a broader, more comparative approach than we pursued. The first is relations of trust in face-to-face contexts, such as science classrooms and laboratories. Our survey data does not account for the likelihood that the profiles, or identities, of faculty mentors differ markedly from their mentees' profiles. Therefore, additional research is needed that will provide information about interpersonal trust between science mentors and undergraduates, particularly whether people extend trust more readily to others whom they perceive as similar to themselves.<sup>23</sup> And what of the general, more abstract characteristics of a university itself? How does the hierarchical and sometimes alienating culture of science (Hurtado et al., 2009), one that tends to prioritize the instrumentality of quantitative skills and job-market prospects over ideas, values, and interpersonal relationships (Brint et al., 2008), influence relations of trust between faculty and students in undergraduate science classrooms?

The second contextual issue centers on higher education policy. New

research should account for how trust and mistrust interact with myriad other reforms in undergraduate science education, a topic our study did not explore. For example, market- and accountability-based reforms are arriving at the university. As in K–12 education, the reforms attempt to ascertain and influence faculty effectiveness in teaching by measuring it against growth in student scores on standardized tests (Hannaway & Woodroffe, 2003). But, will such reforms undermine other reforms in undergraduate education that seek more vital teaching and learning as a consequence of boosting relations of trust between faculty and students?

Third, and last, are the ecological domains that shape human development—family, peer, school, and community (Bronfenbrenner, 1979). The effort to account for trust in undergraduate science education should occur not only within the university, but across these domains. For instance, inasmuch as *familism* is of particular importance among Latinos in higher education (Desmond & Lopez Turley, 2009), then understanding whether trust in parents impacts Latina/o motivation in science may be important for understanding the trajectories of Latino youth in undergraduate science (Alon, Domina, & Tienda, 2010). Similarly, investigating how trust among same-age peers in undergraduate science differs by student race and/or ethnicity seems important in light of often-cited research that suggests that if minorities will only work more collaboratively with their peers, then racial gaps in STEM attainment would diminish (Treisman, 1992). Because it is nearly impossible to isolate these spheres in order to measure the influence of each separately from the others, a more comprehensive and multidisciplinary model of research is needed (Ream, Ryan, & Espinoza, 2012).

## CONCLUDING REMARKS

As a social institution that is both competitive and collaborative, the U.S. community of science is faced with challenges building and maintaining relationships of trust between undergraduates and their university mentors. These challenges may be especially pressing for historically underserved college students for whom the experience of racial tensions and a deep-seated mistrust of science institutions can serve as obstacles to taking a chance with powerfully positioned institutional agents such as well-established scientists (Gambetta, 1988; Guiffreda, 2005). Yet, there can be no trust without risk taking (Rousseau et al., 1998). In effect, science major students must take a chance on mentors, trusting that they will exercise authority benignly, just as mentors must risk losing the approval of university colleagues if they devote too much time and energy to students. Such leaps of faith involve trusting in the good intentions of individuals in

positions of institutional authority, including trusting that one's identity will be positively affirmed by those in authority, and that, by complying with the exercise of authority, one's own interests will be advanced (Erickson, 1993; Louis, 2007, Mitchell & Spady, 1983). Yet, while trust holds promise, we cannot ignore the possibility that feelings of mistrust may protect some students from being taken advantage of or exploited by science (Bogart & Bird, 2003; Gauchat, 2012). Mistrust may inoculate the healthy skeptic from the ill effects of trust misplaced. Perhaps the important concluding question, then, is not so much whether trust matters to historically under-represented undergraduates, but whether minorities can be persuaded to view it as *rational* to take the risks and seek the help that make trust in mentors—not *blind* trust in powerful institutional actors, but rationally *calculative* trust in authentic agents of authority—a possibility, even within mainstream institutions they have perceived to be unworthy of trust.

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#### *Notes*

1. Thus, many sociological studies have concentrated on the influence on undergraduate trajectories of large, "faceless" social forces such as "chilly" campus climates, institutional racism, and leaks in the pipeline into science, while psychological studies have focused on explanations of the achievement goals, personalities, and/or work ethics of individual students (Bensimon, 2005; Enman & Lupart, 2000; Hilton & Lee, 1988; Hurtado, 1994; Hurtado, Carter, and Spuler, 1996).

2. Although there is disagreement over its precise definition, social capital refers generally to individuals' capacity to gain access to scarce resources by virtue of their membership in groups and participation in broader structures of society (Bourdieu, 1986; Coleman, 1988)—resources that include knowledge and information (Becker, 1964), cultured dispositions (Lamont & Lareau, 1988), and/or economic capital and employment opportunities (Granovetter, 2002). By social capital, then, we mean the aggregate of actual and potential resources embedded in social networks that may be converted, via social exchange, into other manifestations of resources for use by individuals and groups (Portes, 1998; Ream & Palardy, 2008).

3. Economic sociologists show that trust, as social capital, greases the wheels

of economic exchange (Gambetta, 1988; Granovetter, 2002); political scientists encourage the perception of trust as social capital by demonstrating its contributions to the health of civil society (Fukuyama, 1995; Putnam, 2000); and scholars in K–12 education employ a social capital framework to show that kids learn more with trust in schools (Bryk & Schneider, 2002; Dika & Singh, 2002).

4. The General Social Survey (GSS), for example, contains three questions that researchers have consistently used to measure trust: (a) Generally speaking, would you say that most people can be trusted or that you can't be too careful? (b) Do you think most people would try to take advantage of you if they got a chance or would they try to be fair? (c) Would you say that most of the time people try to be helpful, or that they are mostly just looking out for themselves? (See <http://www.norc.oregonstate.edu/projects/General+Social+Survey.htm>.)

5. Of course, student reports of their perceptions may consist of projections of their own values onto others. This bias has been targeted as a weakness of research on social dynamics (Kandel, 1996). From a different conceptual orientation, however, tracking college science major students' perceptions of mentor trustworthiness is justified because people often act based on perceptions or other information they think is true, even when it is not (Rosenthal & Jacobson, 1968). Succinctly, meaning is causal for human action (Erickson, 1986).

6. Beyond its social antecedents, the educational importance of motivation has also been widely studied (Benware & Deci, 1984; Connell & Wellborn, 1991; Dweck, 1986; Harackiewicz et al., 2002; McDonald, Ing, & Marcoulides, 2010; Wentzel & Wigfield, 2009). Spence and Helmreich (1983) found that, even controlling for prior SAT scores, motivation predicts grade point averages among college undergraduates. Others demonstrated its association with improved science outcomes for students of color in higher education (Brown, 2002; Carlone & Johnson, 2007; Russell & Atwater, 2005). Engaging in an activity for its inherent satisfactions—the aspect of cognitive regulation that psychologists often refer to as intrinsic motivation—captures particular attention for its many educational advantages, including more behavioral effectiveness, enhanced self-esteem, and better assimilation of individuals within their social groups (Gottfried & Gottfried, 1996; Ryan & Deci, 2000; Schunk & Zimmerman, 2008).

7. For the purpose of survey distribution, the Program directors at each campus were asked if they would be willing to distribute survey packets to their Program-sponsored students (and/or allow members of the research team to do so). Program directors were also asked if they would be willing to facilitate access to one or more high-enrollment classes required for all or most upper division juniors and seniors majoring in the biomedical sciences.

8. Of the 161 undergraduate science major students, 119 completed all three waves of the survey, while 30 had data for the base year and first follow up, and 12 had data for the base year and second follow up. To determine the extent of similarity on study variables between students who did and did not respond to all three survey waves, analyses of variance, controlling for program status, were performed for each continuous observed measure in the base year sample. These analyses revealed no significant differences between students who did and students who

did not complete both follow-up surveys on any of the items in the survey ( $p > .05$ ).

9. Judging the adequacy of the Program sample size ( $N=49$ ) involves recognizing that the MARC-U\*STAR Program sponsors only a select number of talented upper division science major students on each campus. Among the 16 campuses in our survey, the modal number of Program enrollees was quite small—just 6 MARC-U\*STAR students per campus (with a range from 3 to 16 Program-sponsored students).

10. The software employed in the analyses confronts missing data with estimation by full information maximum likelihood (FIML) instead of relying on ad hoc methods such as listwise or pairwise deletion, or mean imputation. Unlike many other imputation methods, FIML estimation uses all the information from the observed data, estimating a coefficient for the relationship between variables (missing data are built directly into the estimation method), as opposed to imputing a value for an otherwise observed variable. For details, see Arbuckle (1996).

11. Data from the spring 2007 wave include responses from recent graduates who were prompted to reflect back on the final term of their undergraduate program when answering survey questions.

12. We examined whether motivation mediates the impact of trust on science outcomes using the four-step process described by Baron and Kenny (1986) and others (e.g., Kenny et al., 1998; Mackinnon & Fairchild, 2009). According to this framework, mediation requires that at least two of four criteria (the second and third criteria below) are met. First, the initial variable (*Trustworthy Mentor*) should significantly impact the dependent variables (expectations to attend graduate school and become a research scientist). Second, the initial variable should significantly impact the mediator (*Internalized Motivation*). Third, the mediator should significantly impact the dependent variables. Finally, complete and consistent mediation require that the impact of the initial variable on the dependent variables is clearly zero when the mediator (its impact on the dependent variable) is included in the model.

13. Because control variables and our latent measure of trust were always exogenous, covariances among these variables and factor loadings for trust were always pre-estimated and imputed in subsequent models that contained endogenous variables of interest. After examining the association between trust and motivation (see Figure 2), we noted the values of all the paths and the factor loadings for *Internalized Motivation* and imputed them in subsequent models that contained additional endogenous/dependent variables.

14. TLI and CFI are practical fit indices designed to address sample size issues; values of .9 and above indicate reasonable model fit. RMSEA is sensitive to the number of estimated parameters, acting as a barometer in estimating model parsimony. RMSEA values of .08 or less indicate reasonable model fit (Browne & Cudeck 1993). AIC is best used to compare competing models, where smaller values indicate a superior model fit.

15. The vast majority of students in the Program (87%) identified their formal MARC-U\*STAR Program mentor, an assigned faculty advisor, or other faculty member as the most influential and helpful institutional agent, while 10% indicated other college personnel. One Program student identified a college guidance counselor; one other Program student indicated a graduate student was most helpful.

16. Although there are no set standards for interpreting differences between group means, Cohen (1988, pp. 25–27) suggested that standardized differences of .20 are small, .50 are medium, and .80 are large.

17. In Figure 2, the trust-to-motivation path is freed for the Program students, but constrained to zero for non-Program students, while the path linking internalized motivation in 2005 and 2006 is free to vary across groups. Difference testing supports the tenability of this single-additional constraint ( $\chi^2\Delta(1) = .25, p > .15$ ).

18. In multivariate analyses, Cohen (1988, pp. 413–414) suggested that standardized parameter estimates of .13 are small, .36 are medium, and .51 are large.

19. In each of these models, we impute, based on coefficients obtained from previous models, (a) covariances among exogenous variables, (b) loadings and item residuals for trust, (c) loadings for internalized motivation as measured in 2006, and (d) all path coefficients directed at internalized motivation. We also constrain or free control paths across groups according to findings from previous analyses. All other coefficients are free. See the Appendix.

20. Time-ordered evaluation of the Program depended, in part, on whether the trust items tapped the same latent construct at each measurement wave. Thus, we constrained and then freed interyear factor loadings for items that corresponded to trust and found, in support of temporal invariance, that the models fit equally well ( $\chi^2\Delta(6) = 5.40, p > .15$ ).

21. To overlook theory as extraneous or even an impediment to STEM education policy could hamper research in science education, the evaluation of government-sponsored programs in the sciences, and the enormous potential of teaching science to undergraduates (Braxton, 2000; Crisp et al., 2009).

22. Such research might furnish particularly vital new information about how pedagogical practices can affect the relation of trust and mistrust to equity in undergraduate science. Recall, for instance, that our evaluation of the MARC-U\*STAR Program showed it had boosted students' interpersonal trust in mentors. However, Web-based and published descriptions of the Program do not mention trust, and mentoring is specified as "academic" and is most often described as monitoring student grades, requirements for graduation, and participation in Program events. Therefore, some benefits of the Program—student motivation and career expectations spurred by the generation of trust between undergraduates and their faculty mentors—are produced without anyone in the Program explicitly planning or recognizing them. They are *unintended* consequences. Yet, without self-conscious knowledge of what the Program is trying to produce, faculty cannot fully monitor or moderate their activities, recognize their accomplishments, or disseminate the Program as a practical, efficacious model for the wider community of undergraduate science education.

23. For instance, do particular facets of faculty identities have to align with or even match undergraduates' identities for trustworthy, pedagogical relations to develop in science classrooms? Do mentors' ethnoracial characteristics have to match their mentees', especially given research that documents a general, negative association in the United States between being non-White and trusting others and institutions (Brehm & Rahn, 1997; Weaver, 2006)?



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## APPENDIX

### COVARIANCES AMONG EXOGENOUS VARIABLES

We began by estimating covariances among exogenous variables including URM, SES, MONTHS, 2006 Trustworthy Mentor, and 2005 Internalized Motivation across groups. The model in which all covariances were constrained to equality across groups ( $\chi^2(34) = 20.79$ ) and the model in which all were freed across groups ( $\chi^2(25) = 12.334$ ) fit equally well ( $\chi^2\Delta(9) = 9.25$ ,  $p > .15$ ). This suggested that covariances among these exogenous variables were equal across groups. Similarly, covariances were equal across groups in the model that included URM, SES, MONTHS, 2006 TR, 2005 IM, and 2005 Graduate School ( $\chi^2\Delta(5) = 6.06$ ,  $p > .15$ ). Covariances were also equal across groups in the model that included URM, SES, MONTHS, 2006 TR, 2005 IM, and 2005 Research Scientist ( $\chi^2\Delta(5) = 1.55$ ,  $p > .15$ ). Thus, all covariances were constrained to equality across groups and imputed to match the values obtained here in subsequent analyses.



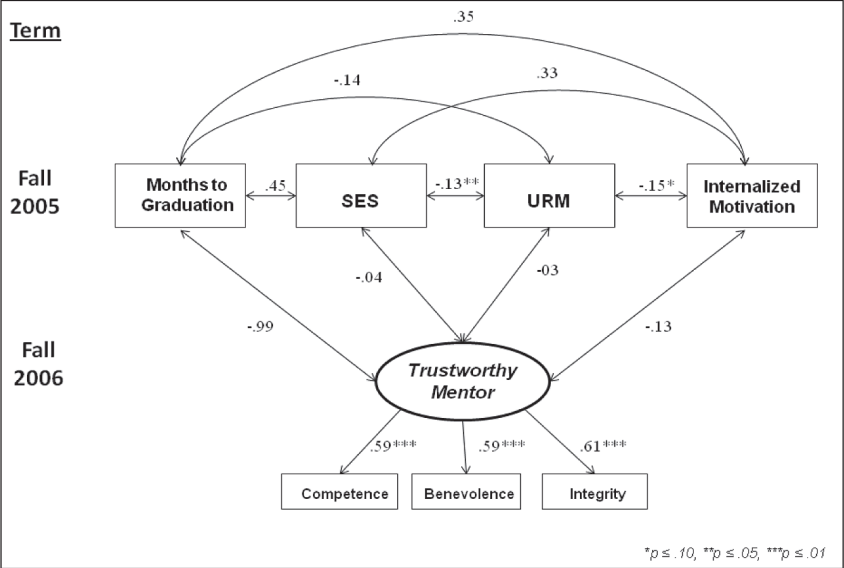
## CONTROL PATHS

We began by regressing 2006 IM on controls including URM, SES, MONTHS, and 2005 IM. The model in which all the paths were equal ( $\chi^2(37) = 35.64$ ) and the model in which all paths were freed across groups ( $\chi^2(33) = 24.10$ ) had a significantly different fit ( $\chi^2\Delta(4) = 11.39, p < .01$ ). To identify which control variable(s) had a significantly different impact on 2006 IM, we tested competing models in which individual paths were freed and compared to the model in which all paths were constrained. Models in which URM, SES, and MONTHS were individually freed did not differ from the fully constrained model. However, the model in which 2005 IM was freed fit significantly better than the model in which all paths were constrained ( $\chi^2\Delta(1) = 31.81, p < .001$ ), suggesting that this path was different across groups. As such, this path was freed to vary across groups in subsequent models where dependent and independent variables of interest were included.

Next, we regressed 2007 Graduate School on controls including URM, SES, MONTHS, and 2005 GS. The model in which all the paths were equal ( $\chi^2(16) = 17.90$ ) and the model in which all paths were freed across groups ( $\chi^2(12) = 7.55$ ) had a significantly different fit ( $\chi^2\Delta(4) = 11.20, p < .01$ ). To identify which control variable(s) had a significantly different impact on 2007 GS, we tested competing models in which individual paths were freed and compared to the model in which all paths were constrained. Models in which URM, SES, and MONTHS were individually freed did not differ from the fully constrained model. However, the model in which 2005 GS was freed fit significantly better than the model in which all paths were constrained ( $\chi^2\Delta(1) = 9.53, p < .01$ ), suggesting that this path was different across groups. As such, this path was freed to vary across groups in subsequent models where dependent and independent variables of interest were included.

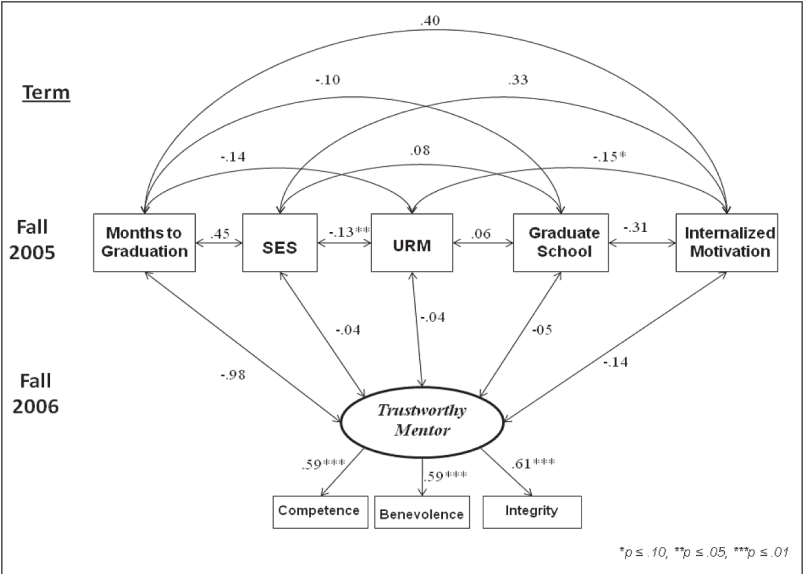
Last, we regressed 2007 Research Scientist on controls including URM, SES, MONTHS, and 2005 RS. The model in which all the paths were equal ( $\chi^2(16) = 10.21$ ) and the model in which all paths were freed across groups ( $\chi^2(12) = 6.60$ ) did not differ significantly ( $\chi^2\Delta(4) = 3.74, p > .15$ ), suggesting that the paths were equal across groups. As such, these paths were constrained to equality across groups in subsequent models where dependent and independent variables of interest were included. See Figures 6–8.

Appendix Figure A1. Covariances among exogenous variables across groups.



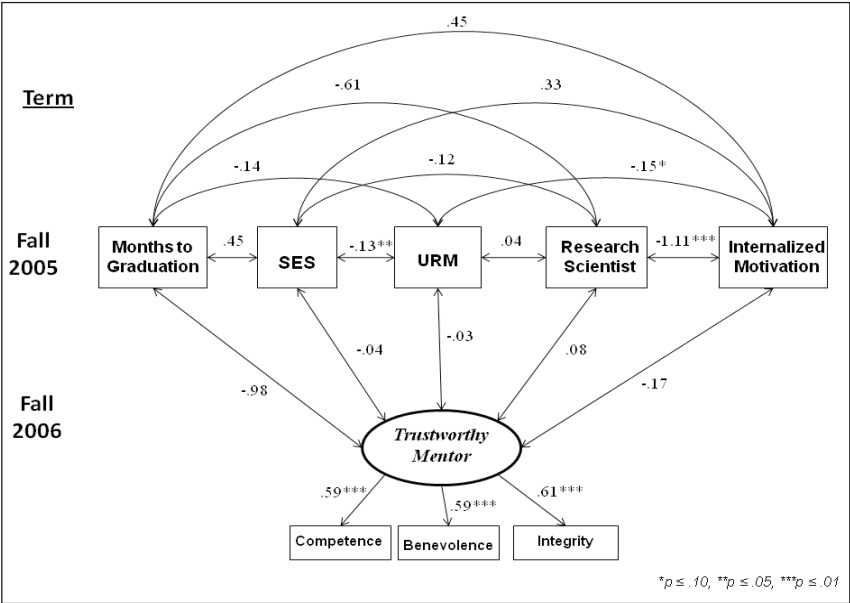
Note: Coefficients are unstandardized. All loadings and covariances are equal across groups.

Appendix Figure A2. Covariances among exogenous variables across groups.



Note. Coefficients are unstandardized. All loadings and covariances are equal across groups.

**Appendix Figure A3. Covariances among exogenous variables across groups.**



Note. Coefficients are unstandardized. All loadings and covariances are equal across groups.

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