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Research Article

Cultivating Minority Scientists: Undergraduate Research Increases Self-Efficacy and Career Ambitions for Underrepresented Students in STEM

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Abstract: In this study, Social Cognitive Career Theory (SCCT) is used to explore changes in the career intentions of students in an undergraduate research experience (URE) program at a large public minority-serving college. Our URE model addresses the challenges of establishing an undergraduate research program within an urban, commuter, underfunded, Minority-Serving Institution (MSI). However, our model reaches beyond a focus on retention and remediation toward scholarly contributions and shifted career aspirations. From a student's first days at the College to beyond their graduation, we have encouraged them to explore their own potential as scientists in a coordinated, sequential, and self-reflective process. As a result, while the program's graduates have traditionally pursued entry-level STEM jobs, graduates participating in mentored research are increasingly focused on professional and academic STEM career tracks involving post-graduate study. In addition to providing an increasingly expected experience and building students' skills, participation in undergraduate research is seen to have a transformative effect on career ambitions for many students at MSIs. While undergraduate research is often thought of in context of majority-serving institutions, we propose that it serves as a powerful equalizer at MSIs. Building on the institutional characteristics that drive diversity, our students produce scholarly work and pursue graduate degrees, in order to address the long-standing under-representation of minorities in the sciences. © 2016 Wiley Periodicals, Inc. J Res Sci Teach 54: 169–194, 2017

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Despite substantial advances and extensive efforts to bridge the divide, significant gaps remain between the educational attainment of minority students and their majority peers (Kao & Thompson, 2003; Viadero & Johnston, 2000). One area of particular concern is in the science, technology, engineering, and mathematics (STEM) fields. As data from the Bureau of Labor Statistics indicate, professional opportunities in STEM fields are expected to grow by some 12.5% between 2012 and 2022, a faster rate than non-STEM fields (Langdon, McKittrick, Beede,

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Khan, & Doms, 2011; U.S. Congress Joint Economic Committee, 2012; Vilorio, 2014). Yet Blacks and Latinos each make up only 6% of the STEM workforce, even though Blacks represent 12.3% and Latinos 17% of the U.S. population (Beede et al., 2011; Santiago, Taylor, & Calderon, 2015). This phenomenon "represents an unconscionable underutilization of our nation's human capital and raises concerns of equity in the U.S. educational and employment systems" (Ong, Wright, Espinoza, & Orfield, 2011, p. 172).

In the late 1990s, we, a leading minority- and Hispanic-serving institution in the Northeastern United States, were faced with a related conundrum—while institutional enrollments in science were defying national trends and increasing, graduation rates were poor, and in fact had stagnated, resulting in a net decrease in retention over time. By the year 2000, there were over 500 undergraduates matriculating in our program yet only 13 graduates. Further, a discrepancy in degree attainment among student subgroups occurred, with minority students consistently less likely to complete the science program. Thus, we were failing in our obligation to provide economic mobility for our students.

Not willing to accept an ability gap between our students and those at other institutions, we began to reflect on how we were teaching science and what support services we were offering. Members of the science faculty designed and implemented a variety of interventions to improve course performance and student retention (see Carpi, Ronan, Falconer, Boyd, & Lents, 2013). In addition, we recognized that we were teaching science as a body of knowledge and not a practice of discovery to be engaged in. In response, we began to explore the impact of engaging these students in the community and practice of science through a formal mentored undergraduate research experience, a program that would later be named the Program for Research Initiatives in Science and Math (PRISM). While the initial goal of PRISM was to aid retention and graduation in our science program (Nagda, Gregerman, Jonides, von Hippel, & Lerner, 1998), tracking post-baccalaureate pathways has revealed that our students are increasingly choosing professional and academic career paths. In this study, we explore students' perceptions of their experience with undergraduate research and how it has impacted their post-baccalaureate choices.

A number of programs promote access to research projects at institutions other than the students' home college. Our model addresses the challenges of establishing an undergraduate research program *within* an urban, underfunded, Minority-Serving Institution (MSI), and thus differs in two significant ways. First, in terms of duration, the undergraduate research experience is a prolonged and iterative process. Second, because it is in-house, the culture of the research program reflects the institution and is responsive to student needs.

Literature on the Impacts of Undergraduate Research

The philosophy underpinning undergraduate participation in research is that by applying classroom knowledge to real-world experiences in a laboratory, students can bridge the gap between classroom academics and practical application (Elgren & Hensel, 2006). The closure of this gap through mentored research encourages students to invest more time and effort into their studies, thereby having a number of positive impacts as reflected in the literature.

Several studies have pointed to specific academic performance gains among undergraduate researchers. Nagda et al. (1998) reported positive impacts on retention of students in the Undergraduate Research Opportunity Program at the University of Michigan, and these impacts were greatest for students at the greatest risk of attrition. Maton, Hrabowski, and Schmitt (2000) have reported increases in grade-point average and graduation rates for students participating in the Meyerhoff Scholars program at the University of Maryland, Baltimore County. And Barlow and Villarejo (Barlow & Villarejo, 2004; Jones, Barlow, & Villarejo, 2010) have shown that students participating in the Biology Undergraduate Scholars program at the University of

California at Davis had greater odds of persisting in basic math and science courses, and of graduating in biology, than did a matched comparison group.

Several studies have pointed to cognitive gains that contribute to self-efficacy and other positive attributes. Hunter, Laursen and Seymour (Hunter, Laursen, & Seymour, 2007; Seymour, Hunter, Laursen, & Deantoni, 2004) attributed significant increases in self-confidence to participation in undergraduate research. Ryder, Leach, and Driver (1999) identified gains in how students perceived themselves fitting into the community and discipline of science. And Lopatto (2007) reported that students participating in a survey of research programs at four liberal arts colleges self-reported gains in independence and intrinsic motivation to learn.

Many studies report that student researchers show enhanced socialization to professional STEM careers, they better understand the demands on scientists and the day-to-day paradigm of conducting research (Bauer & Bennett, 2003; Crawford, Suarez-Balcazar, Reich, Figert, & Nyden, 1996; Hunter et al., 2007; Lopatto, 2004; Russell, Hancock, & McCullough, 2007; Seymour et al., 2004). These gains in research skills have been corroborated by interviews with faculty mentors (Zydney, Bennett, Shahid, & Bauer, 2002). And, as a result, students leave mentored research programs better prepared to discuss research results, give a poster presentation, and apply ethical principles in research (Junge, Quinones, Kakietek, Teodorescu, & Marsteller, 2010).

While these programs share some common components, they often differ in many ways. Russell et al. (2007) attempted to look at how different program components affect positive outcomes and found only two that had significant connections. Students most immersed in the culture of research activity within a laboratory, i.e., those students who had the opportunity to co-author a paper, attend a professional conference, or mentor a younger student, showed greater gains than students not engaged in these activities. Also, the duration of the research experience was correlated with the degree of gains by the student. This later point, that longer experiences are more impactful than short ones, has been corroborated by Thiry, Weston, Laursen, and Hunter (2012).

Some gender differences have been identified through this research. Female students rate their gains in research skills more modestly than male undergraduate researchers (Kardash, 2000). And female students are more likely to attribute increased interest in science with their undergraduate research experiences than are male students (Harsh, Maltese, & Tai, 2012).

Perhaps the most intensely studied, and yet still controversial impact is on post-graduate education and career outcomes. Crawford et al. (1996) found that undergraduate research experiences increased students' ability to gain acceptance to graduate school. In an evaluation of a program at Rice University, Alexander, Foertsch, Daffinrud, and Tapia (1998) found that participants felt the program positively impacted their decisions about, and success in pursuing, advanced degrees. Several other studies have similarly suggested that undergraduate research participants were more likely to pursue graduate education than non-researchers (Bauer & Bennett, 2003; Hathaway, Nagda, & Gregerman, 2002; Jones et al., 2010). However, whether this resulted from their research experience or motivated their participation in these research programs is less clear. In fact, Russell et al. (2007) found that undergraduate research participants were twice as likely as non-participants to have pre-college expectations of obtaining a Ph.D. In an ethnographic study of students at four liberal arts colleges, Seymour, Hunter and colleagues (Hunter et al., 2007; Seymour et al., 2004) found that while undergraduate research increased student interest in graduate school, it did not seem to promote new plans for graduate study among students. Work by Lopatto (2004, 2007) supports this finding. In this cross-institutional survey, over 80% of more than 1,000 respondents continued, rather than started new plans for graduate school. Only 3.5% of respondents reported that research changed their plans toward attending graduate school. However, Russell et al. (2007) further report that in their survey of several thousand students across a range of institutions, undergraduate research experiences had a significant impact in steering students' plans toward obtaining a post-graduate degree. Hrabowski, Maton, and Summers (Maton & Hrabowski, 2004; Summers & Hrabowski, 2006) also found a strong positive correlation between research and post-graduate education when compared to control groups who did not participate in research. In an article in the Chronicle of Higher Education, Guterman (2007) cites scholars who suggest that the differences noted may be due to the academic pre-preparation of students in the various studies. Students at liberal arts colleges and Research-I institutions often enter college with a strong sense of post-graduate career plans and so show less change resulting from their research experiences.

Institutional diversity is in fact an issue facing current studies on undergraduate research. Studies to date have been heavily skewed toward large research institutions (Alexander et al., 1998; Barlow & Villarejo, 2004; Maton et al., 2000; Nagda et al., 1998; Thiry et al., 2012) and liberal arts colleges (Hunter et al., 2007; Lopatto, 2004; Seymour et al., 2004). Though the study by Russell et al. (2007) included a wide cross-section of institutions, and that by Junge et al. (2010) focused on a large Historically Black College.

Methodologically, these studies can also be classified into a small number of categories. The majority consist of surveys given to students, alumni, and/or faculty mentors (Bauer & Bennett, 2003; Harsh et al., 2012; Hathaway et al., 2002; Kardash, 2000; Lopatto, 2007; Russell et al., 2007; Zydney et al., 2002). Several well-structured evaluations have been conducted on individual programs, often with controls identified for comparison (Barlow & Villarejo, 2004; Junge et al., 2010; Maton et al., 2000; Nagda et al., 1998). And Seymour et al. (2004) conducted an ethnographic study of research students at four liberal arts colleges.

The existing literature points to a significant question related to undergraduate research participation—just what effect does participation in undergraduate research have on post-graduate outcomes, especially for students from historically underrepresented groups? More significantly, if these experiences do increase pursuit of post-graduate education among some groups, what is the mechanism by which research experiences affect graduate school expectations? Understanding the differences among various demographic or socio-economic groups will allow us to better tailor programs to the specific needs of the group or groups being served. In this study, we seek to provide an answer to these questions—does undergraduate research lead to new interest among students in pursuing a graduate degree; and if so, by what mechanism is it affecting these career intentions?

Theoretical Framework

Social Cognitive Career Theory (SCCT) is a theoretical framework from the discipline of career counseling that illuminates how learning experiences like undergraduate research experiences (UREs) can impact career ambitions (Brown & Lent, 1996; Lent, Brown, & Hackett, 1994, 2000). Thus, in our effort to explore relationships between UREs and career outcomes, SCCT provides a potential mechanism for changes in career pursuits. SCCT is an outgrowth of Social Cognitive Theory (Bandura, 1977) and positions its elements of self-efficacy and outcome expectancies as drivers of personal career choice actions. Self-efficacy can be defined as "the conviction that one can successfully execute the behavior required to produce the outcomes" (p. 193), whereas outcome expectancy is the expectation that certain behaviors will produce desirable outcomes. In SCCT people's beliefs about themselves are a powerful determinate of career pursuit and attainment. If the student does not believe she would be a candidate of interest to a graduate school, that low self-efficacy will drive the development of career interests, goals, and actions.

In the SCCT model (Figure 1), self-efficacy and outcome expectations are influenced by upstream contributors like personal inputs, background factors, and learning experiences. Personal background factors like socio-economic status and family expectations may affect access to learning experiences. Contextual environmental factors can be distal or proximal and can provide affordances or barriers. For example, a personal input like race or gender may *confer* advantages or disadvantages in a given social context, such as the presence of stereotypes or role models.

To illustrate how SCCT components may interact in the pursuit of research-oriented science careers, consider a Latina first-generation college student. Even when she successfully completes the required science major courses, she may be unlikely to consider herself a candidate for a URE learning experience, or be unaware of the careers paths that require and build upon participation in a URE. Those personal and background factors may impose some barriers in accessing learning experiences, identifying career models, developing self-efficacy and leveraging knowledge of outcome expectancies to discern goals and take career actions. Since individuals are more likely to pursue those careers that match areas of high self-efficacy and whose outcome expectancies have desired attributes, career outcomes associated with UREs remain unexplored or may be prematurely foreclosed in favor of other interests wherein there is a greater degree of confidence.

Brown and Lent (1996) point out that student beliefs about various careers may be faulty and that, as a result, individuals may eliminate some career options prematurely. In particular, students' perceptions of the outcome expectancies associated with those careers may or may not reflect the realities of those fields. While self-efficacy and career goal-setting occur through individual introspection, SCCT describes career discernment as a dynamic and social process, open to the influence of outside parties and new experiences. As a result, interventions aimed at increasing self-efficacy, addressing barriers associated with particular career paths, establishing positive contextual influences, and providing information related to students' outcome expectancies can modify goal-setting and influence career choice.

This model has previously been applied to study student interest and pursuit of STEM fields (e.g., Chakraverty & Tai, 2013; Soldner, Rowan-Kenyon, & Inkelas, 2012), especially among students from groups historically underrepresented in the sciences (e.g., da Silva Cardoso, Dutta & Chiu, 2013; Deemer, Thoman, & Chase, 2014; Lent, Miller, & Smith, 2013) or otherwise vulnerable, as in low-income first generation college students (Garriott, Flores, & Martens, 2013). Lent and his colleagues (2005) explored the career interests and goals of students in introductory engineering courses at both predominantly White and historically Black colleges, finding that

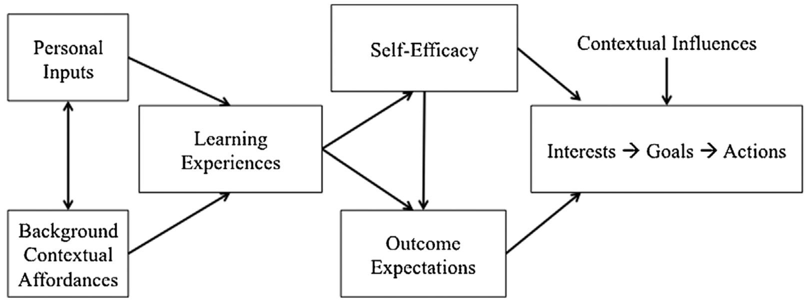

Figure 1. Model of social cognitive influences on career choice behavior. Adapted from "Toward a UnifyingSocial Cognitive Theory of Career and Academic Interest, Choice, and Performance." [Monograph] R.W. Lent, S.D. Brown, and G. Hackett, 1994, Journal of Vocational Behavior, 45, p. 93. Copyright 1994 by R.W. Lent, S.D. Brown, and G. Hackett.

measures of SCCT components were predictive of interests and goals in engineering. Da Silva Cardosso et al. (2013) found that a regression model based on SCCT did identify predictors of STEM career goals. SCCT has also been used to study and describe contextual factors related to STEM career persistence and, where possible, tease out mechanisms of action such as community-building interventions (Soldner et al., 2012) or stereotype threat (Deemer et al., 2014).

URE Hypothesized Role in SCCT

We hypothesize that a URE can function as a powerful contextual factor according to the SCCT model and can thereby influence career choice behavior among its participants. First, we conceptualize a URE as a learning experience through which participants build science self-efficacy and gain knowledge of appropriate outcome expectations. Second, we position mentorship as a proximal contextual affordance, with proximity to career interests, goals, and actions. The extent to which URE provides social supports and other contextual affordances outside of mentorship depends upon the design of the program. Third, we propose that students experience elements of the SCCT framework in an iterative process. While most studies look at a singular personal career choice endpoint, or a major choice as a proxy thereof, we conceptualize a more step-wise process wherein the URE provides incremental acculturation to career pathways and eventual post-graduate actions.

Thus, through a URE oriented toward such ends, our Latina first generation college student may experience a transformation in her career intentions. Her mentor may act as a career model and help to build self-efficacy and confidence gradually through increasingly professional career-relevant learning experiences. She can be exposed to additional career possibilities, gain knowledge of relevant outcome expectancies, and be supported as she takes the steps to turn interests into actions.

The purpose of this study was to establish whether there is evidence of such a transformation of career intentions associated with participation in a URE, and how that transformation may be associated with SCCT elements like self-efficacy, especially for students from traditionally underrepresented groups. As such, the following research questions guided this study:

(1) How do students and faculty view the various learning components of an undergraduate research program?
(2) How does an undergraduate research experience influence students' knowledge about and self-efficacy in pursuing science careers, especially students from traditionally underrepresented groups?
(3) To what extent does an undergraduate research program influence students' career choice behavior, especially students from traditionally underrepresented groups?

Methods

Methodology

To pursue the research questions, we framed a case study of our URE, the PRISM program at John Jay College, City University of New York. The case study affords for rich description of a complex context, within the bounds of a defined system, in this case an educational program (Creswell, 2007). Specifically, we followed Merriam's (2009) guidance for evaluative case studies, "case study is best because it provides thick description, is grounded, is holistic and lifelike, simplifies data to be considered by the reader, illuminates meanings, and can communicate tacit knowledge" (Merriam, 2009, p. 49). This approach also matches the richness of SCCT, which draws upon interconnected internal constructs such as self-efficacy, interests, and goals. As a grassroots intervention wherein educational research was a secondary outcome, a case study design suited the realities and methodological limitations imposed by uncontrolled conditions, like voluntary participation by students. Because the case study began after the launch and early success of the program, some data collection efforts were retrospective, whereas later cohorts participated concurrently. Data collection took place over 3 years leading up to the questionnaire distribution. The case study presented herein is part of a multi-phase effort to evaluate the URE program, other portions of which will focus on robust quantitative comparisons. Future collaborations with other institutions and programs will also address some of the shortcomings inherent in this single-site case study.

Case study design capitalized upon our insider knowledge while necessitating an examination of biases and assumptions. To guard against promoting our own idealized notions of the program, we practiced critical reflexivity (Creswell, 2007) and took a number of procedural actions. These included utilizing reports from our external evaluator, seeking data from students with mentors other than the authors, and enlisting the second author to conduct interviews. The second author has a Ph.D. in Science Education and is not involved in the day-to-day operations or leadership of the program.

Data Sources

This case study entailed analysis of institutional and program data, artifacts of student work and program development (including student research proposals, publications, and grant applications), both formal and informal interviews and focus groups with faculty mentors and student participants, as well as our observations and reflections as the founders and administrators of the program. Consistent language was used across data collection efforts, enhancing reliability and allowing for triangulation and comparison across students and across a student's experience with the program. Interview and focus group protocols and student surveys were designed to address questions of program evaluation, primarily for the purposes of grant reporting. As such, they reflected the language and goals of our funders. Protocols and surveys were refined after piloting. In this context, we prioritized data collection methods that allow participants to share their voices and stories in their own words, essential in the effort to characterize the experience of traditionally marginalized students.

When preliminary analysis suggested a change in career intentions, we developed and administered an open-ended questionnaire for both current students and alumni to probe this area further. The questionnaire asked students about their career ambitions upon entry to the College, any shifts in their ambitions, and to what they attributed those shifts. The questionnaire then asked students directly to comment upon their personal experience with URE and how influential it was for their career path. These items reflect the language and content of relevant portions of the previously validated Undergraduate Research Student Self-Assessment (URSSA) (Hunter, Weston, Laursen, & Thiry, 2009). Open-ended items on the questionnaire were piloted during focus groups with students. The survey was distributed through email contacts and solicited 47 online respondents, including 77% of eligible current student respondents. Survey participants included 30 women and 17 men, across 10 cohorts of program graduates. Nearly 75% of survey participants are from underrepresented groups in the sciences, including 43% Black and Hispanic/ Latin American students, in-line with program data.

Data Analysis

Preliminary data analysis was shared by all authors, shaping the collection of further data and the eventual focus on shifts in career ambitions. Interview and focus group recordings were transcribed *verbatim* and coded using an open emergent scheme that directed continued refinement of questions. Names of initial codes were derived from the data (e.g., "confidence") or from the literature (e.g., "self-efficacy"). Related codes were consolidated into categories that were then aligned with the theoretical framework. Coding categories and example data segments are listed in Supporting Information Table S1. The researchers engaged in monthly ongoing conversation about findings and patterns regarding student career choice, emergent themes, and alignment of findings with the theoretical framework. Program data were obtained and cross-referenced with Institutional data. Questionnaire responses were coded for graduate school intentions using a dichotomous system. After independent coding of the entire sample by the first and second authors, instances of disagreement were discussed and used to refine interpretations until complete inter-rater agreement was reached. Various past and present stewards of the program were invited to provide feedback regarding the interpretation of artifacts and to validate our descriptive statistics and numerical claims.

Institutional Context

John Jay College (JJC), a senior college within the City University System has been recognized as a leading 4-year Hispanic-Serving Institution in the Northeast (John Jay College on the Move, 2006). Located in Manhattan, the College is well-known in the field of criminal justice and related areas of public service. Of the more than 12,000 undergraduates at JJC, 41% identify themselves as Hispanic and 21% identify as Black (John Jay College, 2013). Additionally, more than 42% are first-generation college students, 14% are parents, 81% receive financial assistance, over 50% come from homes earning less than $30,000 per year, and 63% work more than 20 hours/week while attending classes (John Jay College, 2013; National Center for Education Statistics, 2009). The Department of Sciences at JJC offers a Bachelor of Science degree in Forensic Science consisting of 72 credits of natural science courses, with three tracks of specialization: Criminalistics, Toxicology, and Molecular Biology. The major is heavily based in analytical chemistry, and closely resembles that of a chemistry major with specialization at the upper division.

Program Description: PRISM

Background and Mission. Through the late 1990s, undergraduate science majors learned basic scientific skills through traditional lecture and laboratory courses in biology, chemistry, and physics, engaging in standard sets of procedures with prescribed outcomes. There was no formal support system for undergraduate research and, as such, active mentorship of undergraduates in the laboratory setting was rare. A semester-long external internship at one of several local laboratories served as a capstone requirement, wherein students carried out technical procedures akin to entry-level work. In the early 2000s, several faculty began to secure grants to implement an array of student-centered support services (Carpi et al., 2013). Chief among these was the implementation of a mentored undergraduate research program. Unlike laboratory courses that are often designed to give precise outcomes, undergraduate researchers benefit from the realization that science is not a predictable path (Aikenhead, 1996). Though efforts have been made to incorporate research-like experiences in the classroom, structured semester-long courses cannot capture the actual pace and conditions under which original research takes place.

Beginning in 2001, we secured a small grant that enabled a programmatic shift toward mentored undergraduate research. One to two students a year were paired with mentors, provided with small stipends, and given support for conference travel. In our first graduating class, all three of those students paired with mentors moved on to, and obtained, a STEM Ph.D. degree. This was an astonishing result for a program that had sent only five undergraduates on to M.D. or Ph.D. programs in the entire previous decade. As a result, we began to focus on securing funding to expand this program. In 2006, with funding from several sources in hand, we formed PRISM, the Program for Research Initiatives in Science and Math, to formalize and codify research activities, centralize initiatives, provide coordination for future funding efforts, and brand the effort within the College. Unlike remediation and support interventions that are common at Minority- and Hispanic-Serving Institutions including JJC, PRISM was not founded to address a skill deficit, but as a program of excellence. Its mission was to provide access to a high-quality mentored undergraduate research experience while addressing known barriers for underrepresented and under-privileged students.

Like many research experience programs for undergraduates, the goal was for students to engage in meaningful activities that foster close working relationships with faculty and peer researchers. The program was conceptualized as an apprenticeship and can be understood through the lens of legitimate peripheral participation (Lave & Wenger, 1991) wherein a newcomer is taken in by a sponsor, learns increasingly complex tasks, and becomes increasingly acculturated into the ways of knowing and being particular to that community of practice. Legitimate peripheral participation has been previously applied to identity development in the sciences (Brickhouse, Lowery, & Schultz, 2000) as well as learning through research apprenticeships (Feldman, Divoll, & Rogan-Klyve, 2009). In addition to apprenticeship in the laboratory, the surrounding services of the PRISM program are aligned with Tinto's (1993) model for supporting student success through social and academic integration. Program elements were influenced by other successful programs marrying academic supports with rigorous research experiences for underrepresented students, such as the Biology Undergraduate Scholars Program (Barlow & Villarejo, 2004).

In the sections below, we describe the major elements of the PRISM program.

Recruitment. From their earliest days on campus students were invited to PRISM information sessions and seminars to build awareness. Based on performance in academic courses, students were actively recruited in their sophomore year to participate in a 1-week faculty-led research training course to prepare them for the PRISM application process. Students were then paired with a faculty mentor, prepared a research proposal in collaboration with their mentor, and signed a contract of participation. Rather than simply posting an open call for proposals, this layered entry and recruitment process ensured the broadest access possible. As such, we did not assume that students were aware of research opportunities, how participating in research would affect future career paths, or how to write a research proposal. Active recruitment and support through the application process maximized student participation, especially among historically underrepresented student groups.

Mentorship. The heart of the PRISM program was the student-mentor relationship. Simply arranging for students to observe and spend time in laboratory environments is not sufficient to establish self-efficacy for original research. Faculty development seminars were held at the launch of the program to convey expectations regarding mentorship. Mentors met as a group each semester for professional development and to discuss program goals. Students worked with their mentor for 1–3 years, distinguishing PRISM from short-term URE programs that may occur over a semester or summer break. As reported previously (Russell et al., 2007; Thiry et al., 2012), we feel strongly that the lasting nature of the relationship was essential to its success in having impacts on self-perception, self-efficacy, and future ambitions. Further, as a primarily undergraduate institution, PRISM students often interacted with their faculty mentors directly, rather than through a chain of master's students, doctoral students, and post-doctoral fellows. This "flattened" research pyramid afforded a close working relationship between students and mentors and opportunities for older undergraduates to assume leadership and training roles. The balance of independence and supervision makes PRISM a distinctly undergraduate program, not necessarily appropriate for younger students and unnecessarily scaffolded for graduate students already on a professional track.

Community. The program used monthly meetings and regular group field trips to foster a social community and ultimately a sense of belonging in this scientific community, especially important for students from ethnic backgrounds historically underrepresented in science. These students discussed their research with peers and near-peers, stimulating new insights and solutions. The group problem-solving went beyond the lab to include issues like balancing work, home, and academic responsibilities, communication and presentation skills, negotiating degree requirements and graduate school applications. While social networks are certainly not unique to PRISM, the research community at an MSI reflected the values and character of the students therein. Students had the opportunity to develop their identity and self-efficacy in a setting where role models such as upperclassmen and recent alumni share similar demographic profiles and life experiences. By creating this student network, the program addressed two particularly key factors in undergraduate attrition: social support systems and understanding of the formal structures of the institution (Saunders & Serna, 2004; Tinto, 2000; Tinto & Goodsell-Love, 1993).

Addressing Financial Barriers. Considering the desired level of commitment to the program and the high proportion of low-income students in populations like ours, stipends were dispersed to offset the costs that students might otherwise have to cover through outside employment. In addition, students could fully satisfy their science bachelor's degree capstone requirement by conducting 400 hours of mentored research. Both course credits and stipends served to reinforce the importance and legitimacy of student research. PRISM students were also encouraged to attend professional conferences and meetings, with the program providing funds for transportation, lodging, conference fees, and meals. Financial support is one of the most obvious and direct ways to enable broad participation of students, giving them the freedom to exchange non-career relevant work for an experience that supports their developing career ambitions.

Professionalization. The academic science community has practices and language that students must navigate, from the way research questions are identified to the sharing of ideas at conferences and the reproduction of knowledge in academic journal publications. To assist students in developing research and communication skills, PRISM provided scaffolded experiences for students. The internal proposal submission process modeled scientific proposal writing. Students received feedback on their proposal both from their mentor and an objective third-party Program Coordinator. As an iterative process, students were expected to improve and build upon these proposals in each subsequent term to receive continued funding for their work. PRISM sponsored an annual on-campus research symposium where students create and present posters of their work. In preparation, regular lab group meetings and monthly PRISM meetings provided an informal forum to learn from others, rehearse presentation skills and receive feedback. As their research and communication skills matured, students began to participate in outside research events, including academic conferences organized for undergraduates and professional scientists. Before traveling to these external events, students were couched by their mentors and the Program Coordinator on the nuances of scientific presentation and the scientific community.

Students at an MSI like John Jay College benefit especially from the communication support aspects of the program. Many are first-generation college students, do not speak English at home, and are the first in their families to go to College, let alone pursue a professional STEM career. Interventions in this area have an explicit focus on building self-efficacy and confidence in these career-relevant forms of communication (Russell et al., 2007; Seymour et al., 2004).

Post-Baccalaureate Planning. As part of the commitment to increase Hispanic and minority representation in STEM disciplines and degree programs, the PRISM program explicitly promoted Ph.D. and other graduate programs through both informal mentor counseling and formal program events. During monthly meetings, representatives from graduate programs and recent alumni visited campus to discuss opportunities available to graduating students. This career guidance clarified for students the careers they can expect with specific degrees (e.g., Ph.D. vs. M.D.).

Students gain information about career options and pathways from their older peers and mentors as well as formal PRISM programs. As such, scaffolding was formally embedded into the program in which many older students in research laboratories were provided stipends to serve as mentors to their younger peers—training them in methods, talking to them about course scheduling and career planning, and joining in outings and other events whenever possible. The participation of recent alumni in events also underscored student perceptions of their own potential, and each year multiple alumni were invited back to talk to younger students about their current career trajectory and research.

PRISM's Program Coordinator provided individualized guidance and assistance with application requirements such as writing personal statements, preparing for the Graduate Record Examination, requesting references, honing interview skills and other graduate school application requirements. By design, PRISM took responsibility for guiding students through the formal structures and timelines associated with admissions to graduate institutions (Saunders & Serna, 2004) whereas they might otherwise be barriers, especially to first generation college students. In addition to assisting with the formation of their ultimate goals and aspirations, PRISM helped students with their post-graduate transition.

Findings

Learning Experiences

Understanding and Adjusting to the Nature of Science. Students and faculty described the PRISM URE as a learning experience different than their academic classes in the sciences.

> Some of our [classroom] labs lean toward being more independent – the upper level labs involve identifying unknowns. But even if they're identifying unknowns, they eventually find out whether they're right or wrong. . .Even the most open-ended labs don't give them a sense of how open-ended science is. . .. There are some misconceptions that are conveyed by those labs that we have to break them out of. *Faculty Mentor A*

> . . .Understanding that this isn't the same as a typical lab where we give you a protocol and we know what the outcome should be and we assess it. But rather you're in uncharted territory and you have to understand that the lab world is completely different than the classroom. Develop your inquisitive nature more because I think that's kind of suppressed. After memorizing so much for class that by the time you get to a lab you're like 'there's no protocol; what do I do?'. . .And in a lot of cases I have to remind them that we're trying something new, we're going to have to figure out how to make it work. *Faculty Mentor B*

Students must shift from being a member of a community of practice of those *learning about* science to being in a community of practice of those *doing* science.

Facilitating this transition is a major function of the undergraduate research faculty mentor. This experience has become more available to students as the program has grown, as shown in Figure 2.

Mentorship. Students cited their mentors as the key influence in the lab environment, guiding them to become productive members of the lab community.

> I had an amazing opportunity to work with [my research mentor]. This was one of the most fulfilling experiences I have had at my time at John Jay College. With his mentorship I believe I became the critical and well-versed scientist I am today. *Black female, survey response*

> I made a lot of mistakes and learned a lot from them. I'm sure [my mentor] was frustrated at least a few times with me, but she handled it very well. She would just talk to me and ask me to repeat the experiment with proper techniques. I was usually around her when she went through my data, which immensely helped me in formulating hypotheses based on the data. One more thing that really helped me was that she asked me to search for papers and protocols. I hadn't done that before but I learned. Looking back, I can tell how many of my present habits (somewhat improved now) were started in [her] lab. *Black male, survey response*

PRISM students experienced a form of deep mentorship that was differentiated to their needs, abilities, and the demands of their other commitments. The average duration of participation among PRISM graduates was over 2 years. Over the course of these years, students gained practice with many steps of the research process—engaging with the literature, weighing different protocols, planning an investigation, learning new techniques, and collecting and presenting data. Students also began to consider some important questions regarding their role as apprentices—how to ask for guidance, what resources to consult, and when findings should be shared. These questions are crucial in establishing a strong relationship with a faculty mentor, and more broadly understanding how to work within a community of professional scientists.

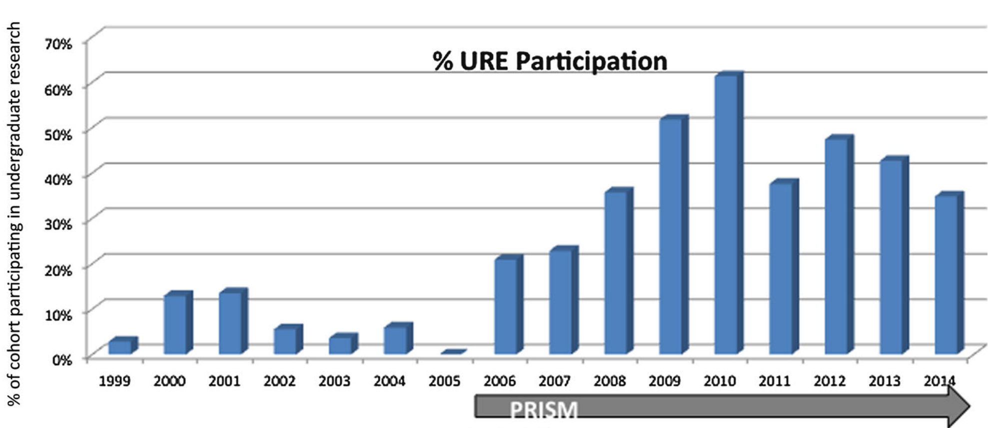

Figure 2. Student participation in undergraduate research, before and during the PRISM program. [Color figure can be viewed at wileyonlinelibrary.com].

Social Supports. Another layer of the student's URE learning experience is the peer relationships with others working with the same mentor and with the PRISM student community overall. One faculty member describes how he structures his research lab to prioritize peer-to-peer learning and socialization of a new researcher,

> For the first couple of months you're basically just watching, learning, and doing chores. . .the chores that you get will be different depending on how long you've been in the lab but we all have chores. . ..washing glassware, going to get fresh water, filling up the water tanks, cleaning out the hot water baths, filling up pipette tip boxes, doing the autoclaving. That would be the lowest level skills . . ..We plan our days around [new lab members]. . . the rest of us can keep it in mind and schedule time so that there'll be things going on that you can learn. . . While you're getting trained you learn by being around it. *Faculty Mentor C*

This first level of lab chores is decidedly low-skill work, however, it is justified in that it provides access to "a wide range of ongoing activity, old-timers, and other members of the community; and to information, resources, and opportunities for participation" (Lave & Wenger, 1991, p. 101). From this generalized role, students learn the physical, conceptual, and social structure of the lab.

Membership in this group involves students in a robust culture of science, both within and beyond their individual lab groups.

> You keep staying in a scientific environment with other people that are doing well and other people that are trying to do even better so the whole culture helped. *PRISM alum*

Increasing Professionalization. As students progressed through PRISM, they became increasingly immersed in the professional community of scientists. This generally began with a low-stakes presentation at a lab group meeting and progressed through a more formal on-campus Symposium event. This paves the way for attending and presenting at a professional scientific conference, whether specifically for undergraduate researchers or for an academic field.

> PRISM allowed me the opportunity to go to present my work at different conferences giving me the confidence to talk science. *Latina female, survey response*

When students can attend a conference and engage in communication successfully with other professionals in the field, it is an empowering experience. Faculty Mentor B described the incremental goal-setting that occurred within his research group.

> Getting posters [accepted] helps, going to a conference. At least they see it's a first step. And it's outside of the college so it's advancing their career. We have three goals this year. Starting last summer, we set a one-year goal to attend a conference,. . .apply to summer programs, we had a goal of at least 5 each and the last one was write your own project proposals. . . Now for next year the goals become ok let's go to a conference again, let's at least have a publication that we submit. *Faculty Mentor B*

Because students contributed meaningfully to ongoing original research and played a role in writing and submitting academic journal articles, many students earned authorship, a major credential of the scientific community.

During their time in PRISM, students contributed to a large volume of scholarly work, including conference presentations and academic publications, summarized in Table 1 and enumerated in Supporting Information Tables S2 and S3. Table 2 compares scholarly output from

Table 1
Scholarly work produced by PRISM students since 2006

No. of students presenting at one or more external academic conferences during their time in PRISM	56
No. of external academic conference presentations delivered by PRISM students	59
No. of published peer-reviewed academic journal articles with PRISM students as authors or co-authors	27
No. of PRISM students listed as author or co-author on one or more published peer-reviewed journal articles	42

PRISM participants with other published studies of undergraduate research programs. Whereas Thiry et al. (2012) found that as many as 10% of undergraduate researchers had been a co-author on a published paper; among PRISM graduates, this rate is nearly triple, with 32% of undergraduates serving as a co-author on a published paper (Table 2). Without PRISM, students at John Jay College would not have had access to these opportunities. The expectation that PRISM students actively contribute to ongoing research distinguishes it from programs at some research universities where undergraduates may be "seen as temporary members who can, for example, develop the skills to help maintain the laboratory and collect data, but are not expected to contribute much if anything to the analysis of data or the creation of new knowledge" (Feldman et al., 2009, p. 450). Despite attending an institution that is disadvantaged in terms of space, financial resources, and even faculty time (due to a high teaching load), PRISM students exceeded expectations of undergraduate research excellence and scholarship.

Proximal Career Choice Influence

In addition to serving as a learning experience, PRISM components served as proximal career choice influences, impacting outcome expectancies and self-efficacy for students pursuing careers in science.

Table 2
PRISM student scholarly involvement since 2006, compared with other published studies

	Thiry et al. (2012) Survey of Four UR Programs at Two Research-Extensive Universities ($N = 73$)	Hunter et al. (2007) Survey of Four UR Programs at Four Liberal Arts Colleges ($N = 76$)	Chaplin et al. (1998) Biology Research Course ($N = 47$)	PRISM Program at John Jay College ($N = 130$)
% of students presenting at one or more external academic conferences	Approximately 10%	9.20%	17.02%	43.08%
% of students listed as author or co-author on one or more published peer-reviewed journal articles		6.60%	(Not reported)	32.31%

Outcome Expectancy. Many students described changes in their knowledge of career paths as an outcome of their experience with PRISM. PRISM provided career knowledge through focused programming and through mentors.

> Being the first in my family to attend college, I was very unaware of the many opportunities available in science. I had always thought that I'd graduate and get a job, but had no further plans for my career. It was [my mentor] who first introduced me to the idea of attending graduate school to further my education and gave me the confidence to pursue it. The experience in his lab also helped me define what I truly wanted to do. *Latina female alumna*

As students learn more about career paths in Forensic Science and science in general, they find that some of their previous working conceptions of career paths were faulty.

> I kind of thought that within 2 years I would apply to either the Police Academy or the FBI Academy and I would be an officer working in the scientific division. I had no concept really of higher education or the workforce beyond that... [Three faculty members] approached me and my friend about joining the [research] program and I thought, ok this is kind of like an honors program, this is cool, I'll do this for the experience. Then at some point they told us that they were grooming us for Ph.D.s and it never crossed my mind that that's what they were doing. *Black male alum, interview*

Learning more about prerequisite qualifications for a particular job prompted a re-examination of this student's interest and values and the development of a new career goal. In addition to providing the relevant information about career paths, PRISM provided a URE that has become increasingly expected among applicants.

> Undergraduate research at John Jay College was pivotal in preparing me for grad school level research and gave me an edge above my peers in being a competent and well-trained student. *Latino male, survey response*

By providing experiences and information related to career outcome expectancies, PRISM addresses known barriers to STEM participation by traditionally underrepresented students.

Self-Efficacy. Through PRISM, students were exposed to high-level careers in the sciences and familiarized with the process for gaining entry into elite graduate programs. All of this would be for naught, however, if the students did not see these paths as true and viable options for them. Many students spontaneously described gains in self-efficacy when asked to describe the impact of their URE in PRISM.

> When I started John Jay College I was not sure I would be able to complete this major, as I had no science background. . .Now that I have completed most of this major my ambitions are sky high. As I am still unsure of my future career, I now know that I have what it takes to go to grad school. . . This [research] experience is absolutely life changing and I could not ask for a more amazing mentor. *White female, survey response*

> [Research] made me realize how much I loved being in the lab and that I could conduct research independently. I was also introduced to the idea of graduate school, something I hadn't previously considered. *White female, survey response*

> Being able to have been in PRISM and having that research experience, and being an intern where I am now and doing research there, it's really helped me a lot. So it has made me realize that this is what I like to do. This is what I am good at, what I plan to pursue later on.
> *Asian female alumna*

These students gained self-efficacy specific to their skills as research scientists. It bears noting that female students were more likely to express gains in confidence in talking about their experiences, and this is consistent with the literature (Harsh et al., 2012). Bandura's model outlines several sources of self-efficacy, including verbal persuasion and mastery experiences. In the vignette below, a student expresses her newfound self-efficacy, illustrating the effect of a mastery experience (attending an academic conference) and the verbal persuasion of her mentor.

> When I first started the forensic science program I wasn't really interested in research... I didn't think I was capable . . . This [project] basically [is] my creation, with help from my mentor and from other people. I had to come up with the protocol. There was a lot of troubleshooting, a lot of research, a lot of investigation. I would have never thought this was possible for me. I'm pretty proud of myself because I've been doing this for about a year and a half now, almost two years and I can't imagine not doing it... I never thought that this was going to be me. So it has taken me to places that I had never thought that I would ever be, but is possible.
>
> There was a moment [of doubt] at the conference... I had a moment where I just wanted to go to the bathroom and say forget it, I can't do this, I can't. But once you get passionate about something it changes your opinion about everything. That day I was nervous but once you start talking about it, you start realizing- I've done a lot. Once you really start actually going through everything you realize this is all me. I have done all of this. . . Only because of nervousness or fear but that's what my mentor was for. . . I was stuck in that spot by my poster with like eighty million posters all around me and I kind of looked at my mentor. We are all the way in California and I was like, he believes in me so much that I've got to believe in myself. A lot of it was for him, but for somebody to believe in you that much there's got to be something there. You've got to tell yourself that and I kept going and if I hadn't, I would have never won. And I got my award, and I feel great about it now
> *Black female student*

In presenting a poster or giving a talk, students knew that they were engaging in an authentic activity and drew confidence from their success.

Career Choice Behavior

As the program grew, there was a concurrent increase in the number of students attending graduate school (see Figure 3), including Ph.D., M.D., and Ph.D./M.D. programs. To determine whether this was due to a difference in the intentions of students entering the program, or whether the program itself shifted intentions, our survey asked students to reflect on their graduate school and career intentions before entering and upon graduating from the PRISM program. Of the 47 PRISM students and alumni who participated in our survey, eleven cited a pre-existing interest in graduate school at the time they began their undergraduate studies. Of those with no previous graduate school intentions, 23 students (68%) developed an interest in pursuing graduate school during the course of their PRISM experience. We examined this shift as a function of gender and race in Tables 3 and 4. Female and male students were equally likely to report a shift in their intentions, with 52% and 50% of all respondents reporting shifts, respectively. However, there was a significant co-variance of changed intentions with demographics, with 79% of Hispanic students

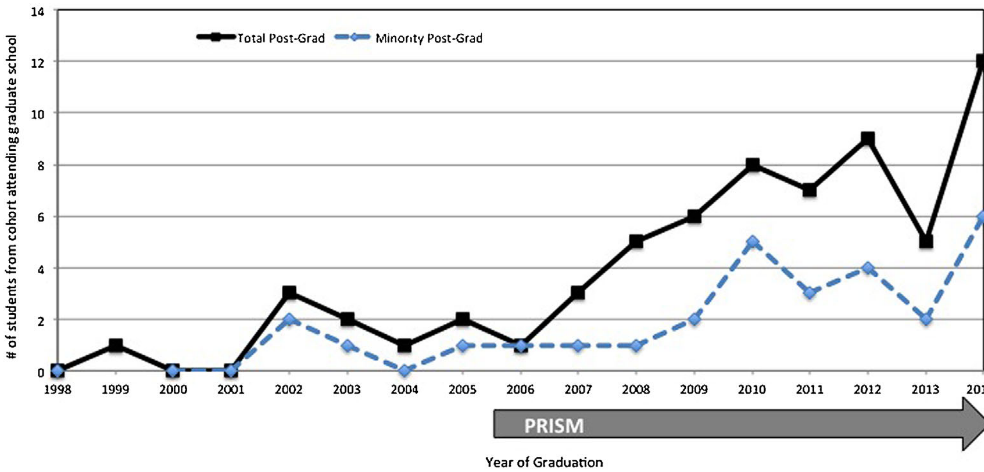

Figure 3. Graduate school attendance of PRISM graduates by cohort. *Because students do not always matriculate directly to graduate school upon earning their Bachelors, these numbers reflect early returns for graduate school attendance and will likely increase over time. [Color figure can be viewed at wileyonlinelibrary.com].

and 54% of Black students reporting a shift in their intentions to attend graduate school, while only 33% of Asian students and 28% of White students report the same shift. Examples of initial and subsequent career ambitions are listed in Table 5.

To further explore whether students attribute this shift in post-secondary outcomes to their participation in PRISM, students were asked to rate on a scale of 1 (little influence) to 5 (very important influence) “To what extent would you say your experience with undergraduate research influenced your career path?” Little difference was seen between females and males, the average rating among female students was 4.2 and 4.4 among males. However, again, greater differences were seen by race, with Hispanic student responses averaging 4.6, and Blacks 4.4, while Asian students rated the experience as less influential at 3.7. White students fell in between these two groups with an average rating of 4.2. These ratings corresponded to intentions, with students reporting a change in graduate school intentions averaging 4.6 in their responses, and those who indicated no intention to attend graduate school both before and after the experience averaging a 3.5 response. Those students who expected to attend graduate school before entering the program, also rated the program as highly influential (4.5) even though their intentions showed no change. On student describes her shift in intentions below.

Table 3
Female and male student intentions to attend STEM graduate school prior to and post-participation in the PRISM undergraduate research program

	No to No	Yes to Yes	No to Yes
Male ($n = 16$)	4 (25%)	4 (25%)	8 (50%)
Female ($n = 29$)	7 (24%)	7 (24%)	15 (52%)

Table 4
Student intentions to attend STEM graduate school prior to and post-participation in the PRISM undergraduate research program by race

	No to No	Yes to Yes	No to Yes
Asian ($n = 6$)	1 (16%)	3 (50%)	2 (33%)
Black ($n = 11$)	3 (27%)	2 (18%)	6 (54%)
Hispanic ($n = 14$)	2 (14%)	1 (7%)	11 (79%)
White ($n = 14$)	5 (36%)	5 (36%)	4 (28%)

> I came to understand that there are constant challenges that come with research and how it is necessary to have flexible thinking. Research uses more creative thinking rather than doing routine experiments which might be prevalent in jobs such as a lab technician. This made me want to pursue becoming a researcher and to obtain a Ph. D. *Black female, survey response*

For many students, graduate school was not something they considered as a possibility when envisioning their future. PRISM exposed students to a landscape of potential degrees and then provided the experience and advising they would need to be successful candidates. These dual functions of graduate school exposure and advising relied on each other—without exposure, there would be minimal demand for advisory services and without advising, many interested students would face barriers in gaining admittance.

Through PRISM, faculty mentors broaden students' knowledge about career options, prepare them intellectually and technically for further study, provide the conditions under which a student may fall in love with the scientific pursuit and, critically, provide a boost of confidence as students contemplate their next steps.

Table 5
Sample student-reported career shifts

Demographic Profile	Initial Career Interest	Subsequent Career Interest
Latino male	Forensic Scientist	Medical Research
Black male	Wanted to work in the field of forensics	Hopefully pursue a research career in either academia or industry. Academia being preferred
White female	I wanted to obtain a BS in forensic sciences, and work in a lab such as the NY OCME	I am currently enrolled in a PhD program in emerging infectious diseases at the Uniformed Services University of Health Sciences, and hope to obtain a research position at a university or within a government agency upon graduation and completion of a post-doctoral fellowship
Latina student	To simply graduate and work in a forensics lab	I want to get my PhD in a biology related field and hopefully work in the pharmaceutical industry or with the government
Asian-American male	To graduate with a BS in Forensic Science and get a job	Now I wish to pursue a Ph.D. in Pharmaceutical Sciences

Institutional Transformation

In addition to the student-centered effects discussed, an emergent finding from this case study was a transformation in the culture of the Department and the STEM research climate in general at John Jay College during the same time period. As undergraduate mentoring took hold as an activity within the Department, searches increasingly focused on research-active faculty who themselves prioritized student mentoring. This was essential to ensure sufficient access to mentors as the PRISM program expanded. Further, as the success of the program became evident, institutional confidence grew as did the commitment to further invest in the program. Thus, when the need for additional mentors and facilities arose, significant resources were dedicated to the Department and the size of the Department grew commensurately. Figure 4 shows the incremental change in size and research activity of the science faculty before and after the initial focus on research mentoring in 2001 and the launch of the PRISM program in 2006.

The shift toward student-centered research was further institutionalized in 2010 when the Department adopted a new mission statement. As stated in the original mission of the Department dating to the 1990s, "The goal of the major is to educate students in the broad principles of the sciences with the aim of their assuming technical positions." The new mission statement adopted in 2010 acknowledges post-graduate opportunities for students and professional science careers, "to equip students with the skills needed to pursue advanced educational opportunities, and to prepare them to become scientific professionals." Another outcome of the transformation of the Department was a nearly threefold increase in the number of graduates from the Forensic Science major (John Jay College Office of Institutional Research, 2013). The increase in graduation numbers was true for the general population of STEM students as well as the subgroups of Black and Hispanic STEM students (see Figure 5). While this increase coincides with the implementation of a number of programs designed to address retention (described in Carpi et al., 2013), PRISM is the flagship program of excellence within this group.

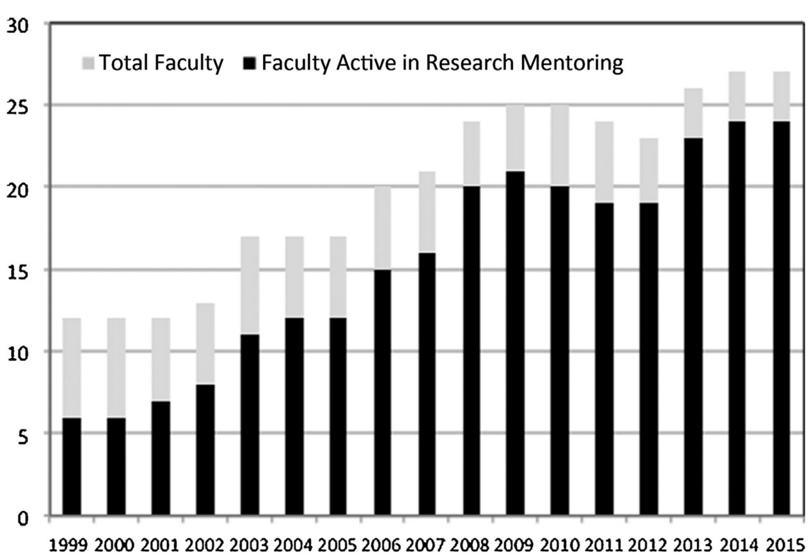

Figure 4. Change in the size and research activity of faculty within the Department of Sciences at John Jay College before and after the initial focus on research mentoring in 2001 and the launch of the PRISM program in 2006.

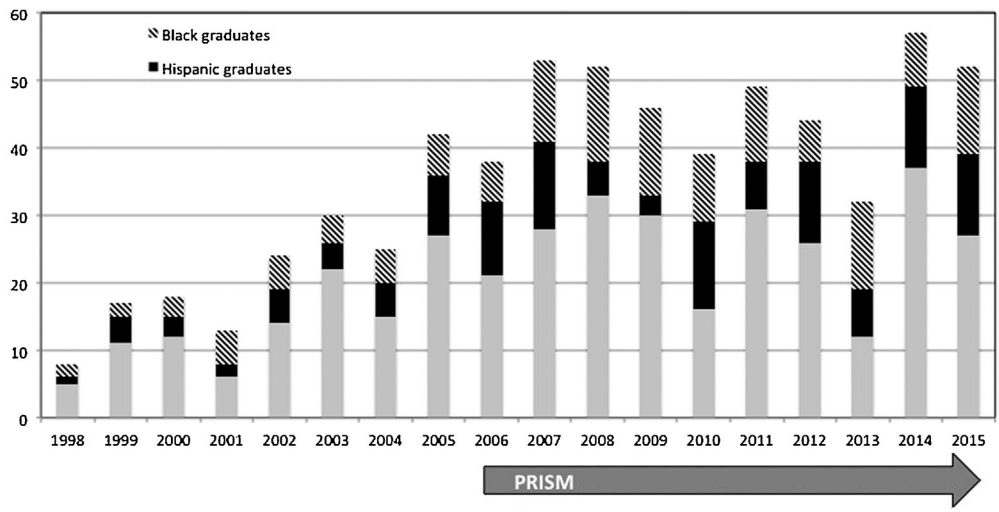

Figure 5. Graduates in Forensic Science, before and during the PRISM program.

The change in research focus of the Department ushered in a growth in financial resources to support these enterprises. Figure 6 below shows the growth in the amount of external funding secured by members of the Department of Sciences during the relevant period. Further, while only one faculty member had secured external funding in 2000, this number had risen to 14 faculty members, or more than half of the Department, by 2015. As a reflection of a cycle of positive feedback catalyzed by the success of research in the sciences, the College established an Office of Undergraduate Research in 2010 to further leverage and expand on the success experienced. As such, these investments benefitted both PRISM and non-PRISM students.

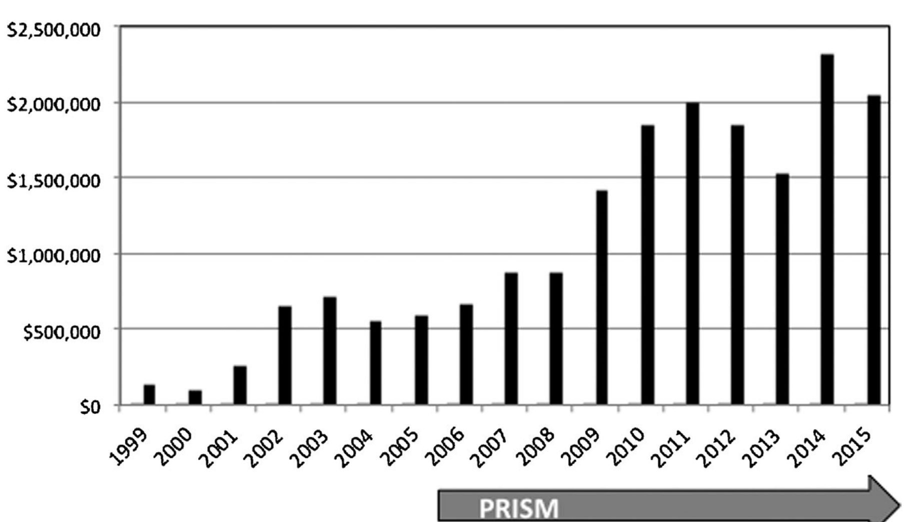

Figure 6. Growth in external funding secured by members of the Department of Sciences at John Jay College from external sources, 1999–2015.

Discussion and Implications

While apprenticeship of junior researchers is a traditional idea for advanced skill building in the sciences, we have found that it serves an additional purpose among students traditionally underrepresented in STEM fields. PRISM succeeds because it raises student expectations of themselves and their future. By setting high expectations for students and expecting them to commit significant time over multiple years toward pursuit of research, students become successful in scientific endeavors and begin to consider careers that they never did before or that they may have dismissed in their earlier thinking. Through interventions aligned with SCCT targeting career knowledge, self-efficacy, and overcoming barriers, the PRISM program illustrates that previously foreclosed or unimagined STEM career pathways can become targets and interests for students at Minority-Serving Institutions.

Based on our experiences and the identified relationships of SCCT, we present what we consider key elements of an URE Program at an MSI. Those who wish to replicate elements of PRISM should carefully consider program characteristics, as we believe several are critical to ensure widespread participation of diverse students.

Duration

As first indicated by Russell et al. (2007), the *duration* of the PRISM experience is a key dimension in support of self-efficacy. Self-efficacy of undergraduate researchers is built through successive, incremental, and iterative experiences proposing, conducting, and disseminating research to an increasingly broad and professional audience, an affordance of a multi-year program. Further, the personal mentor–student relationship is not forged as strongly over the course of several weeks as it is over several years. Mentors are an important source of confidence for students; having a respected role model who believes in your potential to pursue graduate school is critical.

Explicit Career Guidance

For many first-generation college students, PRISM facilitates access to mentors whose explicit career and graduate-school counseling opens new doors and prepares them for graduate school application requirements. Through both formal programs and informal conversations, student interests are encouraged and previously foreclosed or unimagined career paths are brought to light. While some students surely come into PRISM with an established interest in research careers, this is not the norm or expectation.

Minimizing Barriers to Participation

As a program of excellence, PRISM does have entry requirements, though these have been, and must continue to be, carefully evaluated. At John Jay College, course standing and GPA convey viability to complete the science major but they do not necessarily identify students with desired scientific dispositions and abilities. Students who look promising “on paper” may not have sufficient skill for, or interest in, original research. Conversely, some students with blemishes on their grade record in required courses blossom with insight from the lab environment. This lack of correlation suggests limited predictive value of GPA as an entrance requirement. Given the sustained commitment required, monetary support through stipends and travel reimbursement lifts economic barriers to participation. Stipends offset the costs that this population of students might otherwise have to cover through outside employment, and enables participation in conferences, an important learning experience in itself.

Addressing Known Barriers Related to Gender and Race/Ethnicity

For students who may not see themselves in the celebrated scientists discussed in their textbooks, PRISM uses social supports to create a community of young scientists whose way of being is shaped by the cultures of its members. As a result, science is less “other” and more “us.” This process breaks down persistent stereotypes about the characteristics of scientists, which may otherwise be an obstacle in the development of their interests (Brickhouse et al., 2000) or career decision-making (Lewis & Collins, 2001).

These research program attributes may differ from the design of some well-regarded research programs at other universities. Students participating in UREs at Research-I, Liberal Arts Colleges (LAC), and other majority institutions often have well-established career intentions, related to robust exposure to career options earlier in life. We have not only seen a more significant impact on career intentions at a MSI than noted in other studies at majority institutions (Lopatto, 2004; Seymour et al., 2004); but we have further noted a difference between White and Asian students, and Black and Hispanic students at our own institution. As far more minority students are concentrated at MSIs than LACs or Research-1 institutions, these students stand to benefit from exposure to academic career paths to which they have not yet been exposed.

Unfortunately, MSIs are among the least prepared in terms of available financial support and space to offer these experiences to students (National Science Foundation, 1998; National Science Board, 2014). Many institutions serving those students traditionally underrepresented in the sciences have been primarily consumed with providing interventions for remediation in support of improved graduation rates. Further, unlike large Research-I institutions with ranks of graduate students and post-doctoral students who participate in the training of younger students, the laboratory training “pyramid” at MSIs is considerably more flat since many MSIs are also primarily undergraduate institutions. This creates further challenges by straining faculty who must weigh high teaching loads and the competing needs of rapid research and publication for tenure purposes with the desire to train and mentor novice undergraduates.

In addition to developing their intentions, PRISM delivers an important qualification to aspiring graduate school students, especially as participation in undergraduate research becomes more common, and even expected, within the graduate applicant pool. However, if undergraduate research experiences are preferentially available at more financially advantaged institutions, the droves of minority science students enrolled in underfunded public institutions will be further disadvantaged. Thus, while the trend toward undergraduate participation in research may benefit the state of science education nationally, there is an inherent danger of exacerbating current disparities in minority representation if care is not taken to support these experiences at institutions that may not presently be able to afford them. In this climate, it is imperative for MSIs to provide UREs or else risk widening the achievement and opportunity gap for their students.

Conclusion

PRISM encourages students to explore their own potential as scientists and develop confidence and self-efficacy in a career-relevant learning experience. Thus, while John Jay College Science undergraduates have always pursued STEM-area jobs, PRISM graduates are increasingly focused on professional and academic STEM career training. These transformations are achieved not by simply telling students “they can do it/they should do it” but by giving them a chance to see that they can be successful in this line of work. Research experiences and advanced degrees *confer* greater versatility and upward mobility to students who would have been unlikely to pursue them otherwise.

Ultimately, mentored undergraduate research at Minority- and Hispanic-Serving Institutions like John Jay College is a potent tool to address the traditional under-representation of groups in the sciences. It is the institutional characteristics of the College rather than the program's features that drive the participation of racially and ethnically diverse students. Furthermore, because PRISM research activities occur on campus the benefits of research enrich the culture and infrastructure of the College (Carpi & Lents, 2013).

PRISM students come from a variety of academic backgrounds and levels of prior academic success. While the input is varied, the output is often similar—students with intentions to pursue Masters' and Doctoral degrees in the sciences. At a critical juncture before students enter the professional world, PRISM takes students who hail largely from the New York City public schools and positions them to attend elite graduate institutions. As such, we view PRISM as a powerful equalizer—providing access to scientific careers to populations traditionally underrepresented in the field.

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