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Increase in Science Research Commitment in a Didactic and Laboratory-Based Program Targeted to Gifted Minority High-School Students

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Abstract

Underrepresentation of ethnic minorities in science, technology, engineering, and mathematics (STEM) fields has been a growing concern. Efforts to ameliorate this have often been directed at college-level enrichment. However, mentoring in the sciences at a high-school age level may have a greater impact on career choices. The Center Scholars Program prepares gifted minority students for participation in college-level research while they are still in high school. Results from a case/comparison group study demonstrated that 86% of Center Scholars, compared to 50% of the comparison group, plan to pursue a career in science research, suggesting that high-school enrichment programs have a substantial impact on minority participation in science and research fields.

Keywords

career commitment; genetics; genomics; gifted; high school; minority students; research; science

The underrepresentation of ethnic minorities in science, technology, engineering and mathematics (STEM) careers has been a growing national concern for more than a decade (Clark, 1999; Haycock, 2001; National Academies, 2007). This, coupled with the rapid increase in the number of minorities within the population, has resulted in a push by the scientific, education, and government bodies within the United States to begin to think critically about how to increase minority participation in the sciences, thereby training and creating the employable adults required to meet the demanding technological needs of today's workforce. According to the latest population projections, minorities (Asians/Pacific Islanders, African Americans, Hispanics, and American Indians/Alaskan Natives) are expected to be more than half (52%) of the resident college-age (18–24 years old) population of the United States by 2050, up from 34% in 1999. By 2050, Whites will constitute 48% of the U.S. population 18–24 years old, down from 66% in 1999 (Humes,

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AUTHOR NOTE

Dr. Andrew P. Feinberg is responsible for the inception of the Center Scholars Program and proposed the casecontrol design. Dr. Kimberly J. Fraleigh-Lohrfink, with the cooperation of Dawayne Whittington, coordinated and analyzed all study data. Dawayne Whittington developed survey instruments with the assistance of M. Victoria Schneider. Dr. Fraleigh-Lohrfink, M. Victoria Schneider, and Dr. Feinberg wrote the manuscript.

Jones, & Ramirez, 2011). In 2007, minorities made up 28% of the U.S. population but only about 9% of the science and engineering workforce (National Science Foundation, 2007).

A report from the National Academies (2007) addressed the myriad of challenges that stand in the way of developing a well-prepared minority workforce in the sciences. In order for the United States to continue to produce leaders in innovation and scientific research, it is necessary to address the leaks in the proverbial scientific pipeline, which begins with the nation's students in early elementary school and ends with career choice. From an economic standpoint, it is clear that it is important to nurture young minority students into STEM careers. Though degrees in STEM tend to lead to careers that are higher paying and of higher social status, few minority students surveyed pursue careers in these areas (Lorenz & Lupart, 2001). There is potential for losing students along all segments of the pipeline from preschool through graduate school through inadequate academic training and student interest, as well as an overall misperception of what a career in STEM can provide for them. Plugging these leaks will require a comprehensive approach that focuses on education, motivation, and support (both academic and psychological) of students during every phase of their journey to a science career (National Academies, 2007; Nickens, Ready, & Petersdorf, 1994).

There are several factors related to an individual's career choice. These factors include student interest, student achievement, and the role of the community. Student interest is a significant motivator in the pursuit of a career. Interest in science is equal at an early age for minority and nonminority students but is not sustained through secondary school in minority students (Peng, Wright, & Hill, 1995). Though science is the most popular subject in the K–3 grade levels, this interest declines continuously and precipitously with each higher-grade level (Redmond, Saturnelli, & Poponiak, 1993), culminating in a large number of freshmen college students with initial science majors changing their major after the first year (Peng et al., 1995). Wilson and Chizeck (2000) claimed that disenchantment with science and engineering begins “somewhere around grade 5 when a combination of underdeveloped abstract thinking skills and a shift in motivation from intellectual curiosity to personal goals and peer relationships occurs” (p. 1). Therefore, the National Science Foundation Committee on Equal Opportunity in Science and Engineering determined in 2007 that K–12 programs are the key to bringing about an increase in students seeking careers as researchers in science. These goals were based on the fact that students at a young age were unclear as to what science researchers did (in their jobs) and what career opportunities were available. These findings were further supported by the Draw-a-Scientist Study, which was developed by Chambers in 1983 with the goal of providing information regarding children's perceptions of scientists through individual drawings. Evidence suggests that as students progress through higher grades, their perceptions of scientists become more and more stereotypical (White/male/alone) and more difficult to change (Chambers, 1983; Finson, Beaver, & Cramond, 1995; Fort & Varney, 1989; Krause, 1977; Maodohnaigh & Hunt, 1998; Schibeci & Sorenson, 1983). Intervention should include hands-on research experiences. These experiences build student confidences and performance-related skill sets, as well as provide an opportunity to experience a close interaction with mentors at various levels of their professional careers (Clark, 1999; Munn, Skinner, Conn, Horsma, & Gregory,

2011; National Academies, 2007). This exposure may be essential to students envisioning themselves as successful graduate students and beyond.

Student interest often walks hand in hand with student achievement. Is there an achievement gap between minorities and non minorities in the math and sciences as well? In 1997, Ford and Thomas found that while 20% of all gifted students underachieve, 46% of gifted African American students underachieve. *Underachievement* was defined vaguely as “a discrepancy between ability and performance” (p. 1). Petersen, Kraus, and Windham (2005) showed that Asians and Whites are performing better than underrepresented minorities as early as kindergarten and that the gap widens through middle and high school. The need for early intervention is imperative because these gaps in the achievement of minority compared to non minority children occur as early as first grade and the gap widens over time (Olszewski-Kubilius, Lee, Ngoi, & Ngoi, 2004). Without intervention, by the middle grades, this pattern of underachievement can become a lifestyle that is difficult to change (Reis & McCoach, 2000).

In addition to student interest and achievement, the role of the community should be examined. Members of the community can provide the encouragement and support that minorities need in the pursuit of advanced degrees in science. A strong sense of family and responsibilities to the community are factors that play into career and academic choices for many minorities (Oakes, 1990; Smith & Hausafus, 1998). In addition, minority students may not always see the opportunity for career growth or monetary success in scientific research. These students need to be given the opportunity to understand what they can achieve if they choose to pursue careers in scientific research, as well as be provided with the tools they need to access highly competitive college and university programs.

Further supporting the idea that community impacts persistence, Lent, Brown, and Hackett (2000) developed a comprehensive model that explains the persistence of career aspirations. They found that persistence can be attributed to contextual support and personal input, which affect self-efficacy expectations and an individual’s belief regarding how well he or she can perform a task, which, in turn, translate into career interests and career goals. If people perceive their efforts to be impeded by adverse environmental factors, such as inadequate support systems or an intimidating environment, their aspirations are less likely to be translated into goals and thus actions. Achievement and confidence are key factors in determining the likelihood of pursuing a math or science career (Mau, 2003; O’Brien, Kopala, & Martinex-Pons, 1999). Bright underrepresented minorities cannot be recruited into the science/engineering pipeline without continued support and encouragement.

Generally speaking, underrepresented minority (URM) students are more sensitive to noncognitive factors associated with retention, including increased academic confidence, faculty contact, positive faculty–student relationships, involvement in campus activities, and access to role models or advanced peers (Jones, Barlow, & Villarejo, 2010). Professional role models add another component to the development of minorities as scientists. Studies have shown that in order for students, particularly underrepresented minorities, to develop an interest in an area of study or career, they must be able to visualize themselves in that role. For scientists, this means as faculty, professors, or researchers. The lack of a URM presence

in the STEM workforce intensifies the problem. Without knowledge of a support system in the workforce, minority students might become discouraged in considering STEM careers as viable options.

Early intervention, constant and continued support, opportunities to interact with STEM professionals, and educational encouragement in the form of financial support and access to programs are all integral components to successfully moving students through the STEM pipeline. The implications for the future STEM workforce are clear if these types of intervention do not occur. One attempt for dealing with this issue has been the development of specialized residential STEM high schools across the country (Pfeiffer, Overstreet, & Park, 2010). These STEM academies offer intermediate and advanced science and math courses, as well as research and lab experiences not offered in U.S. public high schools. The authors concluded that these residential STEM schools “provide a small and select group of America’s best and brightest high-school students with extensive and in-depth exposure to STEM content and learning and research opportunities” (p. 29). Clearly, these high schools are one option for increasing STEM learning. However, not all students have the opportunity to attend such a STEM program due to the limited number of these high schools and their geographic locations. Moreover, the longterm impact of attending one of these academies is not yet known. Therefore, other options and programs are needed if we are going to bring STEM to the forefront of U.S. society.

THE CENTER SCHOLARS PROGRAM

Andrew Feinberg and the Center for Epigenetics at the Johns Hopkins University developed the Center Scholars Program (CSP) as a component of a Center for Excellence in Genome Science grant (CEGS) funded by the National Human Genome Research Institute. As part of this CEGS grant, Dr. Feinberg wanted to approach the recruitment of talented minorities to the genome sciences in a unique way. The goal of the program is to encourage academically talented high-school minority students to pursue careers in scientific research, specifically in the genome sciences.

Through collaboration with the Johns Hopkins University Center for Talented Youth (CTY; www.cty.jhu.edu), an organization that identifies students with advanced academic abilities and provides academic programs to help them achieve their potential, the CSP looks to discover students with an interest in science early in their academic careers and foster that curiosity. With the help of CTY, Dr. Feinberg developed a 3-week summer course in genome science that provides selected high-school students with an academic foundation and familiarity with basic laboratory skills that they would need to actively contribute in a research laboratory. As a prerequisite to this course, students must also complete CTY’s 3-week summer course in genetics, as well as 1 year of high-school biology. Upon successful completion of these two courses, participants in the Center Scholars program are invited to participate in a 6-week summer research internship at the Johns Hopkins Medical School. In most cases, the program bridges three summers as students complete one course per summer, with the internship occurring the summer following their junior or senior year in high school. Housing is provided for all three components and a stipend is given to interns during their 6-week research stay.

Each piece of this three-tiered program acts as a rung in a ladder, allowing the students to develop their skills and work to gain greater understanding of genomics through each step. The program begins recruiting students who have high ability in mathematics and demonstrate an interest in science as early as seventh grade. Though students would not be enrolled in course work until their ninth-or 10th-grade year, they are able to commit to the program at any time. The academic component of this program provides the opportunity for students to study genetics and genomics at a level that would likely be unavailable at a typical high school. Students perform independent research projects and learn laboratory techniques that are typically not introduced until the undergraduate level. They also interact collaboratively with their peers in an inquiry-and research-based environment. It is in this rigorous academic environment that the program strives to demonstrate to each student the types of things that they will eventually study should they pursue genetics or genomics at the undergraduate level or beyond.

During the internship component of the program, student mentors at each lab offer a diverse perspective as to the type of work that is available in research laboratories. In addition to meeting with the principal investigator, interns work with graduate and postdoctoral students at varying stages in their research careers. By offering students the opportunity to work with mentors of a variety of backgrounds and at different stages in their academic and professional careers, it provides a concrete example of what the pursuit of a degree or career in research will involve. It also helps to dispel any preconceived stereotypes that our students might have otherwise developed about research scientists. At the end of their internship summer, students will have gained experience that is often unavailable until enrollment in an undergraduate or graduate program.

Finally, by providing students with the tools and knowledge that they need to grow one step at a time, the program helps students through difficult transition periods. As students look ahead to undergraduate study, they are armed with knowledge of career potential in the research sciences and laboratory skills that many undergraduates may not possess. As part of the longitudinal follow-up, there is close contact with alumni from the program, and they are kept informed of what is happening within the genome sciences community for 10 years following their completion of the internship. Students also receive communication about other research opportunities available at the undergraduate and graduate levels. In collaboration with other academic institutions, it has been possible to form a pipeline that will allow these students to move forward academically while remaining tied to the genome sciences as they pursue their academic goals.

The CSP integrates the components vital to creating an academic experience that is supportive of students' needs, both academically and emotionally. The program involves a multi touch, long-term academic experience that supplements and expands on school-year learning, builds a community of peers and creates a supportive academic network, focuses on transition times (summer learning and the high school-to-college transition), provides an opportunity to interact with research, identifies career opportunities, and provides role models in the scientific community. Using these pieces over the course of multiple years, the program aims to build confidence within each student while encouraging the serious consideration of academic research as a career.

It is predicted that, when compared to a comparable group of nonparticipants, Center Scholars will demonstrate the following:

- higher and better-defined career aspirations
- increased likeliness to identify science as a career choice and greater interest in genomics and/or genetics research as an area of career focus within science; and
- higher levels of competence in critical science research techniques and research process skills.

METHOD

Participants

URM high-school students are eligible to participate in the Center Scholars Program if they score at the 95th percentile or higher on one or more subtests of a nationally normed standardized test and if their SAT or ACT scores (earned during high school) place them above the mean for collegebound high-school seniors (<http://www.cty.jhu.edu>). URM students are defined by the National Institutes of Health as individuals who self-identify with one or more of the following groups: Black or African American, American Indian, Native American, Hispanic, Latino American, Native Hawaiian, Alaskan Native, or Pacific Islander. At the time of this study, 29 URM students had completed the CSP. One hundred percent of the program participants completed the survey. Of these 29 students, 48% were Hispanic or Latino, 41% were African American, and 11% were other minorities. Fifty-five percent of the CSP students completed the program the summer before 12th grade, 31% completed the program prior to 11th grade, and 14% completed the program between 12th grade and the beginning of college.

A comparison group ($n=37$) was selected from the same CTY applicant pool, scoring at the 95th percentile or higher on one or more subtests of a nationally normed standardized test and whose SAT or ACT scores (earned during high school) place them above the mean for college-bound high-school seniors. In selecting the sample of students for comparison purposes, the research team utilized the database from the Talent Search conducted by Johns Hopkins Center for Talented Youth. This database stores information on all students who take an above-grade-level test in order to qualify for participation in any of the programs run by CTY. Using this database, the team designed a query to select a potential comparison group of students that matched the program students both demographically and on grade in school and that had qualified to participate in CTY courses but had not enrolled in any CTY science courses. The query yielded contact information for 218 students. Adjusting the list of students for outdated contact information and non-U.S. residents, the total possible number of non–Center Scholars responses was 175. Fifty-nine of the non–Centers Scholars actually returned the surveys, which constitutes a 34% response rate. Of those 59 students, all who expressed a *low interest* (3 or below on self-rating scale) in science were removed from the database, yielding a final comparison group of 37 students (see Table 1). Of these 37 students, 84% were Hispanic or Latino, 5% were African American, and 11% were other minorities. At the time of the survey, 57% of the comparison group students were in 12th grade, 41% were 11th graders, and 3% were beginning their college careers.

In evaluating the suitability of our selection of the comparison group, one-way analyses of variance (ANOVAs) were performed to examine significant differences between Center Scholars and non–Center Scholar respondents at the time of recruitment across nine academic talent and performance variables. Students in the comparison group matched well to the prior academic talent and performance of students who participated in the CSP (see Table 1). There were no significant differences between CSP students and the comparison group on ability (SAT scores), number of past science courses, number of advanced science courses, or interest in science.

Materials and Procedure

Data were self-reported using a questionnaire that was designed in Summer 2007 by the project leaders and the external evaluator. The questionnaire contained 24 items related to students' career aspirations, interest in science and research, academic performance in school, and involvement in enrichment programs. In addition, the questionnaire asked students to rate their competence across 11 process skills for science research and 31 different research techniques as an additional measure of their confidence in their scientific ability. Ratings were made on a 5-point Likert scale from 1 (*not at all competent*) to 5 (*very competent*). Several scientists, including the principal investigator for the CSP, contributed to the development of the list of process skills and techniques included on the questionnaire.

Invitations to participate in the study were sent to the 29 Center Scholars who had completed the internship and to the 175 potential comparison group students. The evaluator e-mailed the link to access the electronic version of the survey to all students. As a follow-up to the e-mail, hard copies of the questionnaires were mailed to students' home addresses, with postage-paid envelopes to facilitate the return of the survey. In addition, financial incentives (\$30 gift card of their choice to iTunes, Old Navy, Starbucks, or Barnes & Noble) were included to encourage a high response rate.

RESULTS

Differences in career aspirations between the Center Scholars and the students in the comparison group were examined using a 2×2 chi-square analysis. As shown in Table 2, on completion of the program, the Center Scholars showed significantly higher and better-defined career aspirations than the comparison group. Center Scholars were significantly more likely to express degree level aspirations beyond the master's level compared to the students in the comparison group, $\chi^2=6.30$, $p=.012$. In addition, a higher percentage of students in the CSP planned to pursue both an MD and a PhD, $\chi^2=5.71$, $p=.017$. There was also a trend toward better articulation by CSP students of the application of the advanced degree (career specificity); for example, preparation for a career in genetic medicine, although this did not meet the criteria for statistical significance, $\chi^2=3.62$, $p=.057$. The influence of the Center Scholars program on career aspirations was further supported through comments of the students such as the following:

This program has literally opened up a career path that I had never before dreamed possible. Without the Center Scholars Program, I might have been too hesitant to take on the challenge and pursue the field of Genetics and Genomics. In my high

school, I always felt confident in Math and English classes, but Science and the entire research experience was something that seemed remote and less accessible. However, attending CTY these last 2 years, has removed all the fear of big scientific words and complex experimental procedures.

Although there were no significant differences between the Center Scholars and the comparison group related to *science* as a career choice, Center Scholars were more likely to indicate that they planned to pursue a career in *science research* than were students in the comparison group, $\chi^2=11.51$, $p=.021$, and Center Scholars were also more likely to indicate that they planned to take advantage of research opportunities in high school, $\chi^2=19.43$, $p=.001$. Not surprisingly, in analyzing the specific interest in the specific scientific area of study of the CSP, a higher percentage of Center Scholars were interested in the fields of genetics ($\chi^2=9.46$, $p=.002$) and genomics ($\chi^2=24.33$, $p<.001$) than students in the comparison group.

Students were asked to rate themselves on scientific competency. Differences in self-rating of scientific competence were examined using ANOVA. Center Scholars rated themselves significantly more competent across 30 out of 31 research techniques and skills than did the comparison group. Center Scholars' adjusted mean scale score was 106 out of a potential 155 points, whereas the adjusted mean scale score for non-Center Scholars was 52, $F(1, 63)=66.68$, $p<.001$ (see Tables 3 and 4). Center Scholars rated themselves at the highest competency (4–5 on a scale ranging from 1, *not at all competent*, to 5, *very competent*) in 8 of the 31 areas, many of which are strongly connected to genomic science research, specifically reagent preparation, preparing gels, gel electrophoresis, streaking/plating bacteria, analytical evaluation of DNA, polymerase chain reaction (PCR), micropipetting, and computer search (BLAST). Further analysis showed that the Center Scholars rated themselves at least slightly competent for the remaining 23 areas, whereas students in the comparison group typically rated themselves not at all competent.

Students were also asked to rate themselves on 11 process skills using a 5-point Likert scale with 1=*not at all competent* and 5=*very competent*. Center Scholars students rated themselves as more competent than non-Center Scholars on 4 of the 11 skills (see Table 5), specifically “Working with other science professionals,” $F(1, 64)=6.54$, $p=.013$; “Communicating your research findings orally,” $F(1, 64)=18.06$, $p<.001$; “Preparing a scientific research poster/talk,” $F(1, 64)=9.12$, $p=.004$; and “Facilitating a Q&A session,” $F(1, 64)=16.44$, $p<.001$. Center Scholars rated themselves as significantly lower than the comparison group on “Analyzing a problem & formulating a solution,” $F(1, 64)=5.91$, $p=.018$. Although there were no significant differences in the remaining 6 process skills measured, comparison group students tended to rate themselves slightly higher in the areas of organizing data, interpreting data, working independently in a lab, and reading and interpreting scientific literature, whereas Center Scholars tended to rate themselves higher at communicating research findings in writing and writing a scientific research abstract.

The goal of the Center Scholars program is to encourage academically talented high-school minority students to pursue careers in science and scientific research. Program success has been demonstrated through the achievement of that goal by program alumni. There are

currently 29 students who have completed the Center Scholars program and who are now enrolled in college. Of the 15 alumni who have reported their college major, 11 (73%) are majoring in a STEM discipline. In addition, 4 Center Scholars have already had articles published in scientific journals. These students are clearly “ahead of the game” when compared to their college peers.

DISCUSSION

The principal result of this study is that Center Scholars were more likely than comparison group students to plan to pursue careers in science research. The findings suggest, again, that the Center Scholar experience has perhaps made these young students more aware of the possibility of doing science research earlier in their academic careers. In analyzing the specific areas of interest within science for students planning to make it a career, a higher percentage of Center Scholars were interested in the fields of genetics and genomics than students in the comparison group. These results make sense considering that the Center Scholars were given instruction specifically in genetics and genomics research and were typically paired with scientists whose research focused on genetics or genomics.

Data also indicate that a higher percentage of Center Scholars planned to pursue both an MD *and* a PhD, whereas students in the comparison group were much more likely to list a bachelor’s or master’s degree as the highest degree they planned to earn. The higher percentage in this category suggest that the Center Scholars Program activities may expose underrepresented gifted students to the possibility and benefits of earning the dual degree more than typical enrichment activities in which gifted students participate.

In terms of research competency, Center Scholars rated themselves as significantly more competent across 30 of 31 research techniques and skills and in 4 of 11 research process skills. These results support the importance of building scientific research skills in students during their highschool years. Process areas in which students highly rated their competence varied. For example, Center Scholars’ ratings of competence were significantly higher for skills that were more connected with their real-world experience, such as (a) working with other science professionals, (b) communicating research findings orally with professionals in the scientific research community, (c) preparing a scientific research poster, and (d) facilitating a question-and-answer session related to your scientific research poster. On the other hand, non–Center Scholars rated themselves significantly higher on analyzing a problem and formulating a solution. In addition, non–Center Scholars showed a higher trend, albeit not significant, in other process skills that are typically part of the high-school classroom experience, such as organizing data and interpreting data. One explanation for these Center Scholars’ ratings trending lower than their counterparts in these areas could, again, relate to their real-world experiences. Organizing data, interpreting data, analyzing problems, and formulating solutions are often much more difficult within a real lab context than a course lab component. Given this, Center Scholars are likely to rate themselves lower as a result of real challenges they faced in the research lab working with data from actual hypothesis-driven research.

Limitations of this study are the relatively small number of students participating, the single location of this pilot program, and the self-reported nature of the data, although it still represents a data-driven rather than anecdotal approach to enrichment program reporting. Some of the measures assessed specific skills related to program participants because the program is designed to expose the students to certain science and research techniques, and to the area of genomics, at a younger age. However, the researchers feel that those questions are important to ask in order to evaluate that the program is meeting its established goals. Comparing program students to a comparison group who had a similar interest in science at the outset eliminated much of the bias. In addition, although some of the research technique items were specific to genetics and genomics, others were more related to science in general, skills that all students could have been exposed to in school or in other programs.

The comparison group may not be “pure” due to self-selection through their choice to return the survey. The response rate of non–Center Scholars was so much lower than for program participants that it is difficult to generalize results. Perhaps those students who chose not to respond were busy with other scientific opportunities that would make them more like the Center Scholars. On the other hand, the comparison group students who responded could be those who have been more academically successful and therefore want to share their success. In this case, our results would have been even more significant if those students who were not as successful had also chosen to respond to the survey. It is impossible to know why certain students responded and others did not. However, it is important to note that this self-selection could skew the results in either direction and makes it difficult to generalize to a larger group.

In addition, the limited focus of genetics and genomics makes it impossible to generalize across the entire field of science. However, the model of two advanced summer courses followed by an intensive mentor-based lab experience could be easily adapted into other areas of STEM, including microbiology, chemistry, and even engineering. In the future, the program hopes to expand into other areas of science and scientific research. Given that there is evidence that women are also considered minorities in some areas of science, other than the biological sciences, analyses in other fields may wish to also examine gender differences.

Regardless of these limitations, the study provides support for early intervention for gifted URM students, as well as providing data against the commonly held perception that URM students with science ability will pursue science regardless of these early enrichment activities. Support for an enlarged program such as the CSP, which could be sustained over several summers, within the larger framework of national talent searches for gifted students could have a major impact on recruitment of URMs to science careers.

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Table 1

Center Scholars vs. Non–Center Scholars Matched Across Variables for Academic Talent and Performance

Variable	Center Scholars	Non–Center Scholars	F	p
	M	M		
Number of science courses at time of recruitment	1.61	1.51	0.157	.693
Years of schooling	11.79	11.51	2.392	.127
Cumulative grade point average	4.03	3.86	1.489	.227
Number of science courses taken in prior academic year	1.17	1.41	2.088	.153
Number of advanced science courses (honors/AP) at recruitment	1.34	1.08	1.468	.230
Number of advanced science courses (honors/AP) students took in prior academic year	0.93	1.00	0.226	.636
Students' ratings of their interest in science (on 5-point scale)	4.76	4.68	0.533	.468
SAT verbal scores	534	555	1.512	.223
SAT math scores	587	595	0.396	.532

Note. Center Scholars: $n=29$; Non–Center Scholars: $n=37$.

Table 2

Career Aspirations of Center Scholars After Completion of the Program vs. Non–Center Scholars

	Centers Scholars (%)	Non–Center Scholars (%)	χ^2	<i>p</i>
Anticipated degree level				
Bachelor's	0	9	6.30 ^a	.012
Master's	7	26		
Doctoral	93	65		
MD/PhD	22	3	5.71	.017
Plans for future research	86	50	11.51	.021
Research career	86	50	11.51	.021
Research in high school	97	55	19.43	.001
Specificity in career aspirations	41	65	3.62	.057
No/low	41	65	3.62	.057
Medium/high	59	35		
Interest in genetics or genomics Career				
Genetics	59	22	9.46	.002
Genomics	83	22	24.33	<.001

Notes. Center Scholars: *n*=29; Non–Center Scholars: *n*=37.

^a2×2 chi-square analysis. Due to small *n*, categories were collapsed and comparison was made between bachelor's/master's and doctoral degree; 0 cells have expected count less than 5.

Table 3

Average Scaled Score Across 31 Research Techniques Comparing Center Scholars and Non–Center Scholars

Science Techniques Scaled Score	N	M	SD	Std. Error	95% Confidence Interval	
					LL	UL
Center Scholars	29	106.34	28.22	5.24	95.61	117.08
Non–Center Scholars	37	52.31	25.08	4.18	43.82	60.79

Note. LL=lower limit; UL=upper limit.

$F=66.68, p < .001$.

Table 4
Mean Competency Ratings for 31 Individual Research Techniques Comparing Center Scholars and Non-Center Scholars

Research Technique	Center Scholars (n = 29)		Non-Center Scholars (n = 37)		F	p
	M	SD	M	SD		
Reagent preparation	4.31	1.00	3.00	1.66	13.99	<.001
Micropipetting	4.97	0.19	2.62	1.50	69.99	<.001
Preparing gels	4.62	0.68	1.84	1.21	122.36	<.001
Gel electrophoresis	4.76	0.51	2.16	1.37	94.36	<.001
Streaking/plating bacteria	4.17	1.20	2.14	1.44	37.73	<.001
Analytical evaluation of DNA	4.24	0.95	1.89	1.27	69.30	<.001
Analytical evaluation of proteins	2.86	1.43	1.57	1.09	17.34	<.001
DNA restriction enzyme analysis	3.83	1.31	1.73	1.31	41.84	<.001
DNA ligation and/or cloning	3.45	1.45	1.41	0.83	51.64	<.001
DNA transfection	3.00	1.58	1.27	0.84	32.67	<.001
Bacterial culture	3.90	1.32	2.16	1.32	28.02	<.001
Plasmid isolation	3.28	1.56	1.30	0.78	45.50	<.001
Polymerase chain reaction	4.45	0.91	1.62	1.14	118.98	<.001
Reverse transcription PCR	3.34	1.57	1.32	0.88	43.95	<.001
Chromatography	2.69	1.49	1.97	1.21	4.64	.035
High-performance liquid chromatography	2.07	1.60	1.54	1.02	2.66	.108
Cell or tissue culture	3.48	1.46	1.70	1.18	30.26	<.001
Storing or thawing cell lines	3.03	1.80	1.38	0.79	25.11	<.001
Antibiotic selection of cells or colonies	3.41	1.74	1.54	1.07	28.93	<.001
Computer search (BLAST)	4.00	1.60	1.57	1.14	51.70	<.001
Advanced bioinformatics tools	3.28	1.71	1.27	0.65	43.11	<.001
Chromatin immunoprecipitation	2.07	1.60	1.22	0.63	8.78	.004
Microarrays (sample preparation or analysis)	2.97	1.76	1.38	0.86	23.06	<.001
DNA or protein sequencing	3.97	1.52	1.76	1.09	47.10	<.001
Epigenetic analysis (e.g., DNA methylation)	2.93	1.60	1.27	0.77	30.81	<.001
DNA analysis (e.g., Southern blot)	3.07	1.49	1.43	0.96	29.35	<.001
RNA analysis (e.g., real-time PCR)	3.00	1.65	1.35	0.92	26.57	<.001

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Research Technique	Center Scholars (n = 29)		Non-Center Scholars (n = 37)		F	p
	M	SD	M	SD		
Comparative genetics (e.g., mouse)	2.97	1.76	1.59	1.01	15.79	<.001
In vivo work (animal or plant experiments)	2.66	1.84	1.78	1.23	5.31	.024
Molecular medicine (study of diseased patients or tissues)	2.59	1.80	1.46	1.04	10.14	.002
Human variation (sequence or epigenetic comparison)	3.00	1.67	1.65	1.18	14.79	<.001

Note. Scale ranged from 1 (*not at all competent*) to 5 (*very competent*).

Table 5
Mean Competency Ratings for 11 Process Skills Comparing Center Scholars and Non-Center Scholars

Process Skill	Center Scholars (n = 29)		Non-Center Scholars (n = 37)		F(1,64)	p
	M	SD	M	SD		
Interpreting data	4.28	0.88	4.35	0.68	0.16	.695
Organizing data	4.17	0.85	4.41	0.60	1.71	.196
Working with other science professionals	4.52	0.57	4.03	0.90	6.54	.013
Working independently in a science research lab	4.10	0.77	4.24	0.98	0.40	.532
Communicating your research findings orally	4.62	0.56	3.70	1.05	18.06	<.001
Communicating your research findings in writing	4.14	0.92	3.81	1.10	1.66	.202
Reading and interpreting scientific literature	3.76	0.79	3.89	0.88	0.41	.523
Analyzing a problem and formulating a solution	4.00	.93	4.46	0.61	5.91	.018
Writing a scientific research abstract	3.72	1.16	3.30	1.24	2.03	.159
Preparing a scientific research poster/talk	4.31	0.89	3.49	1.24	9.12	.004
Facilitating a question-and-answer session related to your research poster/talk	4.41	0.87	3.32	1.23	16.44	<.001

Note. Scale ranged from 1 (*not at all competent*) to 5 (*very competent*).