This study explores students' self-perceptions across science subjects (biology, chemistry, and physics) by gender and underrepresented minority group membership. The data are drawn from the Persistence Research in Science and Engineering (PRiSE) project, which surveyed 7,505 students (enrolled in college English courses required for all majors) from 40 colleges and universities across the United States about their backgrounds, high school science experiences, and science attitudes. We compared the responses for three focal items on the PRiSE survey that asked students: "Do you see yourself as a biology/chemistry/physics person?" The results indicate that students' overall self-perceptions toward science are less than ideal. For many students in college, even those pursuing science-related careers, frequencies fell well below the midpoint of the scale. Consistent with other research, females had significantly lower self-perceptions toward physics, and Hispanic females tended to be the most disempowered in their views of themselves with respect to science.

A decade ago, Brickhouse, Lowery, and Schultz (2000) called for more research on "science identity," describing it as how students think science is "related to who they think they are" (p. 443). Gee (2000) further clarified the approach to identity research in education as being the study of a certain "kind of person," where individuals have multiple identities that are related to their social performances rather than purely to their unique being. In other words, an individual could identify as an environmentalist, an athlete, a musician, a science person, and so on. The characteristics that persons manifest and ascribe to, both as individuals (e.g., nurturing, carefree, competitive) and as members of social groups, relate to their identity, as defined by this work. In recent years, science identity-based frameworks have proven fruitful in studying science persistence, with several studies showing that science identity influences science persistence (Aschbacher, Li, & Roth, 2010; Basu, 2008; Carlone & Johnson, 2007; Calabrese Barton & Yang, 2000; Chinn, 2002; Cleaves, 2005; Gilmartin, Denson, Li, Bryant, & Aschbacher, 2007; Olitsky, 2007; Shanahan, 2009).

As the literature expands and explores the development and fluctuation of science identity in greater depth, it is necessary to focus on internal distinctions within the concept of science identity itself. This is particularly important for a better understanding of how science identity fluctuates at the high school level and beyond, where individual sciences are differentiated as separate courses and some sciences may be more effective than others in maintaining student engagement and empowering students in their own learning. Thus, the issue should not only be framed as that of a general "science identity." Greater specificity, such as biology identity, chemistry identity, physics identity, computer science identity, engineering identity, and so forth, promises to lead to a better understanding of why differences in participation and engagement (e.g., gender differences) exist between fields. The need for these distinctions of disciplinary identities is evident in the research on how disciplinary identity mediates students becoming central participants in a specific community of practice, such as a physics classroom (Basu, Barton, Clairmont, & Locke, 2009; Hazari, Sonnert, Sadler, & Shanahan, 2010). Whereas most science identity research focuses on the micro-level, studying how different experiences bring about real-time and nonreflective fluctuations of self-perceptions, our study approaches biology, chemistry,
and physics identity at the macro-level, which "typically requires the person to explicitly reflect on what the person considers stable and characteristic features of his or her identity" (Lichtwarck-Aschoff, van Geert, Bosma, & Kunnen, 2008, p. 375). For our sample, college students who have had many years of learning science, self-perceptions with respect to the sciences are likely to be more stable than for younger children, whose views fluctuate much more as they are exposed to and traverse new experiences with science. Thus, the macro-level approach is appropriate for consideration in this case. In particular, we compare students' self-identification with biology, chemistry, and physics in a large national sample of college students, focusing specifically on gender differences and differences between underrepresented minorities in STEM (science, technology, engineering, mathematics) and White students. This work advances our understanding of science identity across different groups, including marginalized groups, as well as across science disciplines.

**Gender and race/ethnicity differences**

The participation of females and underrepresented minorities (URM; in this paper, URM refers to Black and Hispanic students) has been a persistent topic of concern in STEM education. Comparing numbers by gender reveals that in the United States the percentage of females among students earning bachelor's degrees in 2007 was 60% in the biological sciences, 50% in chemistry, and 21% in physics (National Science Board, 2010). Moreover, females were awarded 5.5 times more biology degrees than physics degrees; by contrast, the corresponding numbers for males were only 1.5 times more chemistry degrees and 8.2 times more biology degrees. Thus, females are much more interested in biology and chemistry than in physics, whereas the differences are not as extreme for males. The percentages of URM students among the 2007 recipients of bachelor's degrees in biology, chemistry, and physics were 14%, 14%, and 8%, respectively. URM students earned 3.9 times more chemistry degrees and 27.7 times more biology degrees than physics degrees. For White students, the proportional differences were again less extreme: 2 times more chemistry degrees and 14 times more biology degrees than physics degrees.

Moving past surface comparisons of participation at the college level, the literature provides insights into how, from an early age, disciplinary interests become differentiated by gender and race/ethnic groups. For example, Farenga and Joyce (1999) found that as early as elementary school, both boys and girls largely adhered to the stereotype that physical science subjects are appropriate for boys, whereas life sciences are appropriate for girls. Jones, Howe, and Rua (2000) found that by the sixth grade, males were already reporting significantly more outside-of-school experiences related to the physical sciences than were females. In high school, Kessels (2005) found that both male and female students perceived peers who preferred physics as possessing more masculine and fewer feminine traits. In addition, boys in Kessels' study were more likely to rate girls whom they perceived to be good at physics as unpopular, and girls who did well in physics reported that they felt more unpopular with boys than girls.

Furthermore, research has found that females are more likely to aspire to interpersonal and communal goals (e.g., helping others, working with people) and that many STEM fields, particularly the physical sciences, are perceived to impede or provide fewer affordances for achieving such goals (Diekman, Brown, Johnston, & Clark, 2010; Diekman, Clark, Johnston, Brown, & Steinberg, 2011; Morgan, Isaac, & Sansone, 2001). However, goal theory may not be sufficient in explaining disciplinary differences given that mathematics, which is perceived as relatively noncommunal, is at parity in gender representation at the bachelor's level. Other research points to females being more risk averse when their "good student identities" are threatened (Carlone, 2004), which may be relevant for physical science-related choices given that females have fewer prior experiences (less comfort) with the physical sciences (Hazari et al., 2010; Jones et al., 2000). With regards to race/ethnicity, a recent study that tracked the changing STEM interests of 33 high school students from 10th to 12th grade found that the majority of the URM students did not persist in STEM career interests and that the few who did persist were primarily low-achieving students who shifted to disciplinary career interests that would require less schooling and often were focused in the health sciences (Aschbacher et al., 2010). The high-achieving persisters in their study were mostly Asian and White students, and several students from those backgrounds developed interests in the physical sciences by 12th grade. Despite these findings, national trends indicate that the pro-
portion among Black Americans and Hispanic Americans planning STEM careers (e.g., 34% and 35% freshmen in 2007) is equal to or more than the proportion among White Americans (29% freshmen in 2007; National Science Board, 2010). This is often explained through social mobility goals (e.g., higher earning potential) perceived to be afforded by many STEM careers (St. John, Hu, Simmons, Carter, & Weber, 2004).

**Intersectionality and identity**

Expanding on the need to understand different disciplinary identities, there is also a need to understand the intersecting role of gender, race, and ethnicity because the normative structures within science communities (e.g., classrooms, departments, fields) have created disadvantages for individuals of certain race, gender, ethnicity, etc., in intersecting and differing ways that are not necessarily additive (Atwater, 2000; Johnston, Brown, Carlone, & Cuevas, 2011). For example, the experience of a woman of color is not necessarily the combined experience of being a woman and being of color—it can be unique in and of itself. Much of the research, however, does not focus on intersectionality, instead classifying people on the basis of their single-group membership. However, not all women are alike, nor are all underrepresented minorities alike. Although it is impossible to account for every intersecting social identity influencing science identity development, it is important not only to bear in mind the unique experiences that students have, but also to account for this uniqueness as best as possible within the methodological approach being used.

Thus, this paper compares college students’ self-perceptions across biology, chemistry, and physics for women and men from among different race and ethnicity groups (White non-Hispanic, Black non-Hispanic, Hispanic). Our approach has several strengths that add to the preexisting research. First, we take an intersectional approach across gender and race/ethnicity for different disciplines. Second, there are very few studies that explore science identity at the college level. Our sample is not only large, but it is also representative of many different types of colleges and universities across the United States, as well as of their student bodies taking required general English courses. Third, the items that we compare across groups were drawn from a previously validated instrument and were again found valid and reliable in our survey. Fourth, very few studies take a quantitative approach when considering science identity. Our findings triangulate and support much of the qualitative research on science identity and lay out a foundational landscape that other explanatory follow-up research can draw from. Our guiding research questions are as follows:

- How do students from different gender and race/ethnicity groups self-identify with respect to biology, chemistry, and physics?
- If differences exist between gender and race/ethnicity groups, are these differences still prevalent for those students who plan science-related careers?

**Methodology**

The data used in this study were drawn from the Persistence Research in Science & Engineering (PRiSE) project, which focuses on identifying high school factors that influence student persistence in STEM disciplines in the transition from high school to college. Funded by the National Science Foundation, PRISE is a large-scale study that surveyed college students enrolled in introductory English courses (only general education courses required for all majors were selected) in the fall of 2007. The sampling process involved drawing a random sample, stratified by institution type (2 year, 4 year) and size (small, medium, large), from colleges and universities in the United States as well as an oversampling of a few special schools to ensure large enough numbers of students from underrepresented groups in the sample. The sample included 34 randomly sampled colleges and universities (by school size and type) and six additional oversampled schools (one Historically Black college, one Hispanic-serving college, and four women’s colleges). Because students enrolled in introductory college English courses were surveyed, the project is able to examine the motivations and experiences of the whole spectrum of students, ranging from those who wanted to continue studying STEM to those who were uninterested in STEM. To ensure an adequate sample of STEM students, we compared the distribution of career intentions with those reported in national reports (National Science Board, 2010), finding an adequate (slightly higher) representation for students intending STEM careers in our sample. For example, the reported physical science career intention in the PRISE sample is 2.7%, compared with 2.4% in the national data for 2007. The survey included questions on students’ demographics, academics, science interests,
and high school science experiences (the survey can be viewed online at www.cfa.harvard.edu/sed/projects/prisel.html). In total, 7,505 surveys were collected from students attending 40 colleges and universities across the nation. The respondents were 49% female and 44% male, with 7% not reporting their gender. In terms of race, respondents were 67% White, 14% Hispanic, and 8% Black, with smaller representations for other minority groups. In terms of class standing, 76.4% were freshmen, 16.7% were sophomores, and the remaining 6.9% were other levels. The class standing groups are not significantly different on their responses to the science identity items introduced in the next section.

**Conceptualizing identity as a “type of person”**

Three focal items on the PRiSE questionnaire asked students: Do you see yourself as a biology/chemistry/physics person? These items were rated on an anchored scale of 1 to 6 (with 1 = no, not at all and 6 = yes, very much). Although ideally we would want to use multiple items for each discipline to examine disciplinary science identity, the survey was not designed with the expressed purpose of examining disciplinary science identity. However, the aforementioned focal items have been used to examine science identity previously (Shanahan, 2007), and our survey had the identical item for biology, chemistry, and physics, thus providing an opportunity for disciplinary comparison. Conceptualizing identity through self-perceptions as a “type of person” has been common in the science education literature and beyond (e.g., Carlone, 2004; Rahm, 2007). Gee (2000) described identity development as people winning, losing, gaining, rejecting, and grasping for recognition as certain types of people. In addition to reflecting a common conceptualization in the literature, these items also reflect a way in which students themselves understand and express their beliefs about identity. Qualitative data collected to provide the foundation for another instrument revealed this as a common phrasing used by students (Shanahan, 2007; Shanahan & Nieswandt, 2011); for example, “All in all, a ‘science person’ is more likely to be expected...
to function with care” and “I’m just not a ‘science person.’” The item “Do you see yourself as a science person?”, which was created based on student responses, was found to be a meaningful item that was strongly and significantly correlated with other related constructs, including the desire to be recognized by others and plans for a future career in science (Shanahan, 2007).

The specificity of the item to a science discipline was further validated and found reliable in our survey (Hazari et al., 2010). In terms of criterion-related validity, if an individual identifies strongly with biology, chemistry, or physics, then he or she should be more likely to plan a related career path. Thus, we tested the ability of our items to demonstrate this connection by regressing them on the likelihood of intending a related career path. This confirms the need to have those points on the scale because they capture the views of many students. However, because the distribution is skewed (not normal), we simplified the comparisons to examining students on the lower end of the scale (responses 1, 2, and 3) who we classified as “low” to students on the upper end of the scale (responses 4, 5, and 6) who we classified as “high.” The remaining analyses in this paper compare the percentages for the high and low groups. This approach was more conservative because it resulted in fewer significant results, with only the most robust group differences observed. Non-parametric Kruskal–Wallis analysis was necessary because of the binary nature of the recoded identity items (high vs. low). The standard errors in the figures were calculated for binary data.

**Results**

Figure 2 shows the percentages reporting a high identification on the disciplinary science identity items by gender and race/ethnicity groups (White non-Hispanic, Black non-Hispanic, and Hispanic) for all students in the PRISE sample. Table 1 summarizes the results of the Kruskal–Wallis tests for significant differences across the groups. Significant differences are observed in all three science disciplines. Three main themes that arise from examining the results are as follows:

- On average, college students in our sample have low self-perceptions with respect to science, as evidenced by the fact that most of the frequencies in Figure 2 are less than 30%.

### Table 1

Kruskal–Wallis tests for gender and race/ethnicity comparisons for all students (only within gender, race, or ethnicity group comparisons are summarized).

<table>
<thead>
<tr>
<th>Group</th>
<th>Biology</th>
<th>Chemistry</th>
<th>Physics</th>
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</thead>
<tbody>
<tr>
<td><strong>K-W χ²</strong></td>
<td><strong>Sig</strong></td>
<td><strong>Group differences</strong></td>
<td><strong>K-W χ²</strong></td>
</tr>
<tr>
<td>All students</td>
<td>28.5 ***</td>
<td>Wh F &gt; Wh M  ***</td>
<td>16.4 **</td>
</tr>
</tbody>
</table>

Note: Significant group differences with labels: Wh = White, Bl = Black, Hi = Hispanic, F = female, M = male.

*p < .05, **p < .01, ***p < .001
Although gender differences in biology and chemistry are small or nonsignificant (up to 6% difference in high identification) and convoluted by race/ethnicity differences, this is not the case with physics (13.0%-20.6% difference). Males, on average, perceive themselves as a physics person more than females do ($\chi^2 = 234.7, p < .001$), regardless of race/ethnicity. Incidentally, the frequency of males having a high level of identification with physics is the only frequency higher than 30% for all race/ethnicity groups. Note that the physics identity item had a higher nonresponse rate because many students who had not taken high school physics courses skipped the item. Thus, the physics item is skewed to the population of students who had taken physics. However, for the 29.8% of students who had not taken physics and still responded to the physics item, their frequency of seeing themselves as a physics person was significantly lower than for those who had taken physics (10.5% and 33.8%, respectively; $\chi^2 = 270.1, p < .001$). Therefore, it is likely that overall physics self-perceptions are lower than those reported.

Comparing results across all groups, trends for Hispanic females show the weakest science identity. For example, in biology, where females tend to have higher self-perceptions, Hispanic females are significantly lower than both Black and White females by 7% and 8%, respectively. In chemistry and physics, Hispanic females perceive themselves less as chemistry or physics people than do Hispanic males by 6% and 18%, respectively.

One question that emerges is whether the trends are different for students who have STEM or medical/health career aspirations. It is reasonable to hypothesize that those who have science-related career as-

![Figure 3](image-url)

**FIGURE 3** Percentages (±SE) of high response on seeing oneself as a biology, chemistry, and physics person by gender and race/ethnicity for students planning careers in STEM and medical/health.
pirations may see themselves more as science people with possibly smaller differences across race/ethnicity/gender. For example, as noted earlier, Aschbacher et al. (2010) found that low-achieving persisters for science-related career intentions, disproportionately made up of many URM students, were more likely to have aspirations to health professions than to other areas. Thus, moving beyond global comparisons, a better understanding of gender and race/ethnicity differences may be gleaned from examining differences among those with STEM versus medical/health career intentions.

We compared the self-perceptions for two subgroups of our sample of college students: those who plan careers in STEM and those who plan to go into medicine/health. For this analysis (based on items on the PRISE survey), STEM includes several career intentions including biologist, Earth/environmental scientist, astronomer, chemist, physicist, engineer, computer scientist, mathematician, other scientist, math teacher, science teacher, or a combination of these choices. The medicine/health group includes students who indicated that they intended careers as a medical professional (e.g., doctor, dentist, veterinarian) and/or health professional (e.g., nursing, pharmacy). Figure 3 displays the percentages reporting a high identification on the disciplinary science identity items by gender and race/ethnicity for these two groups. Table 2 summarizes the results of the Kruskal–Wallis tests for significant differences across the groups. For those interested in STEM careers, a few surprising trends emerged:

- With the exception of White males' attitudes toward physics, even students who are planning STEM careers in college have surprisingly low self-perceptions with respect to science, as evidenced by the frequencies falling below 50%. In particular, among female and URM students intending STEM careers, fewer than half highly identify with biology, chemistry, or physics.
- As with all students, White males also stand out among those with a STEM career interest as exhibiting a relatively strong identification with physics. However, for students interested in STEM careers, this difference is not only large when compared with female students, but it is even more pronounced when compared with URM students. White males intending STEM careers have a 19.1% ($p < .001$) higher frequency of seeing themselves as a physics person than do White females—which is similar to the 20.6% difference seen among all students. White males intending STEM careers have a 15.2% ($p < .05$) and 21.2% ($p < .001$) higher frequency of seeing themselves as a physics person than Black and Hispanic males, respectively, compared with the smaller 6.0% (nonsignificant) and 5.7% ($p < .05$) differences seen for all students.

These trends highlight that for those students who persist in STEM,

<table>
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<th>Table 2</th>
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<tr>
<td><strong>Kruskal–Wallis tests for gender and race/ethnicity comparisons for STEM and medical/health students (only within gender, race, or ethnicity group comparisons are summarized).</strong></td>
</tr>
<tr>
<td><strong>Biology</strong></td>
</tr>
<tr>
<td><strong>K-W x^2</strong></td>
</tr>
<tr>
<td><strong>STEM students</strong></td>
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<tr>
<td><strong>Medical/health students</strong></td>
</tr>
</tbody>
</table>

Note: * Significant group differences with labels: Wh = White, Bl = Black, Hi = Hispanic, F = female, M = male, STEM = science, technology, engineering, and mathematics, ns = not significant. 

*p < .05, **p < .01, ***p < .001
URM students experience disempowerment in terms of how they perceive themselves with respect to science, particularly physics. This result is consistent with the qualitative work of several other researchers (e.g., Aschbacher et al., 2010; Basu, 2008). For those students planning medical/health careers, although several trends look substantially different, there are also a few similarities. The trends include the following:

- Students interested in medical/health professions have higher self-perceptions toward biology than do STEM majors or all students in general, especially among males. Hispanic females have the lowest biology-related self-perceptions among students intending medical/health careers.

- Consistent with the previous comparisons, females in the medical/health group have lower self-perceptions with respect to physics than do male students. These gender differences are significant for White and Hispanic students. Unlike STEM students, however, differences by URM status are diminished; for example, Black and Hispanic males do not have significantly lower frequencies of seeing themselves as a physics person than do White males.

Regardless of career intentions, gender differences in physics are significant when all race/ethnicity groups are combined. The gender difference in physics self-perceptions for all students is 19.5% (36.3% reported for males and 16.8% for females, with $\chi^2 = 234.7, p < .001$); for STEM students is 16.3% (55.4% reported for males and 39.1% for females, with $\chi^2 = 23.4, p < .001$); and for medical/health students is 18.3% (38.1% reported for males and 19.8% for females, with $\chi^2 = 35.7, p < .001$).

Although we wanted to compare students who intended careers in specific STEM disciplines, the numbers of students in each group, particularly URM groups, became too small to make reasonable comparisons. We did, however, compare students intending physical science, engineering, and/or computer science (phys/eng/comp) careers—that is, areas where women are underrepresented—by gender. Our results provide some room for optimism. Females who intended careers in phys/eng/comp were equally likely as males to report that they saw themselves as a physics person (58.9% reported by males and 53.8% by females, with $\chi^2 = 1.3, p = .25$). However, the females who indicated such career interests comprise a smaller fraction of students with these interests (17%), compared with the proportion of females among other science-related career groupings (e.g., 74% female for medical/health, 35% for chemist, 44% for mathematician). Thus, students intending phys/eng/comp careers, although having proportionally fewer females, have high physics self-perceptions, regardless of gender. In addition, female students are also different from male students who intend phys/eng/comp careers in that they see themselves more as all-around science people; that is, they have higher frequencies than males do of seeing themselves as a biology person (22.2% reported by males and 34.3% by females, with $\chi^2 = 11.7, p < .001$) and a chemistry person (30.1% reported by males and 41.3% by females, with $\chi^2 = 8.5, p < .01$).

Discussion

In general, our findings are consistent with other research results. As in this study, depressed views toward physics among females (compared with males), and in some cases among URM students, have been documented in the literature (Adams et al., 2006; Basu, 2008; Gilmartin, Li, & Aschbacher, 2006; Hazari et al., 2010; Kessels, Rau, & Hannover, 2006; Kost, Pollock, & Finklestein, 2009). Among the six gender and race/ethnicity groups being compared, Hispanic females were the only group that never significantly superseded another group in terms of science-related self-perceptions. They were either at the lowest frequency levels by themselves or were not significantly different from other groups at the lowest levels. Thus, Hispanic females may face the greatest challenges in developing a science identity. This may be explained by Aschbacher et al.'s (2010) findings that Hispanic females sometimes felt greater pressure from home to conform to more traditional gender roles, thereby reducing their STEM self-perceptions. Furthermore, our work is consistent with notions of intersectionality, where gender results are not uniform across race/ethnicity groups nor across disciplines.

Although there are some gender differences in favor of White females seeing themselves more frequently than White males as a biology person, these differences are smaller in size than the gender gap in favor of men found in physics, and differences are not observed among students intending medical/health professions in which males have equally high biology self-perceptions. Males are underrepresented in the medical/health profession group (25%), but females...
suffer greater underrepresentation in the phys/eng/comp group (17%). Fortunately, females in the latter group do not differ significantly from males in the group in their propensity of seeing themselves as a physics person and have a higher propensity than males of seeing themselves as a biology or chemistry person. Consistent with this finding, higher proportions of females are found in the subdisciplines of physical science and engineering that involve biology and chemistry (e.g., chemical engineering; National Science Board, 2010). Thus, it is plausible that as the physical sciences and engineering become more interdisciplinary, a greater diversity of students will find interests in physical science and engineering disciplines. Although it is not the goal of this article to explain why these differences exist, the research on socialization cited earlier may provide some insight.

Finally, one major issue that this work highlights is the overall low science identity for many college students. If one of the purposes of science education is to enhance the citizenry’s inclination and capability for thinking about science-related issues, particularly those that impact society, then we need to do a better job in helping students see themselves as science people, regardless of their career trajectory. This lack of empowerment in science may stem from earlier systemic educational issues that result in a decline of science interests that persists into college.

Riegle-Crumb, Moore, and Ramos-Wada (2011, p. 472) wrote with regards to their data on eighth-grade students, “...these patterns suggest that our educational system does a poor job of maintaining students’ love of science as they develop into adolescence, particularly for girls.” Using an identity-based analytic lens allows us to focus on students’ perspectives—on their views of themselves and how science relates to them, as well as the associated behaviors they manifest. Furthermore, identity-based frameworks have been found to be robust in their predictive ability for STEM career choices (Hazari et al., 2010). In future work, these frameworks will help us better understand what factors may act as an impetus for change toward improving attitudes and participation in science, as well as help in making science learning more personally meaningful to students.

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References


