Technical Brief

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Examining Precollege Gender Differences and Similarities among Fourth-Year Undergraduate Students, with a Focus on STEM

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This study provides precollege profiles of fourth-year STEM students based on ACT Composite scores, High School GPAs (HSGPAs), and Interest Inventory scores (shown as Work Task Dimension scores) to estimate gender differences in precollege academic achievement and measured interests.

Even after accounting for students' academic majors, male and female students often differed in their precollege academic achievement levels and measured interests.

Background

Students' academic abilities and interests play prominent roles in their choices of academic majors (Allen & Robbins, 2008; Le, Robbins, & Westrick, 2014; Leuwerke, Robbins, Sawyer, & Hovland, 2004). Consequently, evidence of group differences in abilities and interests may help explain group differences in choices of academic majors. Gender differences in students' choices of academic majors has been well documented, and the underrepresentation of females within science, technology, engineering, and mathematics (STEM) fields has been a subject of national interest (Ceci & Williams, 2007; Ceci, Williams, & Barnett, 2009; Shaw, Kobrin, Patterson, & Mattern, 2012). Male students tend to score higher than females on standardized tests used for admission purposes, but female students tend to earn higher class grades, including math and science courses (Halpern, Benbow, Geary, Gur, Hyde, & Gernsbacher, 2007).

One explanation for why males outnumber females in math-intensive majors is that students tend to select academic majors that match their strengths. Many males with high math ability have lower verbal abilities, so this gap becomes important if male students conclude that they are only good at math (Lubinski & Benbow, 2007). In contrast, many females with high math ability also have high verbal abilities (Achter, Lubinski, Benbow, & Eftekhari-Sanjani, 1999; Wai, Lubinski, & Benbow, 2005). This smaller gap between SAT Quantitative and SAT Verbal scores may give females more career options (Ceci et al., 2009), so even if they are academically prepared for STEM work, they are also academically prepared to succeed in non-STEM fields.

Another explanation given for the STEM gap is that males tend to prefer working with things and females tend to prefer working with people, which is supported by a recent meta-analysis of vocational interests (Su, Rounds, & Armstrong, 2009). Decades of research by ACT (1995; 2009) has also indicated that fields such as engineering are filled by people whose People/Things work task dimension scores, calculated using respondents' ACT Interest Inventory scores, are tilted toward things rather than people.

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In light of these findings, the next logical step would be to examine the differences between males and females within the same academic major, especially STEM majors where females tend to be underrepresented. As there is evidence that academic majors can be differentiated by the average measured interest profile of the students within each major (ACT, 1995; 2009) and their precollege academic achievement profiles of their prospective student members (ACT, 2016; College Board, 2016), persisting male and female students within a given academic major should be quite similar in regard to their precollege academic achievement levels and measured interests. Moreover, if students' choice of academic major is influenced by their relative academic strengths, within an academic major there should be observable differences in students' academic achievement levels across high school subject grades and ACT® test scores.

The current study aimed to answer the following questions:

1. Do male and female students within academic majors differ as much in their precollege academic achievement levels and their measured interests as the overall population of ACT-tested students?
2. Are precollege relative academic strengths associated with students' declared academic major among fourth-year undergraduates?

Data and Analyses

Data for this study came from 120,612 students who initially enrolled at 26 four-year institutions. To increase the likelihood that students had settled on an academic major and had demonstrated satisfactory academic performance within their areas of study, students had to be enrolled at their institution for eight consecutive semesters. Students were categorized by their two-digit classification of instructional program (CIP) codes in the second semester of their fourth year of undergraduate study. Within each institution, only academic majors with at least 10 males and 10 females were included. Seventeen academic majors had sufficient numbers of students (*N* = 71,281) across institutions. These academic majors, the number of institutions, and the number of students are listed in Table 1. The five instructional programs classified as STEM (CIP codes 01, 14, 26, 40, and 51) are highlighted toward the bottom of the table.

Precollege academic achievement measures included self-reported high school grade point average (HSGPA; scored 0 to 4) and ACT test scores (scored 1 to 36). Self-reported grades and years of study were used to estimate average HSGPA in four subject areas: English, social sciences, mathematics, and natural sciences. For measured interests, ACT Interest Inventory scores were used to calculate People/Things and Data/Ideas work-task dimension scores.

Table 1. Institutions and Students by Classification of Instructional Programs (CIP)

		Students (*N*)		
CIP Code and Instructional Program	**Institutions (*k*)**	**Male**	**Female**	**Total**
09 Communication, Journalism, and Related Programs	23	1,819	4,134	5,953
13 Education	23	1,727	5,714	7,366
23 English Language and Literature/Letters	12	544	1,427	1,971
24 Liberal Arts and Sciences, General Studies, and Humanities	15	1,536	1,724	3,260
30 Multi/Interdisciplinary Studies	9	368	1,267	1,635
31 Parks, Recreation, Leisure, and Fitness Studies	15	708	896	1,604
42 Psychology	17	741	2,518	3,259
43 Security and Protective Services	15	605	475	1,080
45 Social Sciences	20	2,335	2,525	4,860
50 Visual and Performing Arts	20	1,233	2,019	3,252
52 Business, Management, Marketing, and Related Support Services	26	8,241	7,932	16,173
54 History	13	610	509	1,119
01 Agriculture, Agriculture Operations, and Related Sciences	7	1,159	1,122	2,281
14 Engineering	10	4,230	1,223	5,453
26 Biological and Biomedical Sciences	25	2,241	3,583	5,824
40 Physical Sciences	18	702	557	1,259
51 Health Professions and Related Clinical Sciences	16	830	4,102	4,932
		29,629	**41,727**	**71,281**

Within each institution, standardized mean differences (*d*; Cohen, 1988) were calculated for comparisons made between the precollege academic achievement measures (ACT scores and HSGPAs) and measured interests of their male and female students within their academic major. Mean differences were calculated by subtracting the female students' means from the male students' means and dividing by the pooled standard deviation. Positive *d* values indicate that the males were higher on the measure. Negative *d* values indicate that the females were higher. The effect sizes were corrected for range restriction and measurement error at the institution level, and the corrected institutional effect sizes (δ) were then meta-analyzed (Schmidt & Hunter, 2014). Corrections for range restriction were conducted using all ACT-tested students in the years that covered the sample in the study: test years 1999 through 2005 (ACT, N = 6,783,762; HSGPA, N = 5,718,341; ACT Interest Inventory, N = 5,968,806).

To explore the issue of relative strength, ACT English and reading scores were averaged to create an English-Reading (ER) test score, and ACT mathematics and science scores were averaged to create a STEM test score. Similarly, weighted high school English & social studies and STEM GPAs were created using subject area GPAs and subject area years of study. Making comparisons between scores on different measures can be misleading because a student with the same scale score on two measures may be considered relatively stronger on one than on the other if the percentile ranks for those scale scores differ. However, as this perceived gap in scale scores has been considered a contributing factor to female underrepresentation in math-intensive STEM fields, the claim warrants a preliminary examination.

Results

Meta-analytic results indicate that within academic majors, male and female students are quite similar in many regards, but they still differ in important ways. The largest effect sizes were found in the analyses of measured interests on the People/Things work-task dimension. As seen in Table 2, across all 17 academic majors, males' average scores on the Things dimension exceeded the average scores of their female peers. Standardized mean differences ranged from 0.27 to 0.63 (median δ = 0.43). Fourteen of the estimated mean differences were smaller than the difference found in the national, ACT-tested population (0.56). Though all the effect sizes associated with the People/Things work-task dimension comparisons were of practical significance (±0.20), the differences between males and females within a given academic major were often smaller

Table 2. Meta-Analytic Results for ACT Work-Task Dimension Score Comparisons for Male and Female Students within Programs

CIP Code and Instructional Program	Data/Ideas	People/Things
09 Communication, Journalism, and Related Programs	-0.13	0.43
13 Education	-0.07	0.52
23 English Language and Literature/Letters	-0.07	0.36
24 Liberal Arts and Sciences, General Studies, and Humanities	0.02	0.50
30 Multi/Interdisciplinary Studies	-0.05	0.58
31 Parks, Recreation, Leisure, and Fitness Studies	0.16	0.37
42 Psychology	-0.17	0.45
43 Security and Protective Services	-0.02	0.62
45 Social Sciences	0.04	0.40
50 Visual and Performing Arts	-0.05	0.27
52 Business, Management, Marketing, and Related Support Services	-0.15	0.50
54 History	0.09	0.39
01 Agricultural Sciences	0.11	0.55
14 Engineering	-0.05	0.36
26 Biological/Biomedical Sciences	0.06	0.38
40 Physical Sciences	0.06	0.39
51 Health/Clinical Sciences	0.02	0.63
National, ACT-Tested Population	**0.01**	**0.56**

than the differences between members of the same gender in different academic majors, as illustrated in Figure 1. For example, the measured interests of female engineering students were more like those of male engineering students than they were like those of female communications/journalism students. In contrast to the results for the People/Things work-task dimension, none of the effect sizes for the Data/Ideas work-task dimension comparisons were of practical significance (-0.17 to 0.16). As compared to the overall results, gender differences on the People/Things dimension for the STEM majors were smaller for engineering, biological/biomedical sciences, and physical sciences but larger for health/clinical sciences.

Meta-analytic results for comparisons made between HSGPAs for males and females within academic majors, presented in Table 3, indicated that female students had higher mean HSGPAs than male students; this was true for the overall results and for each of the five STEM majors. Compared to their male counterparts within their academic major, females tend to enter college with slightly higher grades in high school English (median δ = -0.44), social studies (median δ = -0.20), mathematics (median δ = -0.19), and natural science courses (median δ = -0.23). Differences of practical significance were most common for grades earned in English and natural science courses and less so for grades earned in mathematics and social studies courses. Gender differences in HSGPAs tended to be similar in magnitude within STEM majors as compared to the national reference group with some STEM majors showing slightly smaller gender differences and some showing slightly larger gender differences.

Results for the comparisons between ACT scores within instructional programs are in Table 4, with the differences found in the national, ACT-tested population

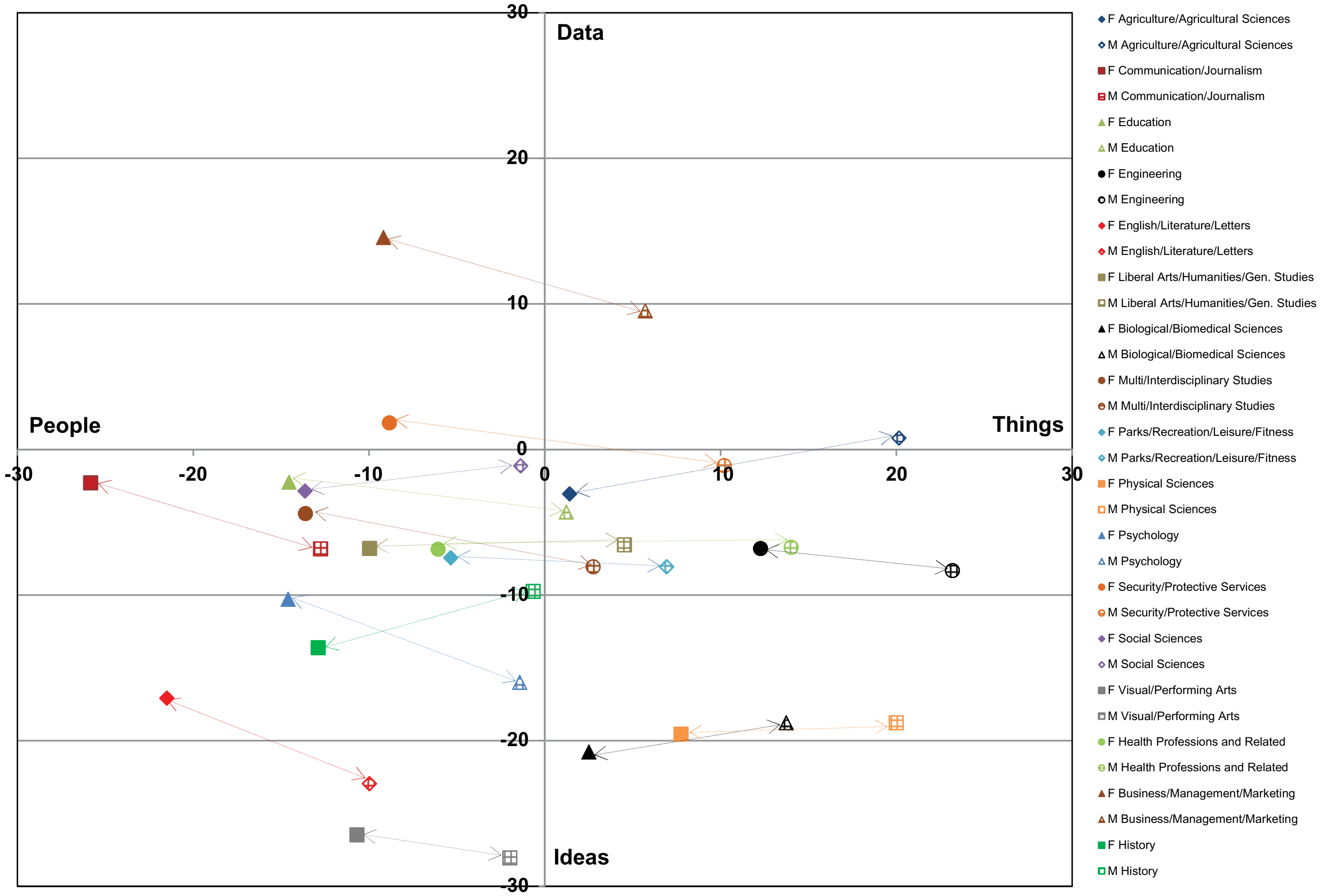

Figure 1. Work-task dimension score plots by academic major and gender

Table 3. Meta-Analytic Results for HSGPA Comparisons for Male and Female Students within Programs

CIP Code and Instructional Program	Overall	English	Math	Social Studies	Natural Science
09 Communication, Journalism, and Related Programs	-0.43	-0.54	-0.31	-0.21	-0.33
13 Education	-0.31	-0.46	-0.19	-0.13	-0.23
23 English Language and Literature/Letters	-0.31	-0.41	-0.17	-0.26	-0.17
24 Liberal Arts and Sciences, General Studies, and Humanities	-0.34	-0.50	-0.16	-0.22	-0.23
30 Multi/Interdisciplinary Studies	-0.48	-0.64	-0.28	-0.24	-0.34
31 Parks, Recreation, Leisure, and Fitness Studies	-0.38	-0.50	-0.26	-0.20	-0.28
42 Psychology	-0.33	-0.47	-0.13	-0.25	-0.22
43 Security and Protective Services	-0.32	-0.43	-0.27	-0.13	-0.19
45 Social Sciences	-0.30	-0.44	-0.17	-0.19	-0.17
50 Visual and Performing Arts	-0.30	-0.39	-0.19	-0.20	-0.18
52 Business, Management, Marketing, and Related Support Services	-0.34	-0.44	-0.24	-0.17	-0.24
54 History	-0.34	-0.44	-0.29	-0.16	-0.23
01 Agricultural Sciences	-0.37	-0.46	-0.28	-0.18	-0.25
14 Engineering	-0.34	-0.41	-0.23	-0.26	-0.21
26 Biological/Biomedical Sciences	-0.21	-0.33	-0.12	-0.08	-0.12
40 Physical Sciences	-0.34	-0.47	-0.19	-0.22	-0.23
51 Health/Clinical Sciences	0.27	0.36	0.19	0.13	0.15
National, ACT-Tested Population	**-0.28**	**-0.44**	**-0.13**	**-0.20**	**-0.18**

Table 4. Meta-Analytic Results for ACT Score Comparisons for Male and Female Students within Programs

CIP Code and Instructional Program	Composite	English	Math	Reading	Science
09 Communication, Journalism, and Related Programs	0.05	-0.18	0.26	-0.09	0.32
13 Education	-0.01	-0.28	0.23	-0.13	0.29
23 English Language and Literature/Letters	0.11	-0.13	0.36	-0.08	0.36
24 Liberal Arts and Sciences, General Studies, and Humanities	0.13	-0.16	0.40	-0.03	0.40
30 Multi/Interdisciplinary Studies	-0.11	-0.27	0.10	-0.28	0.16
31 Parks, Recreation, Leisure, and Fitness Studies	-0.09	-0.34	0.08	-0.17	0.19
42 Psychology	0.22	-0.06	0.47	0.05	0.46
43 Security and Protective Services	-0.01	-0.23	0.22	-0.15	0.24
45 Social Sciences	0.18	-0.06	0.36	0.01	0.42
50 Visual and Performing Arts	0.05	-0.14	0.21	-0.07	0.27
52 Business, Management, Marketing, and Related Support Services	0.05	-0.23	0.27	-0.07	0.31
54 History	0.00	-0.27	0.16	-0.13	0.30
01 Agricultural Sciences	-0.24	-0.54	0.07	-0.35	0.05
14 Engineering	-0.08	-0.33	0.13	-0.18	0.17
26 Biological/Biomedical Sciences	0.11	-0.17	0.33	-0.06	0.39
40 Physical Sciences	0.24	-0.08	0.44	0.08	0.53
51 Health/Clinical Sciences	0.10	-0.26	0.33	0.02	0.40
National, ACT-Tested Population	**0.04**	**-0.16**	**0.24**	**-0.08**	**0.23**

presented in the last row for reference. Across the 17 instructional programs, females tended to enter college with higher mean English (median δ = -0.23) and reading (median δ = -0.08) scores than did their male counterparts within academic majors. The results were reversed for the analyses of mathematics (median δ = 0.26) and science (median δ = 0.31) scores. Differences of practical significance were most common for ACT mathematics and science scores and less so for English and reading scores. Median effect sizes for overall HSGPA and ACT Composite score comparisons were -0.34 and 0.05, respectively. Gender differences within STEM majors tended to be larger than the overall gender differences in the national ACT-tested population.

Regarding relative strengths, exploratory analyses of ACT English-Reading and ACT STEM scores indicated that females' average English-Reading scores exceeded their average STEM scores in all 17 academic majors, as seen in Figure 2. Female engineering students displayed the greatest amount of balance, with their average ER and STEM scores being nearly identical. In contrast, the results for males were mixed, with males in majors such as engineering having higher average STEM scores and males in majors such as communications/journalism having higher average English-Reading scores, as seen in Figure 3. Analyses of high school English-Social Studies GPA and STEM GPA indicated that within each academic major both males and females, on average, entered college with slightly higher English-Social Studies GPAs.

Discussion

This study makes two contributions to the literature on female underrepresentation in STEM fields. Past research has indicated that males and females differ in their measured interest in working with things or working with people (Su et al., 2009). An expected outcome of the current study was that the gaps would be smaller within academic majors than the gap seen in the overall population, but male-female differences on the People/Things work-task dimension remained after conducting analyses at the academic major level. While there were differences within majors, keep in mind that the differences between students in unrelated majors were usually larger.

Among STEM students who had persisted through four years of college, gender differences exist within each of the five STEM major categories. In fact, these differences tended to be larger than gender differences observed for the overall population of ACT-tested students. Though this was not expected at the outset of the study, upon further thought, the results are encouraging because they suggest there is variability among persisting fourth-year STEM students. Female students should not be deterred from pursuing a STEM major in college if their precollege academic achievement levels and measured interests differ somewhat from the averages for students in a particular STEM major. Factors such as test scores, course grades, and student aspirations should guide students'

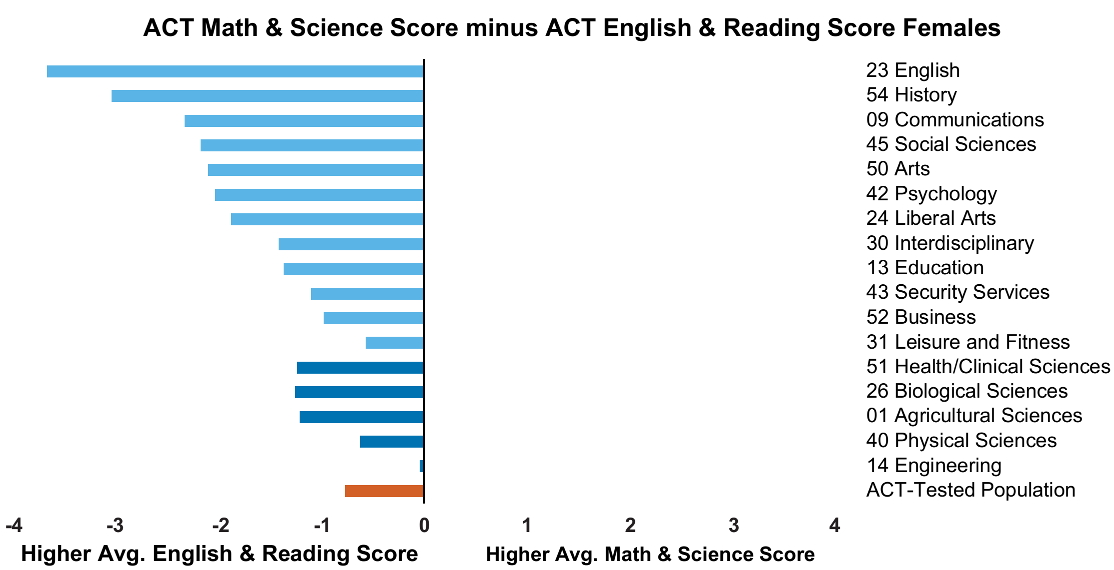

Figure 2. Relative strengths on the ACT, female students

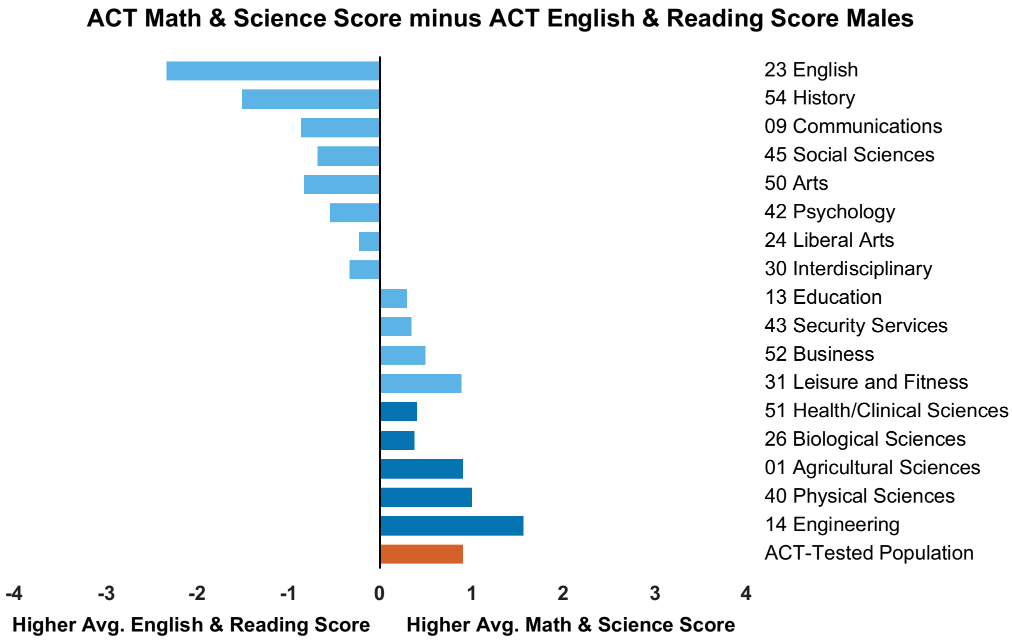

Figure 3. Relative strengths on the ACT, male students

selection of an academic major, but the results suggest that other factors may influence the selection of and persistence in a college major and that these factors may differ for females and males.

This study also contributes to the research on students gravitating toward academic majors that match their relative strengths. One reason given for the underrepresentation of females in mathematics-intensive academic majors is that females with high mathematics ability often have high verbal abilities (Ceci et al., 2009). As female students are more balanced in their precollege academic achievement levels, they have more career options. In contrast, male students with high mathematics ability tend to be more unbalanced in that they have lower verbal ability, and this imbalance may lead males to concentrate their attention on mathematics-intensive careers. The results of the exploratory analyses provide some support for this, at least among engineering students. Male students were also somewhat unbalanced across academic majors, but their tilts were in directions one might expect given their academic majors. Males in STEM majors were relatively stronger on the ACT math and science tests, and males in most of the non-STEM majors were stronger on the ACT English and reading tests. In contrast, the results suggest that female students were relatively stronger on the ACT English and reading measures across all 17 majors, regardless of whether the fields were verbal-intensive or math-intensive. However, the magnitude of females' ACT English and reading tilt varied in predictable ways across academic major areas with verbal-intensive majors, such as English, showing larger tilts and math-intensive majors, such as engineering, showing almost no tilt.

Arguments that scale score gaps may partially explain female underrepresentation in math-intensive STEM fields need further examination. Comparing scale scores on different measures is problematic because the distribution of scores may differ on each measure. While this exploratory analyses helps expand the theoretical understanding of scale score gaps, further research is needed that overcomes the inherent problems of comparing different scales with differing distributions and characteristics.

References

ACT. (1995). *Technical manual: Revised unisex edition of the ACT Interest Inventory (UNIACT)*. Iowa City, IA: ACT.

ACT. (2009). *The ACT Interest Inventory technical manual*. Iowa City, IA: ACT.

ACT. (2016). *ACT profile report—National: Graduating class 2016*. Iowa City, IA: ACT.

Achter, J. A., Lubinski, D., Benbow, C. P., & Eftekhari-Sanjani, H. (1999). Assessing vocational preferences among gifted adolescents adds incremental validity to abilities: A discriminant analysis of educational outcomes over a 10-year interval. *Journal of Educational Psychology, 91*(4), 777.

Ceci, S. J., & Williams, W. M. (Eds). (2007). *Why aren't more women in science?: Top researchers debate the evidence*. Washington, DC: American Psychological Association.

Ceci, S. J., Williams, W. M., & Barnett, S. M. (2009). Women's underrepresentation in science: Sociocultural and biological considerations. *Psychological Bulletin, 135*(2), 218–261.

College Board. (2016). *2016 college-bound seniors: Total group profile report*. New York, NY: The College Board.

Halpern, D. F., Benbow, C. P., Geary, D. C., Gur, R. C., Hyde, J. S., & Gernsbacher, M. A. (2007). The science of sex differences in science and mathematics. *Psychological Science in the Public Interest, 8*(1), 1–51.

Le, H., Robbins, S., & Westrick, P. (2014). Predicting student enrollment and persistence in college STEM fields using an expanded P-E fit framework: A large-scale multilevel study. *Journal of Applied Psychology*, *90*(5), 915–947. Retrieved from http://dx.doi.org/10.1037/a0035998.

Leuwerke, W. C., Robbins, S., Sawyer, R., & Hovland, M. (2004). Predicting engineering major status from mathematics achievement and interest congruence*. Journal of Career Assessment, 12*(2), 135–149.

Lubinski D., & Benbow, C. P. (2007). Sex differences in personal attributes for the development of scientific expertise In S. J. Ceci, & W. M. Williams (Ed.), *Why aren't more women in science? Top researchers debate the evidence.* Washington, DC: American Psychological Association, 79–100.

Schmidt, F. L., & Hunter, J. E. (2014). *Methods of meta-analysis: Correcting error and bias in research findings (3rd Ed.)*. Thousand Oaks, CA: Sage.

Shaw, E. J., Kobrin, J. L., Patterson, B. F., & Mattern, K. D. (2012). *The validity of the SAT for predicting cumulative grade point average by college major*. (College Board Research Report 2012-6). New York, NY: The College Board.

Su, R., Rounds, J., & Armstrong, P. I. (2009). Men and things, women and people: A meta-analysis of sex differences in interests. *Psychological Bulletin, 135*(6), 859–884.

Wai, J., Lubinski, D., & Benbow, C. P. (2005). Creativity and occupational accomplishments among intellectually precocious youths: An age 13 to age 33 longitudinal study. *Journal of Educational Psychology, 97*(3), 484.