The Relationship Between Perceived Confidence, Gender, and Writing in a Biomedical Engineering Research Experience for Undergraduates Site

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Women frequently feel alienated in science, technology, engineering, and mathematics (STEM) environments due to gender biases, ultimately leading them to feel less competent or leave the field altogether. This study utilizes personal statements from a subset of participants from a National Science Foundation (NSF) funded Research Experiences for Undergraduates (REU) Site: Biomedical Engineering in Simulations, Imaging, and Modeling (BME-SIM) to investigate how confidence is shown by participants and how confidence is perceived by faculty reviewers in personal statements. This study compares feedback from faculty reviewers to perceived and self-reported confidence using lexical (i.e., word choices and use) and syntactic (i.e., structures of language segments such as sentences, phrases, and organization of words) features of these personal statements. Women received more negative feedback related to confidence compared to their male counterparts, notably in relation to modesty. Few differences were found between writing styles of genders in their pre- and post-program statements. Overall, writing styles did not seem to correlate with the genders' perceived or self-reported confidence; however, perception of confidence suggested a relationship between genders' pre- and post-program statements when examined by noun and adjective variation. A similar relationship was found between self-reported confidence and noun variation in men and women participants. Findings suggest that writing style perceptions and practices may be influenced by gender norms; however, without looking at the specific diction and content of personal statements, these conclusions cannot be fully established. [DOI: 10.1115/1.4052764]

Introduction

Undergraduate research experiences have been shown to increase understanding of how to conduct research, confidence in skills, and awareness of graduate school [1]. In addition, such programs can clarify, refine, and reinforce science, technology, engineering, and mathematics (STEM) career path goals [2], thus increasing the likelihood of pursuing a STEM graduate degree [3]. The National Science Foundation (NSF) has leveraged research experiences to broaden participation in STEM—especially through the Research Experiences for Undergraduates (REU) program [4]. Research experiences can be vital in developing one's sense of competence within a domain [5]; interestingly, however, it has been found that mastery experiences, or accomplishments, have a higher influence on males' self-efficacy, while women's self-efficacy is influenced more by vicarious experiences and verbal persuasions [6]. In an NSF-funded REU site in Biomedical Engineering in Simulations, Imaging, and Modeling (BME-SIM), female participants self-reported lower confidence compared to male participants both pre- and post-program—even though confidence gains for all the participants were statistically significant [5]. These findings raised several interesting questions. Within the context of a Biomedical Engineering REU program, the objectives of this work are to investigate (1) how confidence shows up in writing samples, such as personal statements, from the reader's perspective; (2) whether personal statement writing style correlates to confidence; and (3) whether gender has an impact on the relationship between writing and confidence.

This novel investigation centers around analysis of writing samples with comparison to self-reported confidence. Writing samples, such as personal statements, are often used to evaluate candidates for career-enhancing opportunities like graduate school or research experiences. Personal statements should highlight an applicant's reasons for pursuing a program, their past accomplishments, and convey confidence in their abilities. This study will investigate how confidence shows up in personal statements and if writing style correlates to confidence—both self-reported and reader-perceived. Finally, given that female REU participants reported lower confidence and knowing women may alter their self-promotion based on social contexts [7], this study will investigate if gender impacts the relationship between writing and confidence.

Background

Women in STEM have historically been underrepresented; women made up only 21% of those who earned a B.S. in engineering from 2017 to 2018 [8]. Some suspect that this gap is caused by a lack of role models for women in STEM, sexism in both the workplace and academia, and self-efficacy beliefs influenced by gender norms [9]. While more research is needed to determine all causes for disproportionately fewer women in STEM fields, a decreased level of self-efficacy and belongingness

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has been identified as a prominent culprit [10]. Self-efficacy is defined as perceived competence in performing various tasks influenced by mastery experiences, or one's own accomplishments; vicarious experiences, or watching another person's accomplishments; and verbal persuasions, or words of encouragement [11]. Women consistently report lower levels of self-efficacy and belongingness within STEM related fields [10,12]. This lowered sense of self-efficacy can deter women from continuing with or pursuing STEM career paths; moreover, it can lead women to feel that they are unable to fit into STEM environments. Engineering experience can play a key role in how self-efficient one believes oneself to be; notably, the experience of "tinkering," or hands-on recreational mechanical experiences, can play a key function in one's belief in personal abilities in engineering [13]. Positive peer interactions and reactions can also increase one's competence and confidence within engineering [13,14]. Research experience can serve as a way for students to gain experience in the engineering field as well as develop relationships with faculty; therefore, serving to develop mastery experience, gain vicarious experience through faculty, and receive verbal persuasions—all factors contributing to self-efficacy development. Women may lack a sense of self-efficacy in engineering due to a small number of role models in the field to look up to and little encouragement due to subtle gendered biases [6]. With a lack of role models in the field, women may feel like achieving an engineering position is not possible; however, when these role models are present, they may feel they can attain these positions. While gender biases that are already present can impact one's self-efficacy, the gender norms taught can also shape one's perceived competence within various fields.

In childhood, women are often directed toward nurturing and collaborative work, while men are pushed toward more competitive and logistical work [10]. This could reveal why there is a disproportionate amount of men versus women in STEM or more women in humanities, elementary education, and domestics than men: individuals tend to approach and stick to domains that they find familiar or comfortable [10]. STEM fields are characterized with more masculine traits leading women to feel as though the female gender is not as STEM-oriented as male counterparts, thus pursuing lower positions within STEM and feeling a lowered sense of confidence and self-efficacy [6]. These societal expectations can lead women to fall victim to stereotype threat: when a stereotype is bought into self-efficacy is lowered, causing a decrease in performance and self-concept [13]. Gender role expectations may not only dictate what fields students decide to pursue but can also influence the ways in which people choose to represent themselves.

Women tend to be modest when discussing their achievements, notably in public spaces, whereas men tend to overestimate their achievements [14]. Studies have shown that women who chose to self-promote, thus violating gender norms, were perceived more negatively than male counterparts who behaved in a comparable manner [15]. This socialized modesty could potentially be damaging to a woman's career—if she fears social backlash due to self-promotion and competitiveness or feels she is not as competent as her male counterparts, she may be inadvertently opting out of career-enhancing opportunities [15,16]. This need to not appear as self-promoting could influence the ways in which women write about themselves in application materials such as resumes, personal statements, or cover letters. Given that women are characterized as communal and nurturing, they tend to use communal language that centers others and avoids self-assertiveness; men, on the other hand, use agentic, or more direct and self-assured, language that centers on oneself and is assertive [17]. However, this language use will vary upon the topic of writing. A study assessing personal statements from applications to a pediatric residency program found that men tended to use communal language equally as much as female applicants; however, men still used more agentic language than women [17]. Given that pediatrics is a female-dominated field of medicine, it is thought that applicants emphasized feminine characteristics in their writing because of the nature of the field. This study suggests that even though the topic and use of the text can influence writing styles, gender differences in presentation may still persevere [17]. In engineering, a male-dominated field that values male characteristics, agentic language may be perceived in higher regard than communal language. This can be a problem for women, who are conditioned to use communal language and avoid self-promotion. Additionally, it has been found that resumes written by women who present with agentic identities were perceived negatively and deemed to lack social skills [18]. Moreover, women statistically use more hedges, or words suggesting tentativeness or possibility, than men do; the ratio is a whopping 68.1% to 31.6% [19]. On the other hand, men are found to use 30% more boosters, or words suggesting certainty or sureness, than their female counterparts [19]. Words such as "obviously" and "clearly" were classified as boosters, while words such as "suggest," "possible," and "may" were classified as hedges [19]. These findings suggest that these written differences may be influenced by gender role conformity—if one does not stick to the status quo, they may face consequences.

Methods

This study was approved by the Institutional Review Board at East Carolina University (ECU) (UMCIRB # 13-002926), and informed consent was received by all participants.

The REU Site in BME-SIM at East Carolina University was funded by NSF in 2014 (EEC-1359183), 2017 (EEC-1659796), and 2020 (EEC-1950507). The goal of the BME-SIM REU program is to broaden participation by providing authentic research experiences to students who are traditionally under-represented in engineering. A description of the mentoring framework [20], support for a methodological theme [21], and outcomes from the last six years have previously been reported [5]. The BME-SIM summer program also provides professional development and mentoring opportunities [5].

During the application process, students are asked to submit a personal statement highlighting the student's personality, goals, and accomplishments. At the end of the program, students are asked to submit an additional personal statement as if they were applying to graduate school. Students were also asked to complete surveys regarding progress toward mastery of knowledge and skills—including confidence in research abilities—using a ten-point Likert scale on the first and last days of the program. A total of 55 students participated in the program from 2014 to 2019. Collected survey data indicated that women who participate in the program report a significantly lower sense of self-efficacy in research abilities when compared to male counterparts in both pre- and post-program participation [5]. During the BME-SIM REU, students attended three writing workshops held by the university's Writing Center, each about an hour and a half long: *Literature Reviews: Making Academic Synthesis Happen*, *Personal Statements: Packing a Punch in 1–2 Pages*, and *Scientific Writing (Abstracts): Conventions of Format, Style, and Content*.

A subset of the students ($n = 16$) participated in this study, eight males and eight females. The above described pre- and post-program personal statements were evaluated. Each personal statement was carefully anonymized to remove identifying information such as home university, gender, and other identifiers. A group of 11 faculty readers from various backgrounds and STEM disciplines reviewed the personal statements.

Reviewers were asked to highlight areas of text in green, yellow, or red: green for content they responded to positively for any reason, yellow for anything they found interesting, and red for content they responded to negatively for any reason. They were instructed that they could highlight any feature of the texts from individual words, to sentences, and paragraphs. Reviewers were also asked to comment on their reasons for highlighting. After marking up a statement, the reviewer completed a survey rating various characteristics the reviewer perceived about the author

Table 1 Participant demographics (this study only)

	Overall $n = 16$	Men $n = 8$	Women $n = 8$
Grade point average	3.746 ± 0.243	3.747 ± 0.279	3.746 ± 0.219
Class-standing			
Freshman	6.25%	12.5%	0
Sophomore	6.25%	12.5%	0
Junior	25%	12.5%	37.5%
Senior	62.5%	62.5%	62.5%
Race			
White	75%	75%	75%
Black or African American	19%	12.5%	25%
Latinx or Hispanic	6%	12.5%	0
Major			
Engineering	62.5%	62.5%	62.5%
Basic Sciences	6.25%	0	12.5%
Kinesiology/Exercise Physiology	25%	25%	25%
Other	6.25%	12.5%	0
Carnegie classification			
Associate's and Baccalaureate Colleges	12.5%	12.5%	12.5%
Master's Colleges and Universities	12.5%	0	25%
Doctoral Universities (Non-R1)	68.75%	75%	62.5%
Doctoral Universities (R1)	6.25%	12.5%	0

based on their reactions to the statement. Reviewers rated traits such as motivation, confidence, collaboration, research experience, overall experience, and STEM success on a five-point Likert scale; judged the overall tone of the writing sample; decided whether they would admit the student to a research program; and elaborated on their admittance decision. Each personal statement was reviewed by three faculty readers, and the readers were blinded to the identity and gender of the writers and whether the sample was written before or after the program.

Reviewers were guided through a norming session to acquaint them with the process of highlighting and commenting on statements and filling out the survey rating various characteristics following markup. Faculty reviewers were not told the premise of the study, only that they would be helping researchers create themes from students' writing samples. Due to COVID-19 restrictions, markup was done through MICROSOFT WORD, and surveys were taken through QUALTRICS. Norming sessions took place via MICROSOFT TEAMS.

A total of 639 comments were collected from the markup process. During an initial review of the comments, several themes began to emerge. Using a grounded theory approach [22,23], researchers defined the themes and chose examples representing each to use in coding all the reviewer comments. Collected comments were then independently coded by each researcher into the themes of confidence, collaboration, motivation, research experience, other experience, metacognition, and writing. The three researchers then compared results to determine the efficacy of the coding scheme and the reliability of individual determinations. Researchers discussed divergences in coding to agree on statements that were coded differently by all three researchers. Additionally, a linguist colleague was recruited as an outside rater to apply the coding scheme to approximately 10% of the data. The outside rater achieved an 85% inter-rater reliability with researchers' collective rating using the coding scheme.

The theme of confidence is the only comment category discussed in this paper as this theme most closely aligned with finding how confidence might appear in personal statements. Comments and highlights were used to gauge perceptions of faculty reviewers and provide insight into content they perceived as confident—notably, whether these perceptions of confidence differed between personal statements authored by men and women. Comments related to confidence were categorized based on the student's ability to convey their strengths, positive attributes, and achievements. Faculty reader comments such as "I like that applicant listed what they think would make them a strong candidate for this program" and "strong attributes that compensate for the lack of research experiences" were coded as confidence-related comments.

In addition to the reader markup, personal statements were analyzed using Dr. Haiyang's Lexical Complexity Analyzer and Syntactic Complexity Analyzer [24–29]. Comparing lexical and syntactic complexity to gender and self-reported confidence levels may reveal how writing styles differ between men and women and provide insight into the writing styles of confident students. The Lexical Complexity Analyzer uses 25 different measures of lexical features to determine lexical, or word, complexity. Researchers evaluated the number of different words (NDW) over the whole paper, the number of different words expected in a random 50-word group (NDWER50), type-token ration, mean segmental type-token ratio, noun variation, verb variation, adjective variation, and adverb variation [24–29]. The L2 Syntactic Complexity Analyzer uses 14 different measures of syntactic features to determine syntactic, or sentence, complexity. This paper will focus on clause per sentence (C/S) and dependent clause per clause (DC/C). To measure how self-reported confidence and perceived confidence correlated to lexical and syntactic complexity, researchers classified correlation coefficients of ±0.3 and less as none, ±0.31–0.49 as weak, ±0.5–0.69 as moderate, and above ±0.7 as strong.

Differences between pre- and post-program confidence (self-reported score and reader-perceived score) and other quantitative writing measures (highlighting amount and type, syntactic and lexical complexity) were examined using a paired Student's *t*-test with a *p*-value of 0.05 indicating a statistically significant difference. Differences in measures by gender were examined with an unpaired, two-tailed, Student's *t*-test.

Results

Participants. From 2014 to 2019, 55 students completed the BME-SIM REU program. Of these, 33 consented to participate in this study. The participants were then limited to those that submitted both a pre- and post-program personal statement for a total of 16 students and 32 personal statements. Demographics of this subset of participants can be found in Table 1.

Surveys. Students' survey scales were shifted down to a five-point Likert scale to match the faculty reviewers' scale. Most faculty reviewers fully completed their surveys, but a few reviewers

Table 2 Comparison of self-reported confidence levels and faculty-perceived confidence levels between pre- and post-program statements

	Student's self-reported confidence		Faculty confidence rating	
	Pre	Post	Pre	Post
Overall	2.75 ± 1.0	4.19 ± 0.83	4.04 ± 0.98	4.27 ± 0.69
Men	3.0 ± 1.2	4.25 ± 0.89[a]	4.1 ± 0.87[b]	4.18 ± 0.73
Women	2.5 ± 0.76	4.13 ± 0.84[a]	4.0 ± 1.09[b]	4.35 ± 0.65

[a]p-value <0.05 comparing pre- and post-program ratings.
[b]p-value <0.05 comparing student to faculty pre-program ratings.

Table 3 Correlations between faculty-perceived confidence and students' self-reported confidence

	Overall	Pre	Post
Overall	0.12991	0.0239	0.0136
Men	0.11896	0.34204	−0.1166
Women	0.15709	−0.4546	0.29222

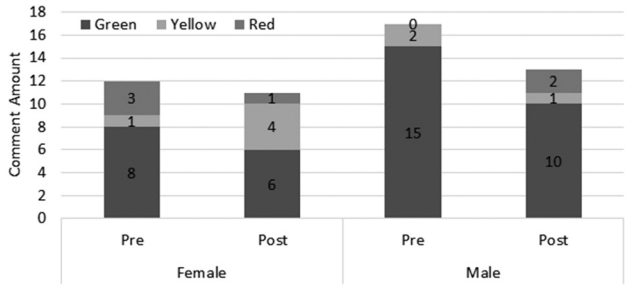

Fig. 1 Comparison of comment categorization and highlight type between men and women in pre- and post-program statements

did not complete them; of 96 expected surveys from the pre- and post-program statements, 94 were returned. Given that each personal statement only had one self-reported confidence level from the student, faculty reviewers' survey results were averaged together and compared to students' self-reported confidence. In this subset of BME-SIM participants, there was a significant difference found between pre- and post-program self-reported confidence for both men and women ($p = 0.01$; $p = 0.01$, respectively) with higher confidence ratings post-program; however, neither men nor women had a statistically significant difference between their pre-program and post-program self-reported confidence (Table 2). A significant difference was found between faculty and student confidence ratings in pre-program statements ($p = 0.0$ women; $p = 0.04$ men). Note the faculty perceived greater confidence than the students reported, particularly for the women. No significant difference was found between the student and faculty ratings post-program. No significant difference was found between faculty-perceived confidence in men's pre- and post-program statements, nor women's pre- and post-program statements. No significant difference was found between pre-program perceived confidence between men and women, nor post-program perceived confidence between men and women. A comparison of these confidence ratings can be found in Table 2.

No correlation meeting the threshold for significance was found between faculty-perceived confidence and students' self-reported confidence overall. Women's pre-program confidence had a weak negative relationship with faculty-perceived confidence—the higher faculty reviewers rated women's confidence, the lower women rated their own confidence in pre-program surveys. Men's pre-program statements had a weak positive relationship with faculty-perceived confidence. No correlations meeting the threshold for significance were found between men's nor women's post-program self-reported confidence and faculty-perceived confidence. These correlations can be found in Table 3.

Faculty Markup and Commenting. Faculty comments were categorized by theme, and researchers report only on the confidence-related comments. Out of 593 comments, 53 were categorized as confidence. Out of the 32 personal statements reviewed, 23 had comments related to confidence. Men were found to have slightly more green, or positive, confidence-related comments than women in both pre- and post-program statements (Fig. 1). Men had 15 positive comments in their pre-program statements and ten in their post-program statements, while women had eight positive comments in their pre-program statements and six in their post-program statements.

Moreover, women were found to have slightly more yellow, interesting, or red, negative, confidence-related comments than men. The negative confidence-related comments that women received tended to revolve around modesty, focusing on the writer appearing boastful, arrogant, or braggy. A sampling of faculty comments and student text can be seen in Table 4.

Faculty Markup Compared to Self-Reported Confidence Levels. To investigate the relationship between feedback type and amount, gender, and pre- and post-program statement, and student-reported confidence levels, the total number of positive (positive value, to the right) and the total number of negative comments (negative value, to the left) in each personal statement were plotted against self-reported confidence level (vertical axis) (Fig. 2). Men were generally clustered in the first quadrant with positive confidence-related comments and overall higher self-reported confidence. Women had more positive comments than negative, but the number of negative confidence-related comments tended to increase with increasing self-reported confidence. Whereas this was the opposite for men, in that as their confidence increased, the number of positive comments increased. The exception is one male student, who had the most positive confidence comments but self-reported the lowest confidence. Reviewers tended to comment on this student's awareness of their skills and their ability to relate these skills back to the BME-SIM program.

Interestingly, students received more positive feedback in their pre-program statements than post-program statements. Men generally had more positive feedback than women overall; however, women received more negative feedback than men did. Negative feedback was given to women when confidence levels were between six and nine, while men received negative feedback when their confidence levels were at six (Fig. 2).

Lexical Complexity Analyzer. To investigate students' lexical complexity, Dr. Haiyang's Lexical Complexity Analyzer was used to measure various lexical features [24–29]. No significant difference was found in NDW or NDWER50 between pre- and post-program statements in men and women. No significant difference was found in NDW or NDWER50 between men's and women's pre-program statements or post-program statements. A significant difference was found in noun variation between women's pre- and post-program statements ($p = 0.03$). All lexical data can be found in Table 5.

A moderate positive trend ($r = 0.60$) was found between faculty-perceived confidence and NDW. No trend was found between student self-reported confidence and NDW. A strong positive trend was found between faculty-perceived confidence and women's NDW ($r = 0.81$) and a positive weak trend between faculty-perceived confidence and men's NDW ($r = 0.49$). There were no trends identified between faculty-perceived confidence and adverb variation between men and women, but there was a weak negative trend found in women's overall noun variation;

Table 4 Sampling of faculty reviewer comments related to confidence

Comment color	Student gender	Student text	Faculty reviewer comment
Green	Male	"This drive to learn is something I am extremely grateful to have developed while still in high school because it enabled me to pursue higher education through scholarships."	"The writer shows humility through the word choice—grateful—and therefore described his ability to get scholarships without bragging."
Red	Female	"I have always been drawn STEM fields, even in the early years of my education. Strong academic success in high school led me to apply to (school); a prestigious boarding school in (location)."	"Comes off as bragging." "Vague start and overly confident, the school should be obvious in the transcripts and this opening makes the student sound boastful."
Red	Female	"I feel that I am a perfect fit for ECU's Biomedical Engineering and Simulation, Imaging, and Modeling program because I am passionate about research and a STEM career path."	"Overly confident."
Red	Female	"I have come to learn that I am fortunate enough to have a natural intelligence and proclivity to learn."	"This crosses the line between confidence, as illustrated in the sentence above, and arrogance."
Red	Male	"In my academic career, I have stood out among my peers."	"This is not for the writer to say, it is boastful and in fact may not be true."
Green	Female	"In the two years I spent there, I took a number of classes that fueled my desire to pursue STEM, some of which include biomechanics, electrical and mechanical engineering, advanced calculus classes, anatomy and physiology, and computer sciences, among many others."	"Impressed that the student got into the program."
Green	Female	"I am a goal-oriented and focused engineer, so I would be a great fit for your REU program. I am very passionate about improving the lives and health of others and I hope that acceptance into your program will give me the experience needed to turn my goals into realities."	"Student is confident without being cocky. They are aware of how they would benefit from the program."
Green	Male	"In two and a half years of undergraduate courses, I have maintained a 3.94 grade point average and distinguished myself in the REDACTED Kinesiology program. In my sophomore year, I was selected as one of two students for the College of Health Sciences REDACTED Program, a program dedicated to promoting leadership, scholarship, and undergraduate research. Along these research lines, I was selected in the fall of 2016 as one of ten REDACTED Undergraduate Research Fellows among REDACTED students."	"This is very specific, with specific instances of the writer's accomplishments. It is not boastful but fact-based."

moreover, when examined by gender between pre- and post-program statements, a strong negative correlation was found between noun variation in men's pre-program statements and faculty-perceived confidence (Table 6). A positive weak trend was found between noun variation and faculty-perceived confidence in women's post-program statements (Fig. 3). A moderate negative trend was found between faculty-perceived confidence and verb variation in men's personal statements, but this trend was not found in women's personal statements. Moreover, this negative trend in verb variation was much stronger in men's post-program statements. A moderate positive trend between faculty-perceived confidence and adjective variation was found in women's pre- and post-program statements (Fig. 4). A moderate positive trend was found in adjective variation between men's pre-program statements and faculty-perceived confidence but was weakly negative in post-program statements. All correlations between differing lexical measures and faculty-perceived confidence in students' personal statements can be found in Table 6.

Self-reported confidence did not seem to correlate with verb, adjective, or adverb variation overall (Table 7). However, there was a moderate positive trend between self-reported confidence and noun variation for women ($r = 0.59$), and a weak negative trend between self-reported confidence and noun variation for men ($r = -0.45$) (Fig. 5). When investigating between the gender's pre- and post-program statements, a moderate negative trend between self-reported confidence and noun variation was found in men's post-program statements. A weak positive trend was also found between noun variation and self-reported confidence in women's pre-program statements, and a weak negative in men's pre-program statements. A moderate negative trend was found in women's pre-program statements between verb variation and self-reported confidence. A moderate negative trend was found in men's post-program statements between adjective variation and self-reported confidence. All correlations between differing lexical measures and self-reported confidence in students' personal statements can be found in Table 7.

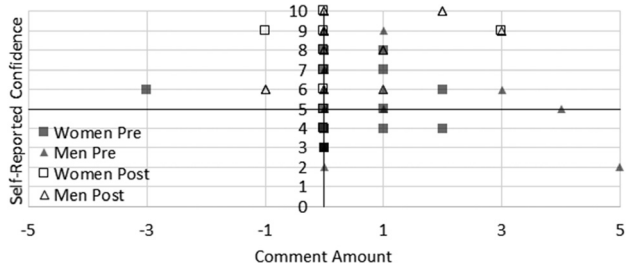

Fig. 2 Faculty feedback amount and type compared to self-reported confidence levels in men's and women's pre- and post-program statements

Syntactic Complexity Analyzer. To investigate students' syntactic complexity, Dr. Haiyang's Syntactic Complexity Analyzer was used to measure various syntactic features [24–29]. A significant difference was found between women's pre- and post-program statements for C/S and DC/C ($p = 0.02$; $p = 0.01$). No significant difference was found between any syntactic category and men's pre- and post-program statements. There was no significant difference found between men's or women's overall clause per sentence or dependent clause per clause. All syntactic data can be found in Table 8.

There seemed to be a negative moderate correlation between faculty-perceived confidence levels for men and C/S ($r = -0.61$) and DC/C ($r = -0.64$). There were weak negative trends between C/S or DC/C and faculty-perceived confidence for women. No strong correlations were found between self-reported confidence and C/S nor DC/C overall, but weak negative relationships were found between women's self-reported confidence and C/S ($r = -0.38$) and DC/C ($r = -0.46$). Correlations between differing syntactic measures and self-reported confidence and faculty-perceived confidence can be found in Table 9.

Discussion

Comparison of Self-Reported and Faculty-Perceived Confidence. Faculty reviewers tended to rate students' confidence higher than students rated their own confidence; however, students' confidence levels rose in post-program statements. The increase indicates that, by the end of the program, students' self-confidence aligned more closely with faculty reviewers' ratings, suggesting that REU programs have a positive effect on students' confidence in their abilities. Faculty reviewers also rated men's and women's confidence the same in pre- and post-program statements, showing no perception of difference in confidence levels for either gender. Faculty perceptions were not found to correlate with student's self-reported confidence levels overall; however, a weak negative correlation ($r = -0.45$) was found between women's pre-program confidence and faculty-perceived confidence—whereas faculty-perceived confidence decreased, student self-reported confidence increased. Overall, students received the most positive feedback when their confidence levels were between five and six; however, positive feedback amount seemed to decrease as self-reported confidence increased until self-reported confidence reached nine. Moreover, men received much more positive feedback than women did. Although women received a good amount of positive feedback, they also received more negative feedback than their male counterparts. These negative comments for women appeared when confidence levels were between six and nine, though men only received them when their confidence levels were at six. This relationship between self-reported confidence and feedback amount could be related to the ways in which students present their accomplishments.

Faculty Perceptions of Writing Style. Writing style was analyzed quantitatively and compared to faculty-perceived

Table 5 Averages of different lexical complexity measures between overall participants, then by gender

	Overall			Men			Women		
	Overall	Pre	Post	Overall	Pre	Post	Overall	Pre	Post
NDW	265.38 ± 55.42	243.44 ± 43.47	287.31 ± 58.57	255.44 ± 65.41	229 ± 39.25	292.75 ± 35.41	275.31 ± 43.11	257.88 ± 45.09	281.88 ± 77.66
NDWER5 0	39.63 ± 1.57	39.46 ± 1.52	39.78 ± 1.66	39.43 ± 1.78	39.56 ± 1.55	40.26 ± 1.01	39.83 ± 1.36	39.39 ± 1.59	39.3 ± 2.09
Verb variation	0.17 ± 0.02	0.17 ± 0.01	0.17 ± 0.03	0.17 ± 0.02	0.16 ± 0.02	0.18 ± 0.03	0.17 ± 0.02	0.17 ± 0.01	0.17 ± 0.02
Noun variation	0.64 ± 0.07	0.63 ± 0.07	0.66 ± 0.07	0.66 ± 0.07	0.67 ± 0.07	0.65 ± 0.07	0.63 ± 0.07	0.6 ± 0.05	0.67 ± 0.06[a]
Adjective variation	0.13 ± 0.02	0.13 ± 0.02	0.13 ± 0.02	0.13 ± 0.02	0.13 ± 0.01	0.13 ± 0.02	0.12 ± 0.02	0.12 ± 0.01	0.13 ± 0.02
Adverb variation	0.06 ± 0.02	0.06 ± 0.02	0.06 ± 0.02	0.07 ± 0.02	0.07 ± 0.02	0.06 ± 0.01	0.06 ± 0.02	0.06 ± 0.01	0.06 ± 0.02

[a]p-value <0.05 comparing pre- and post-program averages.

Table 6 Correlations between differing lexical measures and faculty-perceived confidence in students' pre- and post-program statements

	Overall			Men			Women		
	Overall	Pre	Post	Overall	Pre	Post	Overall	Pre	Post
NDW	0.6	0.58	0.63	0.49	0.51	0.57	0.81	0.78	0.83
NDW(ER50)	0.45	0.32	0.57	0.45	0.19	0.64	0.44	0.42	0.26
Verb variation	−0.32	−0.14	−0.51	−0.54	−0.23	−0.75	−0.06	0	−0.06
Noun variation	0.03	−0.24	0.3	−0.28	−0.86	0.2	0.38	0.16	0.41
Adjective variation	0.24	0.59	−0.06	−0.06	0.53	−0.38	0.64	0.69	0.59
Adverb variation	−0.18	−0.24	−0.06	−0.21	−0.26	−0.15	−0.15	−0.4	0.06

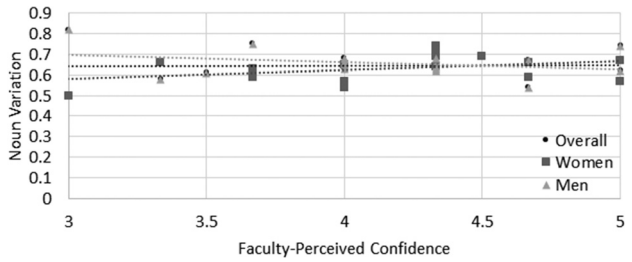

Fig. 3 Correlations between men's and women's faculty-perceived confidence levels and noun variation

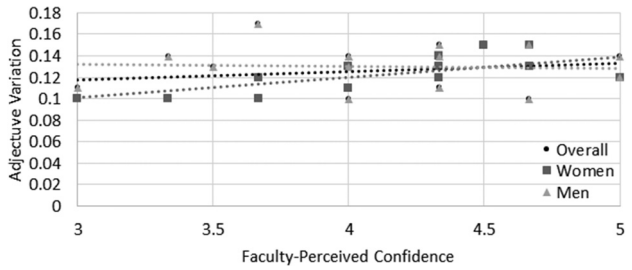

Fig. 4 Correlations between men's and women's faculty-perceived confidence levels and adjective variation

confidence. The number of different words writers used seemed to correlate moderately positively ($r = 0.60$) with faculty-perceived confidence—the more variation in words used, the higher the faculty rated a writer's confidence. The relationship between number of different words used and perceived confidence was also stronger for women than for men.

Overall, the types of words writers used did not seem to influence faculty-perceived confidence. However, when examined by gender, there seemed to be a difference between faculty-perceived confidence of men and women based on verb and adjective variation. Men were perceived as more confident as their verb variation decreased ($r = -0.54$), while women were not impacted. A stronger negative relationship between verb variation and faculty-perceived confidence was seen in men's post-program statements ($r = -0.75$). Men's overall negative relationship between verb variation and confidence may relate to their self-efficacy being most informed by mastery experiences—given that verbs describe actions, men may use verbs to project action in their writing [6]. Men may not be providing thorough descriptions of their experiences through nouns and adjectives, but instead describing what they did during their experiences. This may impact faculty-reviewers' perceptions of men's self-described experiences.

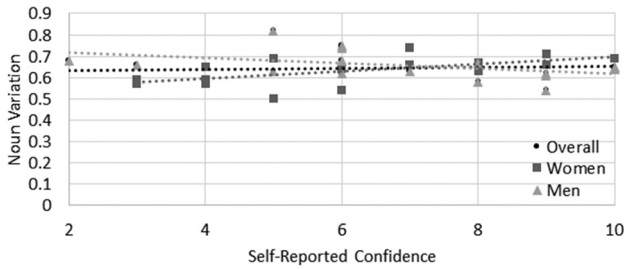

Fig. 5 Correlations between men's and women's self-reported confidence levels and noun variation

In comparing pre- and post-program statements by gender, differences between perceived confidence and writing style were also found. Men's perceived confidence was negatively related to noun variation in pre-program statements ($r = -0.86$). Women were perceived as more confident when their noun variation was increased in post-program statements ($r = 0.41$), while men's perceived confidence was not impacted. Women were perceived as more confident when their adjective variation increased overall ($r = 0.64$) and in both pre- ($r = 0.69$) and post-program statements ($r = 0.59$), while a positive relationship between adjective variation and perceived confidence was only found in men's pre-program statements ($r = 0.53$).

There was no significant difference found between overall use of types of words between men and women; thus, this relationship between faculty-perceived confidence and verb, noun, and adjective variation could be influenced by how these students are using

Table 7 Correlations between differing lexical measures and self-reported confidence in students' pre- and post-program statements

	Overall			Men			Women		
	Overall	Pre	Post	Overall	Pre	Post	Overall	Pre	Post
NDW	0.27	−0.34	0.3	0.25	−0.48	0.31	0.42	−0.04	0.42
NDW(ER50)	−0.14	−0.56	−0	−0.21	−0.59	0.16	−0.01	−0.63	−0.16
Verb variation	0.12	−0.24	0.27	0.14	−0.05	0	0.07	−0.56	0.5
Noun variation	0.08	0.075	−0.25	−0.45	−0.31	−0.68	0.59	0.41	0.27
Adjective variation	−0.1	−0.03	−0.26	−0.38	−0.12	−0.67	0.24	−0.24	0.26
Adverb variation	−0.2	0.07	−0.26	−0.27	−0.15	−0.31	−0.12	0.59	−0.3

Table 8 Comparison of differing syntactic measures between pre- and post-program statements among men and women

	Overall			Men			Women		
	Overall	Pre	Post	Overall	Pre	Post	Overall	Pre	Post
Length of sentence	24.675 ± 3.122	25.363 ± 2.73	23.988 ± 3.417	25.198 ± 3.87	25.576 ± 3.562	24.819 ± 4.367	24.153 ± 2.141	25.150 ± 1.786	23.156 ± 2.088
Clause per sentence	1.992 ± 0.272	2.01 ± 0.27	1.975 ± 0.282	2.025 ± 0.279	1.941 ± 0.276[a]	2.109 ± 0.272	1.96 ± 0.27	2.08 ± 0.261[a]	1.84 ± 0.235[b]
Dependent clause per clause	0.409 ± 0.071	0.421 ± 0.064	0.397 ± 0.078	0.413 ± 0.075	0.397 ± 0.072	0.43 ± 0.079	0.405 ± 0.069	0.444 ± 0.047	0.365 ± 0.067[b]

[a]p-value <0.05 comparing pre-program statement C/S between men and women.
[b]p-value <0.05 comparing women's pre- and post-program statement C/S and DC/C.

these types of words. Overall, there was a moderate negative trend between faculty-perceived confidence and clauses per sentence ($r = -0.5$) and dependent clause per clause ($r = -0.54$); moreover, these negative trends were stronger in men than in women. Given there was no significant difference between the number of clauses per sentence nor dependent clauses per clause between men and women, this negative perception may relate to how students are structuring their sentences. Moreover, women's positive relationship between noun and adjective variation and confidence could be indicative of attempting to adjust their communication styles to fit into STEM environments. This use of adjectives and nouns in women's writing could give the impression of confidence to reviewers—even if this confidence is not seen as "positive."

When looking at the types of feedback students received, faculty seemed wary of students who appeared overly confident or not confident enough—they expressed appreciation for students who were objective and specific about their achievements and skills. Women received slightly more negative feedback related to modesty, receiving feedback perceiving them as "overly confident," "braggy," or "arrogant." Positive confidence-related feedback relating to modesty referred to students appearing "confident without being cocky," or showing "humility"; moreover, most of this negative feedback in women pertaining to modesty appeared in pre-program statements. Women's use of adjectives was positively related to faculty-perceived confidence overall, as well as in pre- and post-program statements. Women's use of adjectives may play into this appearance of cockiness or humility—given that adjective are descriptors, they can significantly change tone based on how they are used. Some women feel that they must overcompensate for their achievements and modify their communication styles to appear more suitable to STEM fields, thus their use of adjectives could be seen as more assertive than males' preference to name what they accomplished [15]. Given past research regarding expectations of women to appear modest, subtle writing cues may signal readers about writers' genders based on stereotypes of gender presentation, thus influencing how these students appear to reviewers [15,16,18]. Moreover, some faculty reviewers used pronouns such as "she" or "he" in reference to personal statement authors, assuming the authors' genders. These assumptions of gender were on the faculty's own accord—researchers did not ask faculty to guess gender in the survey nor was it mentioned during the norming session.

Student Confidence and Writing Style. The relationship between students' self-reported confidence and characteristics of the writing in the students' statements was also investigated. Clause per sentence or dependent clause per clause did not seem related to overall self-reported confidence; however, there were differences when investigating by gender. When women expressed more confidence, the dependent clause per clause ($r = -0.38$) and clause per sentence ($r = -0.46$) decreased in their writing. But men's confidence did not impact clause use. Given that independent clauses must contain a subject and verb, and more clauses make sentences more complex, the negative trend between increased clause use per sentence and confidence could be evidence of overcompensation and overexplaining one's experiences. Moreover, dependent clauses are extensions of thought and often express time, cause and effect, and contrast—these extensions of thought in women may be perceived as overexplaining thoughts or experiences.

Overall, number of different words did not seem to have an impact on self-reported confidence. Types of words did not seem to have an impact of self-reported confidence overall; however, when investigating how types of words influence self-reported confidence between genders, there is differences in noun variation. Women's self-reported confidence had a moderate positive relationship with noun variation ($r = 0.59$); men, however, saw a moderate negative relationship between self-reported confidence and noun variation ($r = -0.45$). Given that men's self-efficacy is

Table 9 Correlations between differing syntactic measures and self-reported confidence in students' pre- and post-program statements

		Overall			Men			Women		
		Overall	Pre	Post	Overall	Pre	Post	Overall	Pre	Post
Faculty-perceived	C/S	−0.5	−0.44	−0.56	−0.61	−0.59	−0.71	−0.39	−0.29	−0.3
	DC/C	−0.54	−0.35	−0.7	−0.64	−0.47	−0.82	−0.42	−0.2	−0.48
Self-reported	C/S	−0.11	−0.1	−0.07	0.12	−0.11	−0.14	−0.38	0.09	−0.21
	DC/C	−0.12	0.02	−0.05	0.15	0.21	−0.25	−0.46	−0.08	−0.01

perceived to be most informed by mastery experience (experiences that can be expressed concretely), and women's self-efficacy is perceived as most informed by vicarious experience and verbal persuasions (experiences that are not as concrete), it can be inferred that these students used language to express the experiences about which they felt most confident [6]. Though this study found a negative relationship between men's confidence and noun variation, many male participants were at a lower class-standing than their female counterparts; thus, they have may have had fewer experiences to write about than women did. More confident men also may not feel the need to repeatedly name specific accomplishments or use a lot of detail in writing about their experiences. Given past research findings that women may feel the need to overcompensate or appear modest, namedropping or using adjectives to convey confidence or humility could be a mechanism to fit into STEM environments [15]. Differences in noun use between genders could also be related to typical writing styles—or stereotypical expectations of writing styles—of men and women. Noun use in men has been found to relate to objects and experiences, while women's use of nouns relates more to other people and teamwork experiences [30].

How Confidence Shows Up in Personal Statements. Given the significant confidence increase in post-program statements, correlations between lexical and syntactic complexity in pre- and post-program statements can be revealing of how confident students choose to write. Overall, no correlations were found between lexical variations nor syntactic measures. However, when investigating by gender, men and women differed in their relationships between self-reported confidence and noun, adjective, and adverb variation. Men's confidence had a weak negative relationship between self-reported confidence and noun variation overall, while women's self-reported confidence had a moderate positive relationship to noun variation overall. When investigating between pre- and post-program statements, men's post-program statements were negative and moderately related to noun variation ($r = -0.68$), while their pre-program statements were barely impacted ($r = -0.31$). Women's confidence was positive and weakly related to noun variation in pre-program statements ($r = 0.41$), but not post-program statements ($r = 0.27$). Men's self-reported confidence was weakly to adjective variation overall, but a moderate negative relationship between adjective variation and self-reported confidence was found in their post-program statements. Women's confidence was not related to adjective variation overall nor in pre- or post-program statements. Men's self-reported confidence was not related to adverb variation overall, but weak in post-program statements. Women's self-reported confidence was not related to adverb variation overall or in post-program statements but had a moderate positive relationship in pre-program statements ($r = 0.59$). Adverbs are used to modify or provide descriptions to other words. Given men's self-efficacy being informed by mastery experiences, it would be expected that men's confidence would have a positive relationship with noun variation as they gained these experiences through the program [6]. This might be explained by the lower class-standing of male participants. A lower class-standing may be indicative of less hands-on engineering work, thus fewer specific nouns to discuss in their personal statements. Women's self-reported confidence being related to noun and adverb variation in pre-program statements could be attributed to frequently identifying their experiences to appear suitable for STEM environments, thus supporting this idea of overcompensation [15]. Clause per sentence and dependent clause per clause did not have a relationship between students' self-reported confidence in pre-program statements nor when broken down by the genders' post-program statements.

Limitations

There are several limitations to this work. Feedback from faculty was investigated more so than the content of the students' writing, thus relying on faculty's interpretations of personal statement content. Students' writing was looked at through quantitative measures rather than the specific contents of the writing. Some faculty reviewers also made more comments than others, which may skew the results of the types and amounts of feedback that each gender received. While this study found differences in types of words used, it did not investigate the specific nouns, adjectives, or verbs that students are using. Insight into how these words are used in students' writing could further answer the question of how students convey confidence, whether the words are being used to overcompensate for a lack of confidence, and whether the type of diction used aligns with gender-typical/stereotypical ways of writing in differing environments.

This study also did not investigate how complex sentences are used to express confidence. Investigating how students express their thoughts through sentence structure may be revealing of confidence; notably, whether students are overstating their experiences to compensate for a lack of confidence. Investigating what students are writing about could provide insight into what students value and further add to the discourse surrounding gender norms and expectations about fitting into STEM environments. All participants in this study were admitted and participated in the BME-SIM program. Comparing admitted students' personal statements to those who were not admitted also may be revealing of writing styles that are successful in application materials.

Participants at the BME-SIM REU also participated in writing seminars guiding them through how to write literature reviews, personal statements, and scientific abstracts. These seminars could have an influence on how students write between their pre- and post-program statements. Moreover, researchers cannot confirm if these personal statements were reviewed by outside sources such as professors, mentors, and peers; however, students were encouraged to have their personal statements revised by outside sources before submission, so potential for revision is possible. Attending these writing seminars and the potential for revision by outside sources could have an impact on the results among students and their pre- and post-program statements. Thus, it would be worth investigating how confidence correlates with initial drafts of students' personal statements before revisions.

Conclusions

Although a significant difference between men's and women's pre- or post-program self-reported confidence was not apparent in

this subset of participants, an increase in self-reported confidence between pre- and post-program confidence overall was noted. This significant difference in confidence levels between pre- and post-program statements indicates that the BME-SIM program was beneficial for all students, confirming findings from the program's six-year review [5].

Overall, faculty seemed to appreciate a higher level of lexical complexity in students' personal statements. Faculty-perceived confidence positively correlated with adjective variation in women and noun variation in men; however, there was no difference in the amount of variation in adjectives or nouns in men and women. This correlation could be related not to variation, but to how these types of words are being used in writing.

Faculty perceived no difference in confidence levels between students, so it would be expected that feedback amount and type should not differ. However, women tended to receive less positive feedback and more negative feedback than male counterparts. Given previous research finding that women who deviate from the gender norm of modesty and the amount of negative modesty feedback that women received, it is possible that subtle gender-revealing cues could be present in writing [15,16,18]. Types of adjectives used could have an impact on the tone of students' writing, whether that tone is meant to convey self-assurance or to show humility about one's accomplishments.

Noun variation seemed to correlate positively with women's self-reported confidence, but negatively in men's self-reported confidence. This may suggest evidence whether and in what ways students modify writing styles to fit into STEM environments—women may feel most confident when they overidentify their specific experiences, while men may not feel the need to do so. Moreover, these relationships were stronger in students' pre-program statements compared to the post-program statements. Given that both genders' confidence levels were lower in pre-program surveys, there may be a relationship between noun variation and self-reported confidence. However, without looking at the specific diction and content of these personal statements, this relationship between noun use and confidence in relation to gender roles cannot be established.

It is important to reiterate that in some instances faculty reviewers used pronouns (he or she) when referring to writers in their comments about the statements. The use of pronouns suggests that readers have preconceptions about students' genders based on their writing even though the faculty reviewers had no way of knowing which genders the students identified with. The readers made assumptions about gender based on their expectations about how men and women present themselves in writing. Researchers can use what is learned through this type of research to help students develop their confidence as writers and highlight their accomplishments more effectively. Researchers may also be able to identify ways that people reading personal statements—whether faculty or potential employers—make assumptions based on the ways writing, and therefore writers, are perceived.

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