Tackling the Underrepresentation of Women in Computing and Finding Novel Help in Athletics

Gloria Childress Townsend
Department of Computer Science
DePauw University
Greencastle, IN, USA
gct@depauw.edu

Khadija Jirari Stewart
Department of Computer Science
DePauw University
Greencastle, IN, USA
khadijastewart@depauw.edu

Sharmin Tunguz
Department of Psychology and Neuroscience
DePauw University
Greencastle, IN, USA
sharmintunguz@depauw.edu

***Abstract*—Researchers address the underrepresentation of women in computer science by conducting a four-year longitudinal study to explore the relationships among athletics, personality measures, gender, and performance in Computer Science I (CS1). The study explores personality traits (openness, persistence, and endurance) that enhance women's performance and persistence in both athletics and computer science, according to a literature review. Experimental results show female athletes out-perform (measured by CS1 grades) all other groups: male athletes, male non-athletes, and female non-athletes. The authors report results from statistical analyses to support hypotheses regarding reasons for female athletes' superior performance in CS1. The paper closes with a Future Work section that indicates how the lessons learned from female athletes in computer science might be applied to addressing the underrepresentation of all women in computing.**

***Keywords*—Gender issues, under-representation in computing, athletics, personality traits, Computer Science I, resiliency in computing**

I. Introduction

During the ten years between 2007 and 2016, the percents of computer and information sciences bachelor's degrees awarded to women hovered between 18% and 19% [6]. The National Center for Educational Statistics recently released the corresponding 2017 percent, 19%. Fig. 1 shows the 11 data points from 2007 to 2017 graphed slightly below the 20% axis. The plateau challenges researchers in gender issues within computing – especially because all other STEM fields, including engineering, [6] exhibit increases over the same period of time. The remaining STEM disciplines break the 20% barrier that restrains computing. The sense of urgency implied by the flat line in Fig. 1 encourages novel research.

During their combined 50 years of computer science teaching experience, the authors observed that female athletes, exhibit resilience in computer science classrooms and seem to thrive on the challenges that projects present. The authors then designed an experiment to explore the relationships among athletics; gender; computing performance; and traits of confidence, intimidation, competitiveness, openness (curiosity), endurance, and persistence. **The research questions: How are female athletes' personality traits similar to or different from those of male athletes, and of non-athletes? How do personality traits, gender, athletic team membership, and grades interact?**

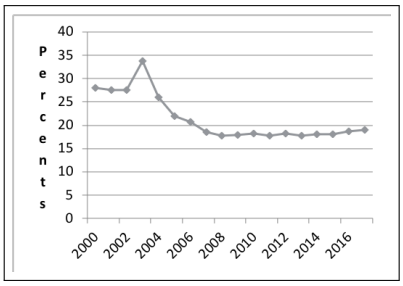

Fig. 1. Percents of female computer and information sciences bachelor's degrees in the US from 2000 to 2017.

II. Literature Review

Psychologists identify five personality traits in the Five Factor Model [1] which provides a widely-accepted taxonomy. The authors examined the literature regarding two of the five traits, openness and conscientiousness, to investigate the relationship of the two traits to success in athletics and to success in computer science.

A. Openness or Curiosity

Some studies associate openness/curiosity with athletes who engage in non-risk sports. Non-risk athletes scored significantly ($p<0.05$) higher in openness than non-athletes, using the Five Factor Scale [4]. Another study [10] also used the Five Factor Scale and found that individual-sport athletes scored higher than team-sport athletes. Moving to the relationship between openness/curiosity and performance in computing: "A meta-analysis on 19 independent samples (total N = 1,695) highlighted that programming aptitude was associated with three personality traits, conscientiousness, openness, and introversion" [3].

B. Conscientiousness or Persistence

Athletes' self-ratings on the Five Factor Scale correlated with coaches' composite scores for conscientiousness ($p<0.05$) and with game statistics ($p<0.01$) [8]. With respect to computing performance, a survey of literature regarding personality and programming found that all 19 reviewed studies

978-1-7281-7172-2/20$31.00

demonstrated positive correlations between conscientiousness and computer programming [5]. The study [3] emphasized in Section A above also points to the association between conscientiousness and programming aptitude.

C. Endurance or Growth Mindset

Coaches foster endurance through long hours of practice. Researchers [9] state that with a growth mindset promoted by practice "…motivation is optimized, participants are invested in the task and persist longer, performance is higher…" The Growth Mindset principle finds its way into current research curated by the National Center for Women & IT [7]. For decades Dweck [2] has investigated the concept that students' intelligence is not "fixed" but is instead "elastic" – the mind can "grow" with hard work and practice.

III. Methods

A. Procedure

Students (457) from a small liberal arts college in the Midwest USA participated in an anonymous survey (available from the authors). Survey invitations were distributed to all (approximately 500) students enrolled in CS1, and to a random sample of students enrolled in courses belonging to all divisions of the university. Students (191 women; 220 men; 26 did not specify gender) indicated current or past enrollment in CS1; and 20 stated that they had not previously enrolled in CS1. Of the 191 females, 49 were athletes with 45 obtaining a "B" or better in CS1; 141 were not athletes with 111 obtaining a "B" or better in CS1; and one student left the athletics category blank. Of the 220 males, 90 were athletes with 69 obtaining a "B" or better in CS1; 128 were not athletes with 106 obtaining a "B" or better in CS1; and two students left the athletics category blank. The survey was administered at the ends of fall and spring semesters over a five-year period (May 2015 through May 2019). The survey took 15 minutes to complete.

B. Participants

Participants ranged in age from 18-22; 15% belonged to an ethnic minority; 23% were international students; and 18.5% were first generation college students. 12% students had at least one parent who worked in an information technology field.

C. Measures

Academic and athletic measures. Participants answered a range of questions that assessed their majors, overall GPA, graduate school plans, academic interests and experience in computer science courses, as well as their participation and level of involvement in an athletic sport.

Personality Measures. Participants completed a personality measure composed of six items designed to tap into their general propensity for resiliency. The items required participants to indicate their overall standing on each of the following traits: confidence, competitiveness, intimidation (reverse scored), **openness to experiences, persistence, and endurance**. Each trait was measured on a Likert scale that ranged from 1 (rarely or not at all) to 5 (almost always). This paper addresses the last three (bolded) personality traits. The researchers created the survey items pertaining to these traits for the purposes of this study and based the survey items on traits which the literature (Section II) indicates that successful computer science majors display. The literature also points to successful athletes' sharing these same three traits. When linking these results, it follows that computer science major athletes should score high on these traits and should outperform computer science non-athletes.

The authors conducted statistical correlations (Pearson's correlation coefficient) for each pair of the three personality traits – in order to strengthen the argument that the three survey items collectively measure what the researchers identify as a resilient personality. The results in Table I reveal five strong correlation coefficients and one marginally strong coefficient.

TABLE I
Pearson's Correlation Coefficients Calculated for All Pairs of Personality Traits Measured in This Paper

Correlated Traits	Female Athletes	Female Non-Athletes
Persistence & endurance	0.67	0.74
Openness & endurance	0.73	0.79
Openness & persistence	0.83	0.93

IV. Experimental Results and Analyses

A. Traits without Grades

Results for the research question **"How do the traits of openness, persistence and endurance for women and men, athletes and non-athletes interact?"** are graphed in Fig. 2 by first calculating the percents of positive survey responses for each category. Next, a set of t-test results (Table II) compares male and female athletes with respect to each of the three traits.

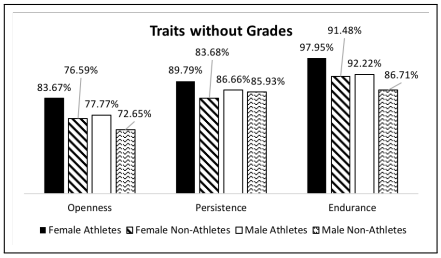

Fig. 2. Percents of positive responses to questions regarding traits of openness, persistence, and endurance for male and female athletes and non-athletes.

TABLE II
Three T-Test Results for Four Sets of Populations

p-values	MA/ MNA	FA/ FNA	FA/ MA	FA/ MNA
0penness	0.370	0.107	0.0399	0.0559
Persistence	0.404	0.0057	0.0089	0.0042
Endurance	0.221	0.0082	0.0007	xxxx

Female athletes self-report higher percents of all three traits compared to the other three groups – female non-athletes, male athletes, and male non-athletes. With respect to openness, women athletes report being open or curious at a rate of 6% higher than male athletes, who self-report only 1% higher

than female non-athletes. Male non-athletes report the lowest percent – about 4% lower than female non-athletes). Overall, comparisons indicate the highest percent of positive responses to the openness survey item for female athletes.

With regards to persistence, female athletes again self-report the highest percent of persistence (defined as persisting in problem solving). The second-highest group is male athletes (at about 3% less than female athletes), followed by male non-athletes and female non-athletes. Female athletes rate their own endurance traits 5% higher than male athletes do and 6% more than female non-athletes. Male non-athletes self-report the lowest percent of endurance (5% lower than women non-athletes and 6% lower than male athletes).

The researchers expanded exploration of descriptive statistics reported in the preceding three paragraphs by conducting t-tests to compare female and male subgroups of athletes and non-athletes. Table II shows no statistically significant differences between male athletes (MA) and male non-athletes (MNA) for all three traits. However, t-tests comparing female athletes (FA) to female non-athletes (FNA) show strong evidence that athletics has an impact on women with respect to the traits of persistence and endurance ($p<0.01$), but the tests show only marginal significance with respect to the trait of openness.

T-tests comparing female athletes to male athletes and to male non-athletes reveal the same trend with respect to persistence and endurance: significant differences ($p<0.01$) for the traits of endurance and persistence. However, there is a significant difference ($p<0.05$) between the two groups with respect to openness.

Finally, t-tests comparing female athletes to male non-athletes show a marginally significant openness result, a significant persistence result ($p<0.01$), and an invalid endurance result. Variance among female athletes scores for endurance is 0.198; male non-athletes, 0.59. Variance for male non-athletes is more than twice the variance for female athletes, creating an invalid statistic. Remaining variances satisfy constraints.

Discussion. Why do female athletes score the three traits so highly? The authors speculate that the worldview of female athletes is different from that of non-athletes. Athletes experience competition essentially daily; they are open to new experiences, because few limits exist in their athletic lives (in part, due to Title IX). Female athletes practice and compete on the same literal playing fields as men do, so they view computer science as a figuratively level playing field, as well.

Female athletes work long hours on and off the courts/fields to hone their skills. A subject such as CS1 which their peers and the media may describe as "hard" seems less daunting to one used to "hard" work in a sporting "classroom". Adopting the preceding sentence's premise indicates why endurance (growth mindset) might be so prevalent among female athletes in CS1.

The researchers conjecture that the coaching relationship translates to the CS1 classroom. Coaches instruct players to improve their performance. Professors take over teaching responsibilities and inspire students (much in the same way as coaches do) to learn algorithmic and problem solving skills. Female athletes conscientiously follow both kinds of "coaches".

B. Traits with Grades

Female athletes receive higher grades than any other subgroup. Results for the research question **"How do the traits of openness, persistence, and endurance for women and men, athletes and non-athletes interact with grades?"** are graphed in Fig. 3 by first calculating the percents of positive survey responses for each category. Next, a set of t-tests compares male and female athletes and non-athletes (with CS1 grades that are "B" or better) with respect to each of the study's three traits. This section examines survey results for 346 students who received a "B" or better in CS1. Fig. 3 provides the portions of those students who record a 4 or a 5 Likert Scale measure in openness, persistence, and endurance.

In Fig. 3, female athletes report the highest percent of openness, about 4% higher than the remaining three groups, which differ about 1% from each other. Male athletes score the highest percent in persistence, followed very closely by female athletes (a difference less than 0.2%) and then male non-athletes (at about the same percent). Female non-athletes self-report much lower levels of persistence than the top groups (a difference of 7%). Endurance follows the same pattern as openness. Female athletes score 6% more positive responses for endurance than male athletes, who score slightly better than female athletes (a difference of less than 3%). Male non-athletes are in the last position at a little over 3% less than female non-athletes.

The authors again conducted t-tests (Table III) for the same four subgroups. The t-test results display no significant openness and persistence differences between male athletes and non-athletes. When contrasting female athletes and female non-athletes, t-tests give evidence that athletics significantly ($p<0.01$) relates to persistence in women who obtained a "B" or better in CS1 – with a marginal p-value for openness. Once again, the variances for female and male athletes with respect to endurance were extremely small (especially for women), disallowing t-test computation for the personality trait of endurance.

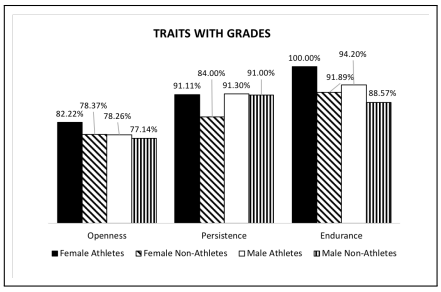

Fig. 3. Traits of Openness, Persistence, and Endurance for men and women, athletes and non-athletes who received a "B" or better.

When comparing female athletes to male athletes and male non-athletes, t-tests show evidence that there is a significant difference in persistence (compared to both male athletes and

TABLE III
T-TESTS FOR STUDENTS WITH CS1 GRADES OF "B" OR BETTER

p-values	MA/ MNA	FA/ FNA	FA/ MA	FA/ MNA
0penness	0.2041	0.0902	0.0885	0.2388
Persistence	0.4682	0.0027	0.0476	0.0376
Endurance	xxxx	xxxx	xxxx	xxxx

male non-athletes). However, in Fig. 3, male athletes self-report persistence at a percent slightly higher than women athletes. This observation warranted a closer look at the self-reported percents of persistence for female athletes, male athletes and male non-athletes. Table IV gives the percents of self-reported persistence for each of the three groups, separated for Likert scales 3, 4 and 5.

TABLE IV
PERCENTS OF SELF-REPORTED PERSISTENCE FOR FEMALE ATHLETES, MALE ATHLETES AND NON-ATHLETES WITH "B" CS1 GRADES

Persistence Level	FA	MA	MNA
Likert scale 5	57.7%	37.68%	40%
Likert scale 4	33.33%	53.6%	51.4%
Likert scale 3	8.8%	7.2%	4.76%

Table IV shows that women self-report a Likert scale 5 on persistence at a much higher percent than both male athletes and male non-athletes (by over 17%). The researchers believe that this large difference is what led to the significance in the t-tests. When the scores of 4 and 5 were combined in Fig. 3, the total masked the large numbers of 5 scores reported by the female athletes.

Discussion. Discussions of the differences (both descriptive statistics and t-tests) between female athletes and female non-athletes are similar in this section concerning student grades to those in the last section, where grades were not measured. The authors add new explanations (now concerning grades alone) to the preceding discussion (without grades) – explanations to account for the large percents of positive scores for the three personality traits and for the statistically significant differences obtained from t-tests.

The researchers reviewed the descriptive statistics and the t-test results from the analyses in the preceding paragraphs to pose some explanations for the success of female athletes in computer science classes – where 92% of female athletes reported grades of "B" or better. First of all, female athletes know that practice is key for game/match preparation; the growth mindset (endurance) trait within the CS1 classroom is a natural extension of practicing for success on courts and fields.

Similarly, in a nod to persistence/conscientiousness, female athletes experience both wins and losses in their sports. The athletes internalize the inevitability of loss and its ability to build a resilient personality. The authors anecdotally report that many female students bemoan a grade that is less than an "A" and feel they are unsuited for computer science with such a grade. Student athletes may better understand "wins and losses" in the "sport" of computing.

Finally, many athletes develop a philosophy whereby they want to compete or practice with players that may be more talented than they are. The athletes understand that playing or practicing with more skilled players improves their own games; they care more about improving than losing. Once again endurance – or a slightly different interpretation of the growth mindset – within sport may translate to the CS1 classroom, where students engage in challenging practice (from supplemental reading to extra website instruction/practice). This desire to improve by utilizing the most strenuous computing "workouts" may lead to better CS1 grades.

V. CONCLUSION AND FUTURE WORK

Conclusion: Among all subgroups (female athletes and non-athletes; male athletes and non-athletes), female athletes report the highest positive rates of curiosity, conscientiousness, and endurance. Female athletes differ significantly from other subgroups in terms of persistence.

Limitations:

- The study's geographic environment is Midwest USA
- The study's school is a selective national-level small liberal arts school
- The student body size is approximately 2000
- The school's athletes play in Division III of the NCAA
- Students do not receive athletic scholarships
- Underrepresented and international students each account for 20% of the student body
- Although the total sample size (457) is large, some subgroups are small
- Students declare majors as sophomores

The authors wish to conduct more quantitative studies, along with qualitative studies, before they launch projects that will leverage conclusions gained from their current research. The group considers both recruiting from athletic teams and also forming "CS1 teams" that resemble athletic teams.

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