# Gender and Engagement in CS Courses on Piazza

Adrian Thinnyun
University Of Virginia
Charlottesville, Virginia, USA
att4wp@virginia.edu

Ryan Lenfant
University Of Virginia
Charlottesville, Virginia, USA
rpl8af@virginia.edu

Raymond Pettit
University Of Virginia
Charlottesville, Virginia, USA
raymond.pettit@virginia.edu

John R. Hott
University Of Virginia
Charlottesville, Virginia, USA
jrhott@virginia.edu

## ABSTRACT

Online discussion forums are being increasingly used in classrooms as a way to encourage collaborative learning and community. Piazza is one such forum that was built specifically for academic institutions, and has been widely adopted. Students have the opportunity to ask questions and seek answers from peers and instructors alike online, allowing them to find the information they need even if they do not know fellow students in the class or if they cannot make an instructor's office hours. However, recent analysis of the popular online discussion site Stack Overflow, suggests that women are more likely than men to withdraw from such a community if they do not identify other members of the same gender. Women are often a minority in computer science courses and can express difficulty interacting with or seeking help from their peers who are predominantly men. Considering the importance of providing equal access to students regardless of gender and the value of resources like Piazza in one's education, it is imperative to assess the representation and impact of gender on Piazza. We analyzed data from over 2,500 Piazza users across three computer science courses at the University of Virginia and found that women on Piazza post more questions than men, spend more time on the discussion site, and achieve higher reputation scores on average. However, they are more likely to both ask and answer questions anonymously than men and less likely to receive responses from members of the same gender.

## CCS CONCEPTS

• **Social and professional topics** → **Gender**; • **Human-centered computing** → **Empirical studies in collaborative and social computing**.

## KEYWORDS

online communities, gender, females in computing, social q&a, peer parity, piazza

## 1 INTRODUCTION

Computer Science has long been plagued by a lack of women. There exists an abundance of work cataloguing the disproportionately low number of women in computing compared to men [2, 13], the lack of confidence women feel in their own abilities [10, 23], and the sexism faced by women from their male peers [20]. Considering the many benefits of a diverse CS community [28, 30] and the important contributions women have made to the field at large [14], it is clear that efforts should be made to support aspiring female computer scientists wherever possible.

Pooja Sankar created Piazza, an online Q&A discussion forum used by colleges and universities across the United States, for this very purpose. As one of only three women in her CS program in India, Sankar understood the feelings of isolation experienced by many women in computer science and created Piazza so that everyone could have an equal opportunity to learn from their classmates [33]. A study conducted by Piazza showed that female CS students were actually more engaged and asked 26% more questions on the platform than their male peers [1]. However, female CS students also displayed less confidence overall, answering 37% fewer questions and using the anonymity feature for both questions and answers more often than male students [34]. Additionally, larger class sizes lead to even greater confidence gaps between women and men on the platform [36]. Student collaboration and participation are some of the most important factors in a successful learning environment [31], so ensuring that women feel comfortable collaborating and participating online with their classmates is critical.

To inform our understanding of Piazza's success in helping women feel comfortable discussing CS material online, we compare it with Stack Overflow. Stack Overflow is a popular question and answer site for programmers with over 10 million registered users [4]. On Stack Overflow, men are not only more represented, but also ask more questions, provide more answers, and achieve higher reputation levels [38]. Additionally, Ford et al. discovered several barriers to participation for women, including feeling unqualified to contribute or give valuable answers, the intimidating size of the

community, and being unable to identify any females or familiar people [12].

The latter of these barriers, being unable to identify fellow women on the site, is connected to a concept known as "peer parity". Ford et al. defines peer parity as "when an individual can identify with at least one other peer when interacting within a community" [11]. They found that women who asked questions and were able to identify a female peer on the resulting thread re-engaged sooner than those who did not; however they did not have higher reputation scores or earn more badges (tokens awarded for various achievements). Although women re-engage sooner after participating in peer parity threads, the chances of a peer parity post occurring is very slim. 97.8% of posts with women do not feature peer parity, indicating the lack of interaction between women [26]. Considering the potential benefits of peer parity and the expressed discomfort at its absence on Stack Overflow, we wish to investigate the frequency of peer parity on Piazza in CS courses.

We are also interested in the difference in usage of the anonymity feature between men and women on Piazza. An anonymity feature allows students to post their questions and answers without revealing their identity, which helps alleviate the concern of sounding "stupid" in front of one's classmates [34]. In one study [5], students who asked for help anonymously reported being grateful for the opportunity to do so while students that did not take advantage of the opportunity generally did not mind it. Another study [17] found that anonymous discussions reduced the influence of interpersonal relationships and peer pressure, leading to better learning achievement. We examine to what extent these influences affect men and women's choice to use the feature on Piazza.

Our research questions are as follows:

- **RQ1:** How does engagement differ between men and women on Piazza in CS courses?
- **RQ2:** How does anonymity usage on Piazza in CS courses differ between men and women?
- **RQ3:** How does peer parity influence how women post on Piazza in CS courses?

In order to be consistent with previous studies, we consider gender as a binary factor for the purposes of our analysis. We acknowledge that many individuals do not conform to the gender binary and hope to gain insights into their experiences in the future with the availability of more data and more accurate/nuanced information about each user's gender identity. Additionally, we acknowledge that not all individuals identify with the gender they were assigned at birth. Thus, we use the terms "woman"/"female" and "man"/"male" in order to refer to those who identify as such rather than as a reference to their biological sex.

## 2 BACKGROUND & RELATED WORK

### 2.1 Women in Computing

It is no secret that the number of women in computer science is disproportionately low compared to the number of men. The National Center for Education Statistics reported that in 2017 just 20% of students receiving undergraduate degrees in computer science were women, compared to 37% in 1983 [2]. The real mystery is *why* are there so few women in computer science?

One contributing factor is the low sense of belonging women feel towards STEM fields. Women STEM students often perceive that they have to exert more effort than their peers in order to succeed, a perception that reduces their sense of belonging and, in turn, their motivation [35]. Lewis et al. [21] found that even after controlling for conventional predictors of academic achievement, women felt a lower sense of belonging than men in STEM. Moreover, women's sense of belonging explained their persistence intentions and actual persistence in their STEM coursework. Lastly, low female enrollment numbers in STEM also serve to reduce women's sense of belonging, creating a self-fulfilling prophecy [27].

Another factor that discourages women is the "geek culture" pervasive throughout STEM. This culture serves as a gatekeeping mechanism where men are praised and reinforced for their success while women are continually challenged on their abilities and competence [23]. Many women in STEM are the only woman on a team or at a site and are thus unable to find support as they undergo hostile macho cultures and sexual harassment [16]. Women in undergraduate CS programs are frequently told that they "got in" only because of their gender [24]. Even subtle environmental cues like sci-fi posters and video game paraphernalia can broadcast masculine stereotypes and alienate women [6]. Combined with the tendency of women to be interrupted far more frequently than men [15, 19], women may feel that they simply do not have a voice in STEM.

There has been much work concerning strategies for encouraging more women in CS [9, 29, 32]. Cuny et al. [9] stresses the importance of broadening the criteria used in admissions and accepting applicants from non-traditional backgrounds. Indeed, women in general have less computing experience than men [18, 37], so focusing on other predictors of success like leadership and communication skills, work/volunteer activities, or academic records may help even out the admissions pool. Providing role models [32] and having classes taught by female instructors [19] could also improve female participation.

### 2.2 Participation in Online Communities

Prior research has found a number of differences in the ways that men and women engage with online communities. Vasilescu et al. [38] provided a quantitative study of the representation of men and women on Stack Overflow, finding that men are more active on the site across all measures. While Stack Overflow does not require users to list their gender, the researchers developed the Python tool genderComputer[1] for automatic gender inference and manually inspected user profile pictures and social media to fill in the gaps. We use genderComputer as a primary tool for determining gender in our own analysis. Follow-up work by the same authors [39] found that after controlling for overall length of engagement, women ask more questions than men on average. This difference is not only reaffirmed in work by May et al. [25] but also used to explain the reputation differences between men and women. Effectively, women ask more questions while men answer more questions, but answers are rewarded more than questions, resulting in men achieving greater levels of reputation.

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[1]https://github.com/tue-mdse/genderComputer

Ford et al. [12] conducted 22 interviews with female developers that used Stack Overflow (including a top 100 ranked user) in order to identify 14 barriers to participation on the site and then conducted a survey of 1470 male and female developers based on the barriers they identified. The 5 barriers identified as significantly more problematic for women than men were: awareness of site features, perception of slacking, qualifications, intimidating community size, and stranger discomfort. Stranger discomfort was further explored in a 2017 work by the same authors [11], where they introduced the concept of "peer parity". In their analysis of Stack Overflow, they define a peer parity thread as a thread containing more than one distinct woman. They found that when women experienced peer parity in the thread resulting from their first question, they were more likely to re-engage sooner. Another study following the same approach to peer parity [26] showed that while it was generally very uncommon for a woman to receive an answer or comment from another woman on a post, it was more likely to happen on posts initiated by women. However, they found inconclusive evidence with regards to the impact that peer parity posts had on women. These studies motivate our interest in studying peer parity and its effects on women, and we follow a similar approach towards studying it in our analysis.

While the previous studies mentioned have all focused on Stack Overflow, there is a growing body of work analyzing the engagement of male and female students using Piazza. Piazza's own study [1] encompassing 1.126 million total student enrollments over nearly 2 years found similar trends to those seen on Stack Overflow, showing that female computer science students ask more questions than their male peers but answer fewer of them. Additionally, they were more likely to both ask and answer questions anonymously than male CS students. Sankar et al. [34] uses these two metrics – the number of answers given and the usage of the anonymity feature – as a measure of the confidence gap between men and women. This gap persisted as students progressed to upper-division and graduate courses (with both men and women becoming slightly less confident over time); however it was not observed at all in humanities, social science or business courses, suggesting that it is a feature exclusive to CS and STEM. Follow-up work [36] showed that the confidence gap between men and women increased as class sizes increased, and that the gap was wider in CS classes than other STEM classes. These studies suggest that women experience similar difficulty participating on both Stack Overflow and Piazza.

## 3 METHODOLOGY

### 3.1 Piazza Overview

Piazza functions like a typical Q&A forum, with a unique distinction between "student" users and "instructor" users (e.g. faculty or teaching assistants). Each question thread contains a space for a "student answer", which can be written or edited by one or many students, and an "instructor answer", which can be written or edited by one or many instructors. In addition to the two answer fields, the thread contains a section for "followup" posts which are analogous to comments, and replies to followup posts are termed "followup responses". In addition to question threads, users can post a "note" (non-question post often used for announcements) or a "poll". Lastly,

students have the option to post anonymously to other students[2]. In this work, we primarily focus on question and answer posts, as these represent the core function of Piazza.

### 3.2 Data Collection and Preprocessing

In order to collect the necessary data to answer the research questions, data was extracted from seven different Piazza sections of three different undergraduate computer science courses taught by two of the authors. These courses include an introductory course, an intermediate course, and an advanced course in order to gauge the interactions of students at all academic levels.

We developed a Python script in order to preprocess the data which removes the name, email address, and other identifying information from each user and instead adds a field for gender. To identify the gender of a particular student, we used two packages, genderComputer and gender-guesser[3]. These packages take in a given name and output its predicted gender. Initially, we used genderComputer to attempt to classify the students as male or female. If the gender was classified as "unknown" by genderComputer, the name was plugged into gender-guesser. If neither package was able to identify the gender, the gender was classified as "unknown". We discuss limitations of and possible improvements to this approach in Section 6. To distinguish between instructors – who tend to be much more highly engaged and post more answers – and students, we automatically marked all users who had posted or edited an "instructor answer" as an instructor and used manual inspection to identify any remaining instructors (i.e. instructors that had never posted an answer).

### 3.3 Data Analysis

We use four primary metrics to measure engagement on Piazza:

- The *number of questions* asked by an individual;
- The *number of answers* given by an individual;
- The *length of engagement* in the community, measured as the number of days between an individual's first and last post;
- The *reputation* earned by an individual, measured as the sum of the scores on each of the individual's posts.

Based on these metrics, we propose a number of null hypotheses to be tested via statistical testing, which state that men and women show equal engagement on Piazza. Based on the results of previous work on Piazza [34], our alternative hypotheses state that women ask more questions, engage for longer, and earn more reputation than men, but give fewer answers than them. These hypotheses, along with all other null and alternative hypotheses mentioned in this section, can be found in Table 1. Mirroring the methodology of Vasilescu et al.'s work [38], we utilize the Mann-Whitney test, a non-parametric test that evaluates whether one of two independent populations tends to have larger values than the other [22]. The test calculates a statistic $U$ and compares the result with its distribution under the null hypothesis, generating a $p$-value. The

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[2]Piazza does provide the ability for users to post with "full anonymity", where neither students nor instructors can identify them. However, this feature was disabled in all of the classes included in this dataset. Thus, users were only able to post anonymously to students.

[3]https://pypi.org/project/gender-guesser/

**Table 1: Mann-Whitney Test Hypotheses**

| Measure | Null ($H_0$) | Alternative ($H_1$) | RQ |
|---|---|---|---|
| Questions | Women formulate a number of questions statistically similar to men's | Women formulate more questions | **RQ1** |
| Answers | Women provide a number of answers statistically similar to men's | Women provide fewer answers | **RQ1** |
| Days | Women engage for a length of time statistically similar to men's | Women engage for longer | **RQ1** |
| Score | Women and men achieve statistically similar reputation levels | Women achieve higher reputation levels | **RQ1** |
| Questions (Anonymity) | Women and men use anonymity for a statistically similar proportion of their questions | Women use anonymity for a higher proportion of their questions | **RQ2** |
| Answers (Anonymity) | Women and men use anonymity for a statistically similar proportion of their answers | Women use anonymity for a higher proportion of their answers | **RQ2** |
| Questions (Peer Parity) | Women who experience peer parity on their first question formulate a number of questions statistically similar to women who do not | Women who experience peer parity on their first question form more questions | **RQ3** |
| Answers (Peer Parity) | Women who experience peer parity on their first question provide a number of answers statistically similar to women who do not | Women who experience peer parity on their first question provide more answers | **RQ3** |

lower this $p$-value is, the more statistically significant the results are. Traditionally, a $p$-value less than 0.05 has been interpreted as sufficiently significant to imply that the alternative hypothesis is true. To measure the effect size, we calculate Cohen's $d$ [8] – where higher values represent differences of greater magnitude – using the appropriate transformations of the test statistic [7].

For measuring the usage of the anonymity feature on Piazza, we use two metrics:

- The *proportion of questions* asked anonymously by an individual;
- The *proportion of answers* given anonymously by an individual.

Our null hypotheses based off of these metrics state that women and men use the anonymous feature in equal proportions while our alternative hypotheses state that women use it more frequently, in line with findings from previous work on Piazza [34]. We evaluate these hypotheses using a Mann-Whitney test where each user is assigned a value in the range [0.0, 1.0] corresponding to the proportion of their questions (or answers) written anonymously. Thus, a user that asks 10 questions anonymously and 10 questions non-anonymously is assigned a value of 0.5 and a user who gives 1 answer anonymously and 3 answers non-anonymously receives a value of 0.25. This formulation assigns equal weight to "power users" who post on a regular basis and less active users who post only infrequently, which we determined was ideal for capturing the complete spectrum of participation; however we ignore individuals that did not post a single question (or answer) to avoid theorizing about the anonymity usage of non-posters.

Finally, we use two metrics to measure the frequency of peer parity on Piazza:

- The *number of questions* asked by students featuring peer parity;
- The *number of students* whose first question featured peer parity.

For our purposes, we define "peer parity" as cases where a user who asks a question receives a response (either an answer or a followup) from another user of the same gender, and both users can identify one another. Under this definition, anonymous responses to questions cannot create peer parity, and anonymous questions

cannot feature peer parity unless the person responding to the question is an instructor, since instructors can still see the identity of a user who posts anonymously. To measure the effect of peer parity on women's engagement/posting habits, we form two additional null hypotheses stating that women who experience peer parity on their first question post a similar number of questions and answers as those who do not, as well as two additional alternative hypotheses stating that women who experience peer parity on their first question post more questions and answers. These alternative hypotheses are based on the finding that women on Stack Overflow who experienced peer parity on their first question re-engaged sooner [11] and the discomfort expressed by women developers at the lack of other women on the platform [12].

## 4 RESULTS

### 4.1 General Statistics

Overall, our database had a total of 2,647 users, 2,501 of which were students. Of the 2,501 students, 1,398 were classified as men, 811 were classified as women, and 292 could not be identified as either. 32.4% of the students in our dataset were considered women, a number similar to the 29.5% of CS majors at the University of Virginia who identify as women [3]. Of note, the proportion of women was lower in higher-level courses, with women making up 37.6% of the introductory course, 31.5% of the intermediate course, and 27.9% of the advanced course. Among the 10,873 posts made by students and instructors, there were 3,725 questions, 2,630 instructor answers, 1,179 student answers, 535 notes, 1,315 followups, 1,485 followup responses, and 4 polls.

### 4.2 Engagement

Course engagement between genders is one of the key factors we wanted to measure. The results of the Mann-Whitney tests can be seen in Table 2. In the rows regarding engagement (Rows 1-4), $n_1$ represents all female students and $n_2$ represents all male students. The tests for number of questions, length of engagement, and reputation levels all achieved high statistical significance, suggesting that women ask more questions, engage for longer, and achieve higher reputation levels than men. However, the effect sizes suggest that the difference in the number of questions is small, and that

## Table 2: Results of Statistical Tests

| Test | $n_1$ | $n_2$ | Mean (Overall) | Mean ($n_1$) | Mean ($n_2$) | $U$ | $p$ | $d_{Cohen}$ |
|---|---|---|---|---|---|---|---|---|
| Questions | 1398 | 811 | 1.45 | 1.93 | 1.12 | 633,803 | <1e-07 | 0.198 |
| Answers | 1398 | 811 | 0.47 | 0.46 | 0.44 | 566,572 | 0.4861 | N/A |
| Days | 1398 | 811 | 80.98 | 85.04 | 79.52 | 592,998 | 0.0354 | 0.077 |
| Score | 1398 | 811 | 1.73 | 1.87 | 1.58 | 587,291 | 0.0352 | 0.06 |
| Questions (Anon.) | 385 | 525 | 0.66 | 0.70 | 0.63 | 107,840 | 0.0299 | 0.115 |
| Answers (Anon.) | 126 | 216 | 0.60 | 0.69 | 0.55 | 15,651 | 0.0058 | 0.252 |
| Questions (Peer Parity) | 48 | 337 | 4.06 | 4.10 | 4.06 | 7,860 | 0.6281 | N/A |
| Answers (Peer Parity) | 48 | 337 | 0.97 | 0.44 | 1.05 | 6943 | 0.9723 | 0.162 |

the differences in length of engagement and reputation levels are negligible. Additionally, the test for number of answers achieved low statistical significance, suggesting there was not a significant difference in the number of answers given by men and women.

These findings agree with previous work showing that women ask more questions and are generally more engaged on Piazza than men [1], but disagree with research showing that men provide significantly more answers than women on both Piazza [34] and Stack Overflow [25, 38]. We note that, despite sharing similar methodologies, our results should not be directly compared to the work of Vasilescu et al. [38], as they chose to omit individuals who did not post any questions (answers) when analyzing the distribution of questions (answers) while we did not[4].

### 4.3 Anonymity

The anonymity feature was widely used by all students on the forum regardless of gender. When looking at all of the student data, 69.1% of students who posted had made a post anonymously. 74.0% of the 3,622 student questions were posted anonymously, as were 57.3% of the 1,179 student answers.

Nevertheless, both of the Mann-Whitney tests for anonymity (Table 2) achieved high statistical significance, implying women use anonymity for a higher proportion of both questions and answers. In the rows regarding anonymity (Rows 5-6), $n_1$ represents all female students that posted at least one question (answer) and $n_2$ represents all male students that posted at least one question (answer). The effect sizes imply that there was a greater difference in anonymity usage for answers than for questions; however both effect sizes are relatively small. At the aggregate level, 79.3% of questions and 63.1% of answers by women were posted anonymously, compared to 68.2% of questions and 51.6% of answers by men.

These results mirror the trends of Piazza's own study [1] showing that women in CS ask and answer questions at a higher anonymous rate than men. Interestingly however, the students in our dataset all posted anonymously at a much higher rate than the students

analyzed by Piazza. While men and women in our dataset used anonymity for 68% and 79% of their questions respectively, men and women in CS studied by Piazza used it for just 41% and 52% of their questions. Similarly, men and women in our dataset used anonymity for 52% and 63% of their answers respectively, while men and women in CS studied by Piazza used it for just 23% and 35% of their answers.

### 4.4 Peer Parity

78.3% of the 1,570 questions asked by men received a response from another man, while just 13.1% of the 1,564 questions asked by women received a response from another woman. Of the men who asked at least 1 question, 89.0% received a response to their first question and 64.8% experienced peer parity on it. Of the women who asked at least 1 question, 86.9% received a response to their first question and 12.3% experienced peer parity on it. These findings are summarized in Table 3. Overall, peer parity is rarely experienced on Piazza by women in CS. For women who do experience peer parity on their first question, the results of the Mann-Whitney tests (Table 2) suggest no significant difference in the number of questions they post compared to women who do not. However, the results of the test did indicate that women who experience peer parity on their first question actually provide *less* answers rather than more. In the rows of Table 2 regarding peer parity (Rows 7-8), $n_1$ represents female students who experienced peer parity on their first question and $n_2$ represents female students who did not.

The 13.1% of questions asked by women we found to have peer parity is comparable to but moderately higher than the 2.2% of posts with women found to have peer parity in Morgan's work [26]. Ford et al. [11] found that 45.2% of their sample of 1000 women experienced peer parity on their first question, compared to 12.3% of women in our sample. However, Ford et al.'s sample was comprised of women who had posted at least 2 questions, while ours was selected from women who had posted at least 1. Regarding the impact of peer parity on women's posting habits, we found no significant difference in the number of questions by women who experienced peer parity on their first question vs. those that did not, mirroring the inconclusive findings of Morgan's work [26]. While our test did show that women who experienced peer parity on their first question posted statistically less answers, this result may be due to the abnormally low sample size (only 10 of the 48 women who experienced peer parity on their first question also posted an answer) and likely should not be considered a real effect of peer parity without further testing.

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[4]We chose to include all individuals in order to measure whether women in general post more questions (answers) than men, rather than measuring whether women who posted at least one question (answer) posted more than men who posted at least one question (answer). Although the difference in the average number of questions posted by women and men (who posted at least one question) was not very large (roughly 4 to 3), 47.5% of women posted questions while only 37.5% of men did, revealing that not only did women post more questions but also that more women posted questions. Thus, we determined that including all individuals provided a more relevant answer to our original research question, but for the sake of comparison we note that a test omitting individuals that did not post any questions (answers) yields similar results (Questions: $\{p = 0.0023, d_{Cohen} = 0.182\}$, Answers: $\{p = 0.1562\}$).

## 5 DISCUSSION

### 5.1 Piazza vs. Stack Overflow

The high engagement of women in CS on Piazza contrasts with that of Stack Overflow, where women represent a minority of users and an even smaller minority of contributors. The differences in engagement may be due to the differences in the communities themselves. One such difference is the size of each community. Stack Overflow has over 10 million registered users [4], while there are generally only a few hundred combined students and instructors on a single Piazza forum. Women on Stack Overflow previously identified its "intimidating community size" [12] as a barrier to participating on the site, and female CS students on Piazza displayed less confident behaviors in larger classes [36]. Thus, Piazza's higher rate of women engagement could be explained by its smaller, more intimate environment.

Another major difference is the members in each community. Piazza is a forum comprised of students and instructors in the same course at the same school, while Stack Overflow is a community made up of users from vastly different backgrounds all across the world. Students on Piazza are more likely to be familiar with one another and closer in computing experience/ability than users interacting in a thread on Stack Overflow. Given that discomfort with strangers and lack of qualifications were cited as two significant barriers to participation by women [12], it makes sense that women would generally feel more comfortable posting on Piazza than on Stack Overflow.

### 5.2 Anonymity vs. Peer Parity

Our results showed that women in CS classes on Piazza used the anonymity feature for a significant proportion of their posts – even more so than men – and that they rarely experienced peer parity. An observant reader will notice that these two phenomena are inversely related: the more that women post anonymously, the less that they will be able to identify one another on the forum. Given that women choose to use the anonymity feature so often, whether to avoid the risk of sounding "stupid" in front of peers [34] or to prevent their post from being colored by their identity [17], one could reason that disabling the feature for a class would lead to an overall decrease in women's participation on the forum, which is clearly undesirable. Additionally, since neither our results nor those of Morgan's work [26] found conclusive evidence about peer parity's effect on women's participation, it would be imprudent to sacrifice anonymity for it. However, considering the expressed desire by women developers for peers to identify with on discussion forums [12] and the consequences of feeling isolated or alone [16], there is reason to continue investigating other ways to increase interaction between women.

We note that anonymity is not the sole cause of low peer parity among women compared to men. CS classes generally contain more male students, making it more likely for them to interact with one another. Additionally, the majority of instructors are men, and instructors not only post more answers than students do but also do so non-anonymously. Thus, hiring more female CS faculty and

Table 3: Peer Parity

|  | Women | Men |
|---|---|---|
| Asked at least 1 question | 385 | 525 |
| Received at least 1 response to their first question | 338 | 471 |
| Received at least 1 response to their first question from a member of the same gender | 48 | 343 |

teaching assistants could be a good way of increasing peer parity[5] among women.

## 6 THREATS TO VALIDITY

**Internal Validity** – Since our dataset consists of different levels of CS classes across many semesters, it is possible for a single person to be represented as multiple "users" in different Piazza sections, which may confound the results. This is particularly true for instructors, who may teach or TA the same class for multiple semesters.

**External Validity** – Piazza has a different set of features, user-base, and overall purpose from Stack Overflow or other online discussion forums, so our results may not generalize perfectly to those communities; however we suspect that similar trends in gender participation and barriers can be found. Additionally, our dataset was drawn from undergraduate CS students at a single American university, and other institutions may have a different culture/enrollment within their program.

**Construct Validity** – The heuristic-based gender identification tools we used may not accurately determine the actual gender identity of every user. To be more confident in our gender identification, we could have used an ensemble approach combining `genderComputer` and `gender-guesser` as seen in May et al.'s work [25], classifying a user as either male or female only if the two methods agree. However, this approach would also fail to identify individuals who do not conform to the gender non-binary, so the only truly accurate method would be to use self-reported gender identities. Additionally, this analysis only investigates online discussion activity on Piazza and does not capture offline interactions or private communications. Lastly, we only measured posting activity by quantity and volume and did not consider content or quality, except through the scores accrued by each post.

## 7 CONCLUSION

In this paper, we quantitatively investigated the differences in how male and female CS students interact on Piazza by measuring their engagement, use of the anonymity feature, and experiences with peer parity. While women generally show strong engagement and activity on the platform, they also choose to remain anonymous more often than men and are rarely able to identify and interact with one another. These findings should help CS educators understand the role of Piazza and similar online discussion forums in their

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[5]While faculty and teaching assistants may not be "peers" in the strict sense of the word, having fellow women to learn from could still be beneficial for female students.

courses and inform interventions to help make participation more comfortable for students of all genders.

One direction for future work on this subject would be further investigating the effects of peer parity on women. Although we did not find evidence that experiencing peer parity affects women's posting habits, it could have other effects we did not account for like self-esteem/confidence, learning achievement, or persistence in courses. Additionally, we stress the importance of expanding current notions of gender and capturing the experiences of non-binary students in CS. Self-reported gender identities could be used for more accurate analysis and identification, and larger populations may yield sufficient power to make claims about non-binary experiences with confidence.

## REFERENCES

[1] 2015. STEM Confidence Gap. https://web.archive.org/web/20170623181749/http://blog.piazza.com/stem-confidence-gap/. Accessed: 2020-08-16.
[2] 2019. National Center for Education Statistics. https://nces.ed.gov/programs/digest/d19/tables/dt19_325.35.asp?current=yes. Accessed: 2020-08-16.
[3] 2019. Which Colleges Are Best and Worst at Enrolling and Graduating Women in Computer Science and Engineering? https://www.chronicle.com/article/which-colleges-are-best-and-worst-at-enrolling-and-graduating-women-in-computer-science-and-engineering/. Accessed: 2020-08-17.
[4] 2020. All Sites - Stack Exchange. https://stackexchange.com/sites?view=list#users. Accessed: 2020-08-16.
[5] David J Barnes. 1999. Public forum help seeking: the impact of providing anonymity on student help seeking behavior. *Computer Based Learning in Science (CBLIS'99)* (1999).
[6] Sapna Cheryan, Victoria C Plaut, Paul G Davies, and Claude M Steele. 2009. Ambient belonging: how stereotypical cues impact gender participation in computer science. *Journal of personality and social psychology* 97, 6 (2009), 1045.
[7] Barry H Cohen. 2008. *Explaining psychological statistics.* John Wiley & Sons.
[8] Jacob Cohen. 2013. *Statistical power analysis for the behavioral sciences.* Academic press.
[9] Janice Cuny and William Aspray. 2002. Recruitment and retention of women graduate students in computer science and engineering: results of a workshop organized by the computing research association. *ACM SIGCSE Bulletin* 34, 2 (2002), 168–174.
[10] Allan Fisher, Jane Margolis, and Faye Miller. 1997. Undergraduate women in computer science: experience, motivation and culture. *ACM SIGCSE Bulletin* 29, 1 (1997), 106–110.
[11] Denae Ford, Alisse Harkins, and Chris Parnin. 2017. Someone like me: How does peer parity influence participation of women on stack overflow?. In *2017 IEEE symposium on visual languages and human-centric computing (VL/HCC).* IEEE, 239–243.
[12] Denae Ford, Justin Smith, Philip J Guo, and Chris Parnin. 2016. Paradise unplugged: Identifying barriers for female participation on stack overflow. In *Proceedings of the 2016 24th ACM SIGSOFT International Symposium on Foundations of Software Engineering.* 846–857.
[13] Karen A Frenkel. 1990. Women and computing. *Commun. ACM* 33, 11 (1990), 34–46.
[14] Denise Gürer. 2002. Pioneering women in computer science. *ACM SIGCSE Bulletin* 34, 2 (2002), 175–180.
[15] Adrienne B Hancock and Benjamin A Rubin. 2015. Influence of communication partner's gender on language. *Journal of Language and Social Psychology* 34, 1 (2015), 46–64.
[16] Sylvia Ann Hewlett, Carolyn Buck Luce, Lisa J Servon, Laura Sherbin, Peggy Shiller, Eytan Sosnovich, and Karen Sumberg. 2008. The Athena factor: Reversing the brain drain in science, engineering, and technology. *Harvard Business Review Research Report* 10094 (2008), 1–100.
[17] Bin-Shyan Jong, Chien-Hung Lai, Yen-Teh Hsia, and Tsong-Wuu Lin. 2012. Effects of anonymity in group discussion on peer interaction and learning achievement. *IEEE Transactions on Education* 56, 3 (2012), 292–299.
[18] Maria Klawe and Nancy Leveson. 1995. Women in Computing: Where are we now? *Commun. ACM* 38, 1 (1995), 29–35.
[19] Catherine G Krupnick. 1985. Women and men in the classroom: Inequality and its remedies. *On teaching and learning* 1, 1 (1985), 18–25.
[20] Sophie L Kuchynka, Kristen Salomon, Jennifer K Bosson, Mona El-Hout, Elizabeth Kiebel, Claudia Cooperman, and Ryan Toomey. 2018. Hostile and benevolent sexism and college women's STEM outcomes. *Psychology of Women Quarterly* 42, 1 (2018), 72–87.

[21] Karyn L Lewis, Jane G Stout, Noah D Finkelstein, Steven J Pollock, Akira Miyake, Geoff L Cohen, and Tiffany A Ito. 2017. Fitting in to move forward: Belonging, gender, and persistence in the physical sciences, technology, engineering, and mathematics (pSTEM). *Psychology of Women Quarterly* 41, 4 (2017), 420–436.
[22] Henry B Mann and Donald R Whitney. 1947. On a test of whether one of two random variables is stochastically larger than the other. *The annals of mathematical statistics* (1947), 50–60.
[23] Jane Margolis and Allan Fisher. 2002. *Unlocking the clubhouse: Women in computing.* MIT press.
[24] Jane Margolis, Allan Fisher, and Faye Miller. 2000. The anatomy of interest: Women in undergraduate computer science. *Women's Studies Quarterly* 28, 1/2 (2000), 104–127.
[25] Anna May, Johannes Wachs, and Anikó Hannák. 2019. Gender differences in participation and reward on Stack Overflow. *Empirical Software Engineering* 24, 4 (2019), 1997–2019.
[26] Savannah Morgan. 2017. How are programming questions from women received on stack overflow? a case study of peer parity. In *Proceedings Companion of the 2017 ACM SIGPLAN International Conference on Systems, Programming, Languages, and Applications: Software for Humanity.* 39–41.
[27] Mary C Murphy, Claude M Steele, and James J Gross. 2007. Signaling threat: How situational cues affect women in math, science, and engineering settings. *Psychological science* 18, 10 (2007), 879–885.
[28] Scott E Page. 2019. *The diversity bonus: How great teams pay off in the knowledge economy.* Princeton University Press.
[29] Paul De Palma. 2001. Why women avoid computer science. *Commun. ACM* 44, 6 (2001), 27–30.
[30] Vreda Pieterse, Derrick G Kourie, and Inge P Sonnekus. 2006. Software engineering team diversity and performance. In *Proceedings of the 2006 annual research conference of the South African institute of computer scientists and information technologists on IT research in developing countries.* 180–186.
[31] William Rau and Barbara Sherman Heyl. 1990. Humanizing the college classroom: Collaborative learning and social organization among students. *Teaching Sociology* (1990), 141–155.
[32] Eric S Roberts, Marina Kassianidou, and Lilly Irani. 2002. Encouraging women in computer science. *ACM SIGCSE Bulletin* 34, 2 (2002), 84–88.
[33] Pooja Sankar. 2020. Our Story. https://piazza.com/about/story. Accessed: 2020-08-16.
[34] Pooja Sankar, Jessica Gilmartin, and Melissa Sobel. 2015. An examination of belongingness and confidence among female computer science students. *ACM SIGCAS Computers and Society* 45, 2 (2015), 7–10.
[35] Jessi L Smith, Karyn L Lewis, Lauren Hawthorne, and Sara D Hodges. 2013. When trying hard isn't natural: Women's belonging with and motivation for male-dominated STEM fields as a function of effort expenditure concerns. *Personality and Social Psychology Bulletin* 39, 2 (2013), 131–143.
[36] Melissa Sobel, Jessica Gilmartin, and Pooja Sankar. 2016. Class size and confidence levels among female STEM students [Impact]. *IEEE Technology and Society Magazine* 35, 1 (2016), 23–26.
[37] Joy Teague and Val Clarke. 1996. Improving gender equity in computing programmes: some suggestions for increasing female participation and retention rates. In *Proceedings of the 1st Australasian conference on Computer science education.* 164–170.
[38] Bogdan Vasilescu, Andrea Capiluppi, and Alexander Serebrenik. 2012. Gender, representation and online participation: A quantitative study of stackoverflow. In *2012 International Conference on Social Informatics.* IEEE, 332–338.
[39] Bogdan Vasilescu, Andrea Capiluppi, and Alexander Serebrenik. 2014. Gender, representation and online participation: A quantitative study. *Interacting with Computers* 26, 5 (2014), 488–511.