

Gender-Inclusive Design: How Web Design Elements Affect Sense of Belonging in Classrooms

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ABSTRACT

We encounter web interfaces every day for almost any activity we can think of — shopping, relaxing, learning, and more — making inclusive web design more critical than ever. This paper explores the impact of specific web interface design elements on people's sense of belonging in an academic setting. More specifically, we investigate how women's sense of ambient belonging in computer science classes is affected by web design. To accomplish this, we conducted a study in which we deployed four different web pages for an introductory college computer science course; one was gender-neutral and three were manipulated to evoke masculine stereotypes through varying web design elements. We found no demonstrable difference in measures of ambient belonging between women exposed to the masculine web pages and women exposed to the neutral one. Our findings did not suggest that individual web design elements can evoke gender biases that negatively affect women's sense of belonging in classrooms.

INTRODUCTION

As the Internet's reach expands, web design impacts an increasingly diverse array of individuals. These interfaces often attempt — either consciously or subconsciously — to appeal to a specific audience [9, 5]. Prior research has also offered recommendations to help with targeting a particular demographic [11, 20]. However, this can lead to biased online spaces that cause marginalized users to feel a lack of ambient belonging, or the feeling of "fitting" into an environment [2]. More specifically, web design in course websites has been shown to have significant effects on women's sense of belonging in computer science, which can influence their decision to enter the field [10]. In 2016, only 19 percent of bachelor's degrees in computer science went to women, a drop from 27 percent in 1997 [4]. As people spend increasing lengths of time on the Internet [13], the impact of web design on female representation in computer science may continue to grow.

Prior work has laid the foundation that overall design can influence women's feelings about computer science. Research has discovered that the design of physical as well as virtual classroom environments can be manipulated to discourage women from pursuing computer science [2, 6]. The literature has ex-

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tended further to show that being exposed to stereotypical web design elements in combination can negatively affect women's sense of belonging in computer science [10]. However, the extent of each individual design element's effects have not been articulated. While language, color, and imagery have been shown to influence ambient belonging by themselves in the physical world, they have yet to be explored separately in the context of web design and computer science education [19, 15, 14]. The individual impact of these elements in digital interfaces on women's ambient belonging are unknown.

In this paper, we separate these digital design elements and measure their impact on feelings of belonging in computer science education. Few website designs are created to maximize stereotypes and bias, but many incorporate visual elements that may communicate subtle cues about who belongs in the space [10]. While previous research studied the impact of multiple biased design elements combined, our goal is to isolate these cues in web interfaces and measure each one's individual psychological impact, so website creators and visitors can better understand the extent of their effects.

To accomplish this, we exposed college-aged students to four different web interfaces for an introductory computer science course. We designed a gender-neutral site with a white background, gender-inclusive language, and nature imagery. We then created three additional skins by manipulating either the neutral site's color, language, or imagery to evoke gender-related stereotypes. Besides these changes, the content across all versions of the site remained the same. Forty college-aged students were randomly assigned one of the four sites to review. We evaluated which design elements had the most impact by having participants report their sense of belonging, desire to take the course, confidence in their success, interest in majoring in computer science, ability to do well in the course, and belief of whether their performance in the class would be linked to their gender.

We found that women who viewed a masculine web page generally felt no difference in the aforementioned areas compared to women who viewed the gender-neutral web page. The exception was that women who viewed the masculine-language page felt greater gender-related anxiety. Men's answers were also not significantly affected by which condition they viewed. Our results do not suggest that stereotypical color, language, and imagery are separately capable of triggering biases and influencing sense of belonging. Future work can still explore how these elements may have effects in other gender-biased fields outside of computer science education or the effects of other design elements on sense of belonging.

We contribute the first study on the effects of three individual elements of web interface design (color, language, and imagery) on women's sense of belonging in and desire to pursue computer science education. This builds upon existing work by exploring whether the negative effects of biased web design can be attributed to specific design elements. Our work can help web designers and users identify bias and increase inclusivity in web design.

RELATED WORK

Previous work on biased design has explored the concept of ambient belonging, or the inherent level of comfort an individual feels in a space [2]. More specifically, ambient belonging has been shown to be a key factor in influencing women's interest in science, technology, engineering, and math (STEM) fields [2]. Changes to the physical environment of a class have been demonstrated to deeply impact women's sense of belonging in an academic concentration [18]. For instance, research has shown that when women sit in a classroom with decorations that imply computer science stereotypes (i.e. video games, comics, computer parts, and a Star Trek poster) as opposed to a classroom with neutral decorations (i.e. water bottles, general interest books, coffee mugs, and a nature poster), their confidence in their technical abilities and interest in computer science declines [2]. Similar effects have been observed in virtual classroom environments [1].

Beyond classroom environments, small actions such as marking one's gender on a math test or being taught by primarily male teachers also negatively impact women's confidence in their success [12]. Using gender-exclusive language around women makes them feel isolated from a group. For example, using "he" or "him" as the default in place of using gender inclusive terms like "they" in a job interview causes women to feel decreased motivation, a lower sense of belonging, and less identification with the job [19]. These impacts are not limited to women, however. Ambient belonging has been researched in the context of other marginalized populations within STEM fields such as people of color [21], people with disabilities [6], and low income communities [14]. In each instance, ambient belonging has been a driver of confidence and perception of success.

In addition to physical settings, elements that are commonly present in web interfaces have been demonstrated to have psychological impact. Color palettes, for instance, invoke emotional reactions in users [16]. Appealing colors in a website cause users to perceive the site as more trustworthy [3], although colorfulness impacts demographic groups differently. For example, women have been shown to like colorful websites more than men [15] and use more colors when they design websites themselves [11]. Research has demonstrated that adding imagery and language in online ads specifically targeted at women, such as an image with all women and a statement about the importance of women in programming, increases women's enrollment in STEM courses, and combining verbal and visual cues creates a stronger effect than incorporating them separately [8]. Women who view a website for a computer science course that contains neutral design elements (i.e. a nature background and green colors) feel more sense of

ambient belonging in the course, confidence in their technical skills, interest in studying computer science, and other positive effects compared to women exposed to a website that evokes masculine stereotypes. Designing digital content taking these preferences and psychological effects into account can be used to increase women's sense of belonging in STEM. [10].

Overall, previous research has articulated that the design of both physical and digital settings can impact sense of belonging. Prior work has focused on how gender-exclusive environments versus gender-neutral environments impact ambient belonging in the context of women in STEM education. Furthermore, design elements such as color, language, and imagery have separately been shown to impact ambient belonging in the physical world, but not in digital interfaces. We seek to determine how these digital design elements separately impact ambient belonging for women in STEM education.

METHOD

Participants

We recruited fifty-four college-aged participants (ages 18 to 25) using Amazon Mechanical Turk, selecting for people in the United States to control for potential cultural differences and language barriers. Amazon Mechanical Turk is an online crowdsourcing platform regularly used for psychology experiments where anonymous workers are compensated for completing tasks. All of the participants passed the requisite attention checks; however, one respondent did not choose to disclose their gender identity and was thus excluded from the analysis.

At the end of the survey, participants were asked to provide demographic information about gender, age, education level, and computer science experience. Of all the participants, 35.2% were men and 64.8% were women, which meant there were far fewer results for males for each condition. The mean age across all participants was 22.3 years (22.6 years for women and 22 years for men). Participants of both genders reported similar education levels with the majority marking that the highest level of education they had completed was "some college."

Out of the male participants, 31.6% reported they had no computer science experience, 42.1% had some computer science experience (e.g. self-taught or program for fun), and 26.3% had substantial experience (e.g. taken courses in computer science). Of the female participants, 45.7% reported they had no computer science experience, 34.3% had some computer science experience, and 23% had substantial computer science experience. Overall, the male participants tended to have more experience in computer science and programming than the female participants.

Web Interface Stimuli

Four web pages were developed with content pulled from the website of a real introductory computer science course offered at a large university (see Figure 1). Each web page contained identical fonts and layouts with similar content. Drawing on prior research [1, 10], we created a gender-neutral baseline web page and three variants that differed from the baseline

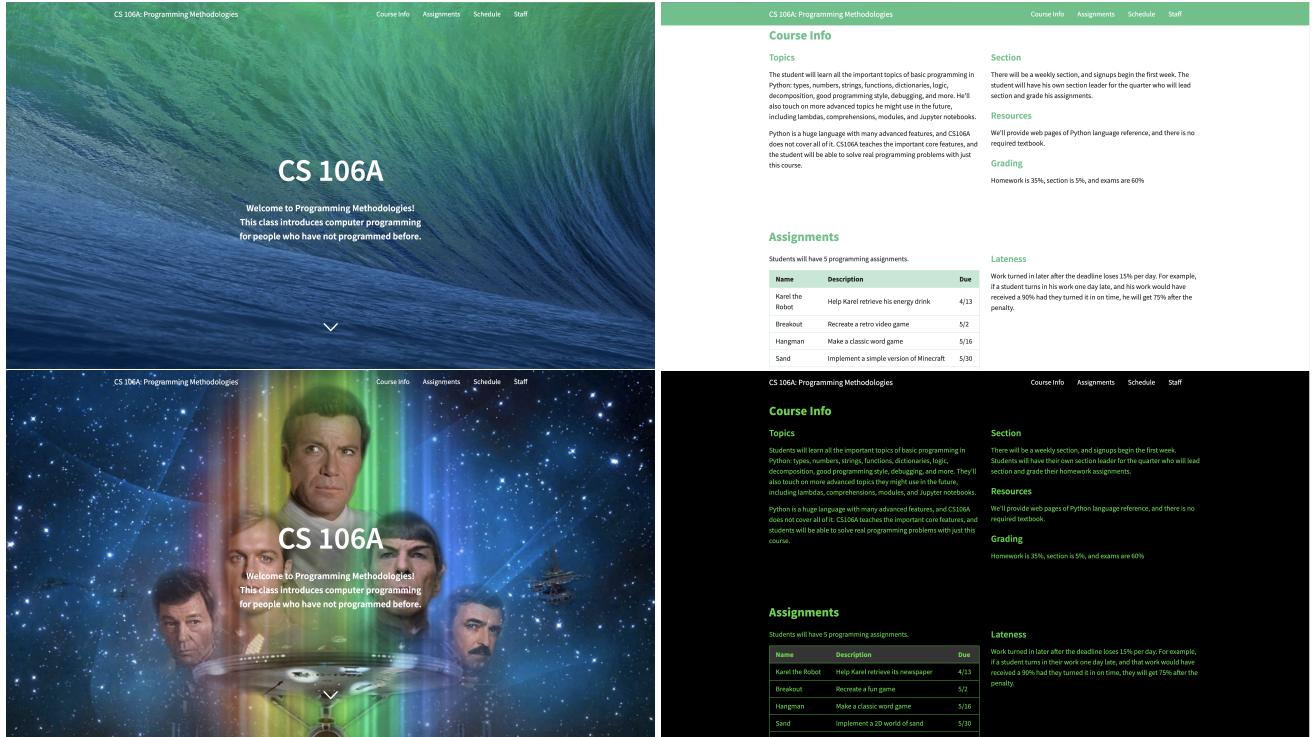


Figure 1. The neutral image was of an ocean wave (top left), while the masculine imagery interface had an image from Star Trek (bottom left). The neutral color palette had green and white (top right), while the masculine color interface used colors that resembled a computer terminal (bottom right).

in either color, language, or imagery that evoked masculine stereotypes.

The gender-neutral web page displayed a splash image of a large wave, a white background with green accents in headings and tables, and gender-inclusive language throughout (see Figure 1). The decision to display a nature theme was pulled from prior experiments with virtual classrooms and course websites, which incorporated nature in their gender-neutral conditions or environments [1, 10].

For the masculine-imagery condition, the wave image was switched to a Star Trek background, evoking the geek stereotype that is associated with successful computer scientists. The masculine-colored web page had a black background and lime green body text that mimicked a computer terminal and media's portrayal of hackers [17]. The masculine-language condition had the same appearance as the gender-neutral condition, but contained gender-exclusive language (e.g. "he" and "him") and stereotypical content. For example, the professor's biography was manipulated from the gender-neutral condition to say that he or she (gender not specified) enjoys "making computers, watching Star Trek, and reading science fiction."

All of these masculine stereotypes were drawn from prior research on the impact of stereotypes in environments on women. According to past studies, people associate computer scientists with objects such as science fiction books, computer parts, Star Trek, and junk food [1, 10]. These elements evoke a geeky and nerdy stereotype that dominates the media's portrayal of hackers and nerds — evident in shows like the *Big Bang Theory* — and dominates current perceptions of what a computer scientist is like [17]. Themes like masculinity, Star Trek, video games, and anti-social attitudes all surround the definition of a computer nerd [17]. It is this combination of masculinity and nerd culture that has created a computer science culture that often excludes women, and it is this combination that we sought to portray in our stereotypical web pages.

Procedure

We asked participants to view one of the four course web pages. In order to ensure that the demographics of participants in each condition did not differ significantly, the Qualtrics survey randomly assigned them to one of the four interfaces.

After studying their assigned web page, participants were asked a series of comprehension questions to confirm they had paid attention to the design of the web page. All of the masculine conditions had customized attention checks that ensured the participant was aware of the specific design element that had been manipulated. For example, the masculine-imagery survey included the question, "What do you see in the background screen?" which guided the participant to gaze at the Star Trek image. Participants then answered survey questions pertaining to their sense of belonging, interest in computer science, gender-related anxiety, and the rest of the six main measures detailed below.

Measures

Drawing from prior work [1], we measured six components that contribute to sense of belonging on a 1-7 scale (with 1

equating to “not at all” and 7 to “extremely”). The six measures were enrollment intentions, ambient belonging, anticipated success, self-confidence, future CS study intentions, and gender-related anxiety. In our survey, we asked one or two questions for each measure. This is how we defined each of the six categories:

1. *Enrollment Intentions*: how willing the participant was to take this course (e.g., “How likely would you be to take this class during your time in college?”);
2. *Ambient Belonging*: how much the participant felt like they fit in and belonged in the course (e.g., “How well do you think you would fit in with the students of this course?”);
3. *Anticipated Success*: how well the participant believed they would do if they took this course (e.g., “How well do you think you would do in this course?”);
4. *Self-Confidence*: how confident they felt in their computer science skills (e.g., “How confident are you in your abilities in computer science?”);
5. *Future CS Study Intentions*: how interested they were in learning about computer science and programming (e.g., “How interested are you in studying computer science (taking multiple courses) in college?”);
6. *Gender-Related Anxiety*: how much the participant felt that their gender would affect their performance in the class or if other students would interpret their abilities based on their gender (e.g., “How much would you worry that if you performed poorly in this course, others would attribute your poor performance to your gender?”).

The responses for each measure were averaged to obtain a final data point per category. These measures were directly taken from prior work on sense of belonging and web design, confirming their validity [2, 3].

Drawing on prior work about women’s belonging in computer science, we hypothesized:

H1: Women exposed to a website containing either color, language, or imagery evocative of masculine stereotypes will feel less belonging, confidence, and interest in computer science compared to men who saw any of the websites and women who saw a gender-neutral website.

RESULTS

We analyzed the survey data using planned contrast analysis and did not find sufficient support for our hypothesis. For each interface with stereotypically masculine colors, language, and imagery, women were overall not negatively affected in the six measures outlined above.

Qualitative Analysis

We performed a planned contrast analysis on each of the six quantitative measures we collected using contrast coefficients calculated by prior work, particularly the results reported in Cheryan 2011 and Metaxa-Kakavouli 2018 [1,2]. As such, the coefficients were -3 for women in the masculine condition and 1 for women in the neutral conditions for each design element.

For men, the coefficients were 1 and 1 for the masculine and neutral conditions for each design element. This effectively embeds the hypothesis that women in the masculine conditions should feel more harmful psychological effects compared to the rest of the participants.

Compared to women in the neutral condition and men in either the neutral or masculine conditions, women in the masculine color, language, and imagery conditions generally did not feel different effects from viewing the web interfaces. The women in the masculine color, language, and imagery conditions did not express less interest in enrolling in the class (respective to color, language, and imagery: $t(23) = 0.442, p = 0.669; t(20) = 0.561, p = 0.291; t(25) = 0.03, p = 0.488$). They did not feel less ambient belonging ($t(23) = 0.497, p = 0.312; t(20) = 0.607, p = 0.276; t(25) = 0.375, p = 0.356$). They also did not anticipate less success in the class ($t(23) = 0.552, p = 0.293; t(20) = 0.74, p = 0.234; t(25) = 0.795, p = 0.217$), and they did not feel less confident in their technical skills ($t(23) = 0.124, p = 0.549; t(20) = 0.316, p = 0.622; t(25) = 0.283, p = 0.61$). Furthermore, they did not feel less interested in studying computer science in the long term ($t(23) = 0.169, p = 0.566; t(20) = 0.048, p = 0.481; t(25) = 1.356, p = 0.0942$). Lastly, women in the masculine color and imagery conditions did not feel more anxiety regarding perception of their gender by classmates ($t(23) = 0.692, p = 0.248; t(25) = 0.831, p = 0.207$). However, women in the masculine language condition did report feeling more gender-related anxiety ($t(20) = 2.891, p = 0.00487$).

These results are illustrated in Figure 2, where participants in each condition’s average responses to each of the six measures are shown. Overall, the biggest differences between men and women’s responses occurred in the gender-related anxiety measure, specifically in the language condition.

DISCUSSION

In the present research, websites containing a design element stereotypically linked to computer science — Star Trek visuals, masculine pronouns, or terminal-like colors — did not decrease women’s interest in joining the field. They felt a similar sense of ambient belonging and confidence in their computer science abilities as women who viewed the gender-neutral site. Women exposed to biased and stereotypical language, however, did feel greater gender-related anxiety. These results did not suggest that biases in web interfaces are salient enough to influence user psychology in real life. Stereotypical language may increase women’s anxiety about how their gender is perceived, however.

Anyone who designs a website may communicate signals that welcome certain audiences more than others, but we did not find evidence that biases present in only color or imagery influence the visitors to the website. Overall, our findings did not support the hypothesis that websites with a single stereotypical design element decrease women’s sense of ambient belonging, confidence, and interest in computer science. The literature has established that biased design can have consequences on women’s feelings of belonging and future intentions regarding computer science, however, so future research in this area remains crucial.

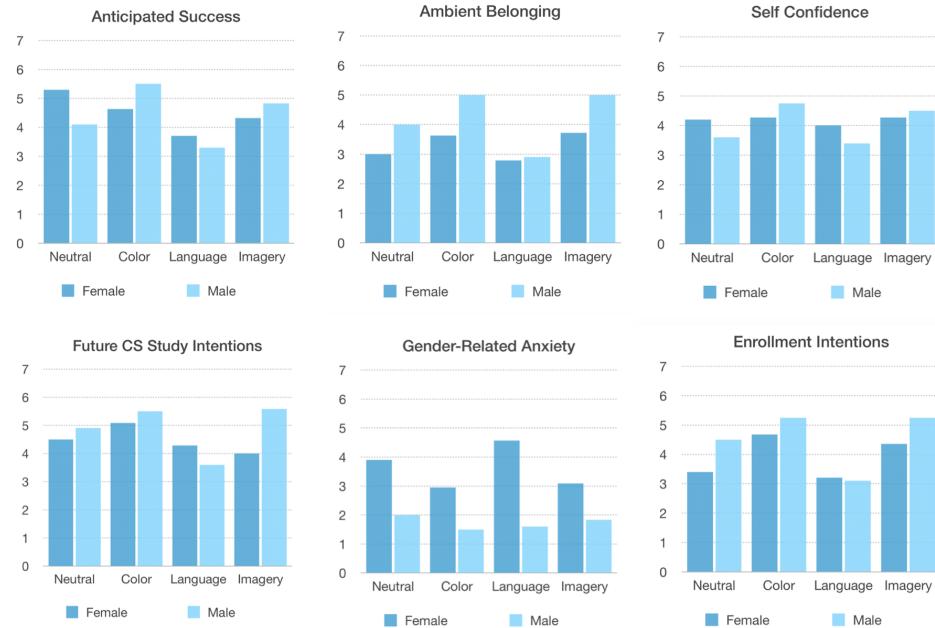


Figure 2. Male versus female (Female in dark blue, Male in light blue) responses by website condition for each of the primary dependent variables. Higher scores represent higher response for that dependent variable.

Limitations

In this paper, we focus on the effects of interface design biases on women, a historically underrepresented population in computer science. However, we acknowledge that race and socioeconomic status can also have impacts on participation in the field, which we did not examine. Prior work has shown that some technologies are biased against both rural users and users of lower economic statuses [7], and these are areas that should be considered in future studies.

We also recognize that we did not exclude computer science students from the results, as done in prior research. Using Amazon Mechanical Turk, we made the assumption that most participants would not have any experience with programming or learning computer science. After analyzing the demographics of the 55 participants, 68.4% of males either had some or substantial experience with computer science and 54.3% of women also had some or substantial experience with computer science. Because a significant amount of participants had at least some experience, the results may not have been as representative as having only participants with no or little prior experience.

In addition, following prior work on web design and ambient belonging [10], we did not measure real students' enrollment in the course. We accommodated for this assumption by filtering our participants to be between the ages of 18-25 and instructing them to pretend they were prospective college students considering the course. This hypothetical situation was necessary to gather enough participants in the limited amount of time we were given, and it may have influenced the generalizability of the results.

Another major limitation in our studies was the budget, which caused us to restrict the number of participants to a greater extent than prior work. With the constraints of the study's budget, we collected the maximum participants possible, which may have affected the significance of our results. If this were to be repeated, a greater number of participants may lead to more results with significance. As a consequence of attempting to recruit as many participants as possible, we were not able to include manipulation checks in our survey. As a result, we do not know how participants perceived our design manipulations. This information could have potentially added another dimension to the interpretation of our results. However, we designed our stereotypically masculine interfaces to align with previous works, which did include the manipulation checks [10].

Our approach also only focuses on three design elements: color, imagery, and language. Our study does not encompass other design elements like layout, complexity, or font, which could potentially be factors that contribute to women's ambient belonging in the classroom. The three isolated masculine elements we selected were demonstrated to not have significant effects on women's ambient belonging, but this does not rule out the potential impacts of other website design elements.

Future Work

As people spend more time on the internet, they are susceptible to biases on websites such as job application portals, social media platforms, and online stores. Although this paper found little significant impact of individual stereotypical web stimuli on women's sense of belonging in computer science, small exposures to biases may compound. The effects

of repeated or long-term exposure to stereotypical web design elements can be examined in future studies. In addition, future work can examine the impact of web design elements on other areas of life: applying to jobs, self-expression on social media, and entry to other academic fields such as art, nursing, and science. Different design elements such as font and layout must also be studied to provide a more comprehensive understanding of design elements' capacity to convey bias in interfaces. Ideally, future work around ambient belonging in computer science education could study the enrollment of real college students with no prior experience in computer science, which the limitations of our study did not allow us to do.

In addition, understanding the barriers that prevent women from entering the field of computer science is an important area that needs to be researched further. The lack of minority representation in the technology sector is a significant issue that affects users of interfaces and tech products around the world. Education is a major route to entry in the field, and further research on how interface design or other aspects of academic settings affects interest in computer science courses can help remedy the lack of racial and gender diversity in technology. This paper only explores women's ambient belonging in the context of computer science course website design, but this can be expanded to study how professors affect ambient belonging through lectures, how classmates increase gender-related anxiety through their behaviors, and more. Course websites are only one small aspect of computer science courses that can potentially impact students' sense of belonging.

CONCLUSION

Our work examines the impact of singularly stereotypical design elements in web interfaces on ambient belonging in computer science. With a controlled experiment, we exposed participants to either a neutral website or a website with one design element that was stereotypically masculine. Through this experiment, we did not find that isolated stereotypical design elements (color, language, and imagery) in web interfaces are salient enough to negatively effect women's sense of belonging and participation in computer science; it is only when the elements are used in conjunction that these negative feelings arise. This highlights that more work is needed to understand how digital interface design affects women's feelings in the computer science classroom. Additionally, there are many more underrepresented populations that could benefit from more inclusive web design practices.

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