Impacting the Inclusivity Mindset of Online Computer Science Students

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Abstract

While online Computer Science (CS) degree programs can attract diverse students, many students still feel excluded in the online CS classroom. One reason students feel excluded is because their gender is underrepresented among their classmates. At Oregon State University, only 27% of online CS students are women. This is better than the on-campus statistic—12%—but still very far from gender parity. This can lead to such experiences as a student being the only woman in their course project team of five.

To help women—and all online CS students—feel more included, we created new, online-specific course materials for teaching students to design inclusive software. The course materials incorporated research findings about cognitive differences in how people problem-solve in software. It also covered a method for designing software to support cognitively diverse users. The research and methods both originated from the The GenderMag Project, an OSU-based research group that has developed multiple methods for gender-inclusive design.

Online CS faculty incorporated the new course materials into their existing CS content and we measured the effects through a field study with 75 online CS students. Students who experienced the curriculum felt included by it, used it to examine their own biases, and behaved inclusively toward their peers. This paper discusses a subset of the course activities, methods and findings from one online CS course.

Introduction

Research has shown that software is biased against women (Borkin et al., 2013; Burnett et al., 2011; Showcat & Grimm, 2018) which means that, in addition to women being underrepresented in Computer Science (CS), the software tools available to them for learning and doing CS can create additional barriers. For example, GitHub is a popular platform for collaborative opensource software development but is biased against the cognitive styles women tend to use (Padala et al., 2020). One cognitive style that many—but not all—women tend to use in GitHub (and other software) is comprehensive information processing; statistically, women are more likely than men to gather complete information before taking an action in software while men are more likely to tinker (Burnett et al., 2016)[1]. In Padala et al.'s study, 78% of women encountered an information processing style barrier in GitHub documentation compared to 54% of men. GitHub is used in multiple courses at Oregon State University (OSU). In addition to CS learning tools being biased against them, women also tend to have less previous coding experience than men when they start a CS degree (Fisher & Margolis, 2002). Thus, in their first CS course, the experience of some women is: (1) their classmates mostly do not look like them; (2) they are learning programming for the first time; and (3) the tools they need to learn programming are unusable. The message comes through to women loud and clear: "You do not belong here" (Fisher & Margolis, 2002; Lewis, Bruno, Raygoza, & Wang, 2019). Between Fall 2020 and Spring 2021, the number of OSU women and gender queer CS students decreased 55% between the first and third introductory CS course, compared to 21% for men.

Inclusive software design provides a way of solving the third problem: biased tools. Inclusive software design involves identifying ways software is biased against a group of people, fixing the design flaws, and re-developing software that is more usable to everyone. An analogy is curb cuts: ramped sidewalks at crosswalks that were designed to help wheelchair users but are useful to others, too, including people pushing strollers or shopping carts, carrying large furniture, or roller-skating.

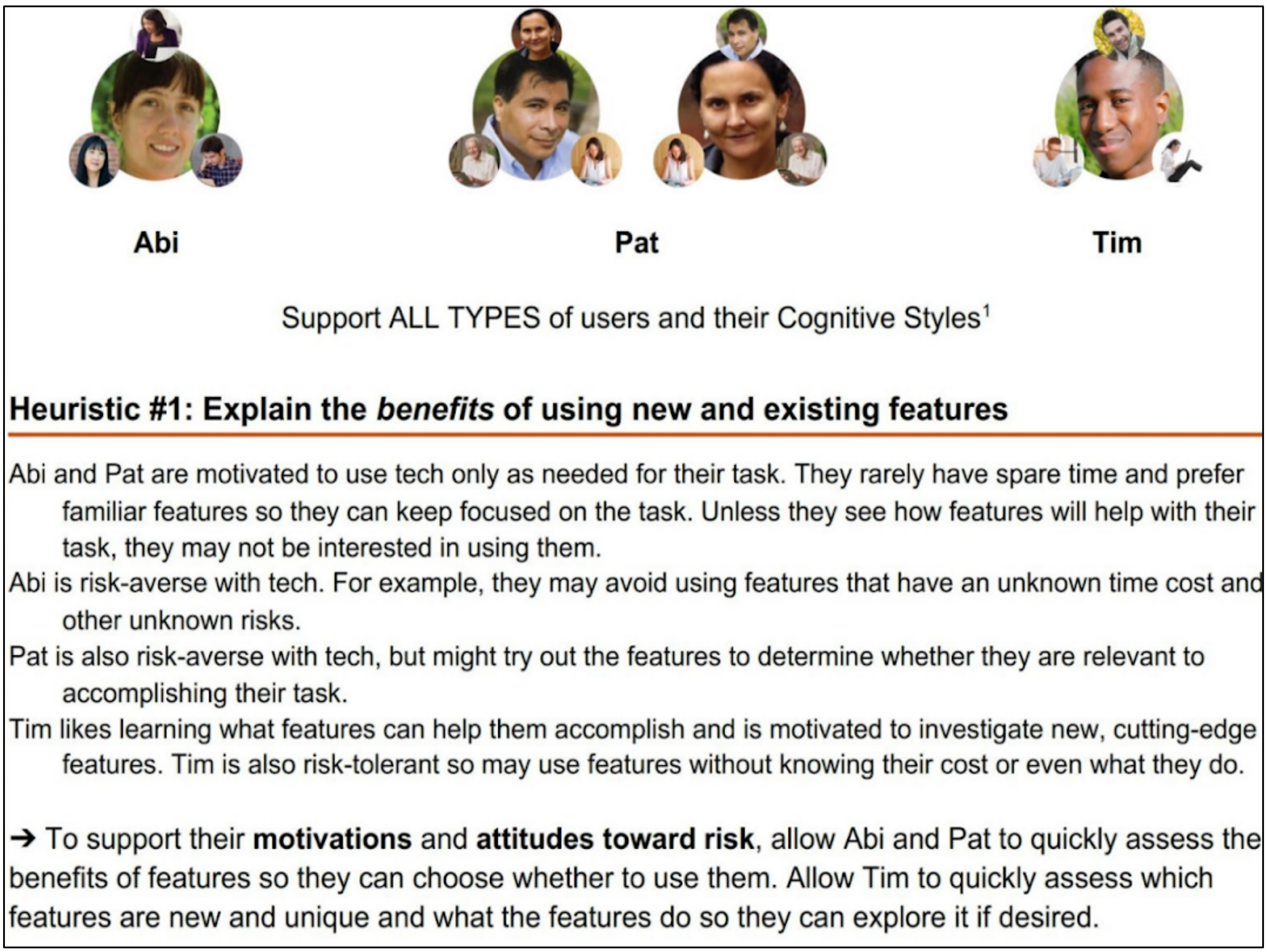
The GenderMag Project, an initiative run by research teams at OSU and City, University of

[1] Unfortunately, little data is available for genders besides women and men.

London, has developed multiple inclusive software design methods for treating gender bias (Burnett et al., 2016). Through our Ecampus Research Fellows project, we adapted one of those methods, software evaluation using the Cognitive Style Heuristics (CSH) (Burnett et al., 2021), for two online Computer Science (CS) courses at OSU. The CSH (see example shown in Figure 1) are a set of guidelines for what a software user interface can provide to make it usable to cognitively diverse users across the spectra of five cognitive *facets*:

1. **Motivations** for using technology
2. **Attitude toward risk** when using technology
3. **Self-efficacy** when using technology
4. **Learning by process vs. tinkering** when using technology
5. **Information processing style** when using technology

Figure 1. *One of the eight Cognitive Style Heuristics (CSH) online CS students learned for evaluating and improving software inclusivity. When software reflects the CSH, it supports cognitive and gender diversity, as represented by personas of Abi, Pat, and Tim.*



To help software developers empathize with users who have traditionally under-served cognitive *facet values* (also called "cognitive styles"), The GenderMag Project developed three personas: Abi, Pat, and Tim. A persona is a fictitious representation of a group of users. Personas usually have a name, photo, and personal background information.

Excerpts from the Abi, Pat, and Tim personas are shown in Figure 2 below, along with their facet values. Abi represents facet values women tend to have, Tim represents facet values men tend to have, and Pat represents a third set of facet values, some in common with another persona and some unique.

Figure 2. *The three GenderMag personas, each with a different set of five cognitive styles*

In general, software designs are typically biased against women (Burnett et al., 2016). Research has shown that if Abi cognitive styles are better-supported in software, the design becomes more usable to women (Vorvoreanu et al., 2019). Research has also shown that when a team of only one gender designs software, the software tends to be preferred by others of that gender (Zabel & Otto, 2021).

We developed a set of activities for teaching online CS students both how and *why* to use the CSH to improve their software designs. The activities we developed are available within our OERCommons community.

We incorporated the CSH activities into two online CS courses and then empirically evaluated the effects over four terms. We had two research questions:

RQ1: How do the CSH activities affect how included online CS students feel, and how inclusively they behave toward others?

RQ2: How do the CSH activities affect online CS students' respect for users' diversity, and their ability to create more inclusive technology for these users?

Overall, our results indicated that not only were Ecampus students successful in learning to create usable software for a greater number of cognitive styles, they also: 1) felt included by the CSH activities; 2) behaved inclusively because of doing the CSH activities; and 3) reported positive effects on the teams they were in during the course that resulted from doing the CSH activities. Full results are discussed in our published conference paper ([Letaw, Garcia, Garcia, Perdriau, & Burnett, 2021](#)).

In what follows, we discuss a subset of the course activities. We chose this subset based on applicability across and beyond CS. The activities we discuss can be included in many courses and also workplace practices. The activities include: (1) an interactive reading about cognitive styles; (2) an individual self-reflection assignment in which students considered their own cognitive styles; and (3) a team discussion assignment in which students talked about each other's cognitive styles.

We will discuss the activities in the context of one course: Software Engineering I, a junior-level offering that is required for the online post-baccalaureate CS degree at Oregon State University. In this course, students worked with the same five-person team for the entire 10-week term, ultimately producing a portfolio-quality software product together using processes and practices learned during the course.

To begin, we detail three CSH activities students completed, discussing how we incorporated the activities into an online course. Then, we present and discuss a subset of relevant results.

Curricular

Development of the CSH activities was guided by the Community of Inquiry (CoI) model (Garrison, Anderson, & Archer, 1999). CoI is a popular framework for engaging online students and guiding both students and instructors to construct meaning by incorporating three different presences into the online course design. The first is social presence, which involves opportunities for students to interact with their peers. The second is cognitive presence, which provides students with opportunities to interact with learning materials in different ways. The third is teaching presence, which focuses on interactions between students and their teachers or other instructional staff.

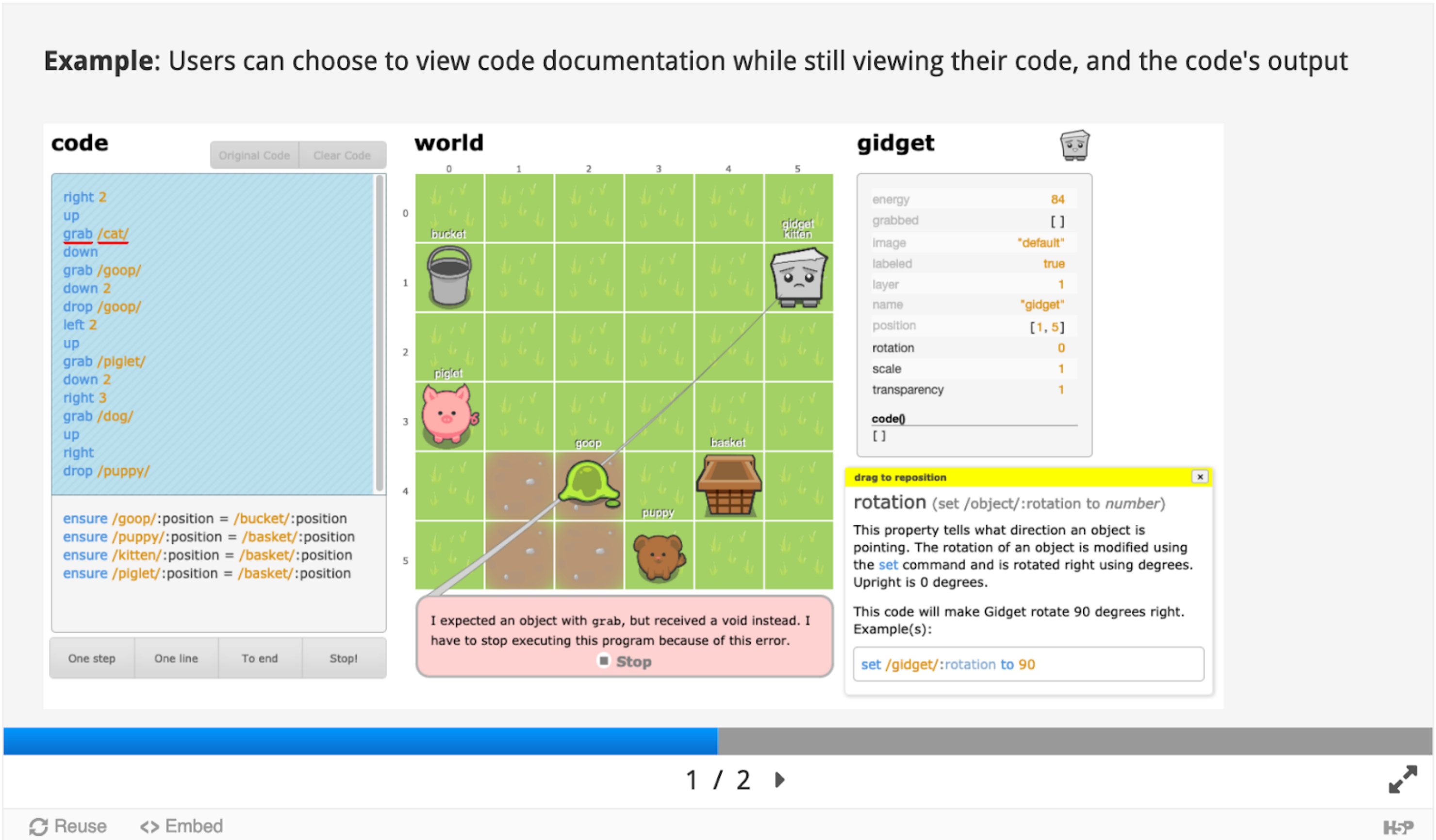
Supporting cognitive and teaching presence through learning exploration

The interactive reading supported cognitive presence by providing opportunities for students to engage with the learning material through interactive components embedded in a Canvas page, and teaching presence, by including a section of the reading where the instructor and teaching assistants (TAs) modeled how to discuss one's own cognitive styles.

This Canvas page was also developed for students to learn about cognitive styles and the Cognitive Style Heuristics (CSH). The reading included text describing the five GenderMag facets, the personas (see Figure 2), the CSH (see Figure 1), and GenderMag background and research citations. Students could check their learning via embedded quiz widgets and were also provided slideshow widgets for seeing examples of inclusive software designs. For example, Figure 3 on page 6 shows a slideshow widget containing two inclusive designs.

The design in the figure shown below is inclusive because it gives users a way to see code syntax documentation while they code, which supports diverse information processing styles (Jernigan et al., 2015). The reading was available to students starting at the beginning of the course.

Figure 3. *Embedded slideshow widget giving students an example of an inclusive design*

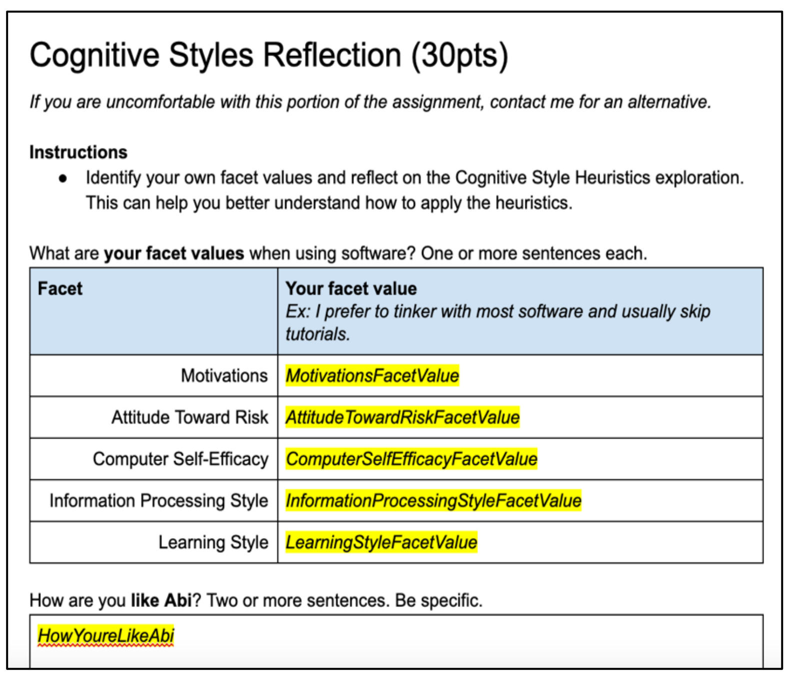


Supporting social and cognitive presence through self-reflection

A reflection assignment in which students self-identified their cognitive styles supported both cognitive presence (because it was a reflection) and social presence because students could participate as their "real" selves.

This assignment was given in the first two weeks of the term. Students described their self-identified facet values and answered reflection questions about how they were like Abi, how they were like Tim, cases in which their facet values might change, and how their facet values affect how they interact with technology (see Figure 4).

Figure 4. *Self-reflection assignment template*



Cognitive Styles Reflection (30pts)

If you are uncomfortable with this portion of the assignment, contact me for an alternative.

Instructions

- Identify your own facet values and reflect on the Cognitive Style Heuristics exploration. This can help you better understand how to apply the heuristics.

What are **your facet values** when using software? One or more sentences each.

Facet	**Your facet value** *Ex: I prefer to tinker with most software and usually skip tutorials.*
Motivations	*MotivationsFacetValue*
Attitude Toward Risk	*AttitudeTowardRiskFacetValue*
Computer Self-Efficacy	*ComputerSelfEfficacyFacetValue*
Information Processing Style	*InformationProcessingStyleFacetValue*
Learning Style	*LearningStyleFacetValue*

How are you **like Abi**? Two or more sentences. Be specific.

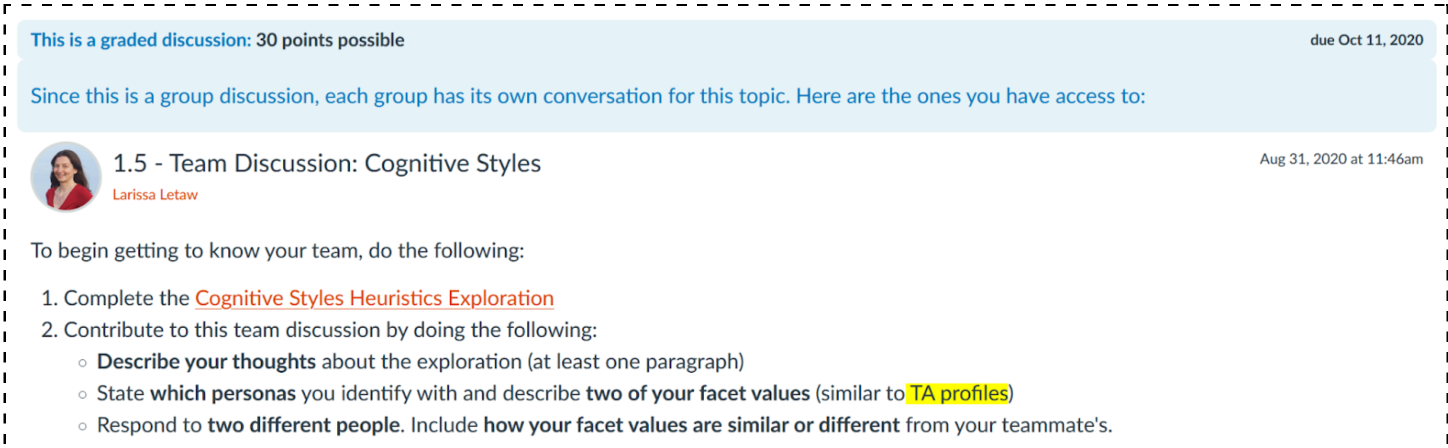
HowYoureLikeAbi

Supporting social presence through team discussion

Finally, a team discussion fostered social presence by inviting students to share and learn about each other's identities. Students were prompted to participate in the team discussion after their self-reflection.

In their teams, students shared and discussed some of their facet values with the four teammates. This discussion was the students' first assigned interaction with their teammates, with whom they would be working with for the rest of the term on a software project (see Figure 5).

Figure 5. *Prompt for the team discussion wherein students shared their own cognitive styles and identified how they were cognitively similar and different from their teammates*



In the following section, we describe how we designed our study to detect effects of these CSH activities on the online CS climate (RQ1), how online CS students viewed users (RQ2), and how well online CS students could design software for diverse users (RQ2).

Method

Participants and educational setting

Participants were students enrolled in the OSU Ecampus post-baccalaureate CS program who took CS361 Software Engineering I during the 2020-21 academic year. As with all Ecampus courses, there were no synchronous class sessions or meetings. Although students must meet term-bound due dates and deadlines, students from across the world are able to enroll and complete this course, and all other courses in this degree program asynchronously. The larger study had a total of 75 participants. In this paper, we focus on a subset of 34 participants from one term of CS361.

Data collection

As part of their participation in the research study, students consented to allow us to use their coursework for research. They also agreed to complete a pre- and post-questionnaire. The questionnaires were adapted from the NCWIT Student Experience of the Major survey (National Center for Women & Information Technology) and included Likert scale questions that were asked at the beginning and end of the course, for example:

1. How likely are you to complete a CS major/minor?
2. I feel I belong in the CS major/minor.
3. I feel represented in the CS major/minor.

We also asked students (pre/post course) what they would take into consideration when designing a software user interface and how included/excluded different aspects of the course made them feel (e.g., learning cognitive styles, discussing cognitive styles, feedback from TAs, interactions with teammates, interactions with classmates outside their team, etc.).

Our full questionnaires and all GenderMag-related assignments can be found in Letaw et al. 2021b.

Results and Discussion

To answer RQ1, we examined student coursework and questionnaire responses to identify how the activities influenced feelings of inclusion (feeling included and feeling like including others) and acts of inclusion (within teams and when designing software).

Effects on students

Out of all aspects of the course we asked about, on average, the cognitive styles content made students feel the most included. In particular, discussing cognitive styles made the greatest percentage of students feel included (88%). As Table 1 shows, none of the participants felt excluded by learning or discussing cognitive styles. Discussing cognitive styles during the course (e.g., during team discussions) made almost everyone feel included. Students who identified as Abi and women students felt especially included. Furthermore, learning about cognitive styles during the course also made most students feel included (see Table 1 for additional details).

Table 1. *Inclusion/exclusion aggregates from CS361 post-questionnaire responses (n=34)*

Student responses about whether cognitive styles made them feel included when they...										
		Discussed with others							Learned it	
	n	Included (Discuss)	Excluded (Discuss)	Very inclu.	Some inclu.	Neither	Some exclu.	Very exclu.	Included (Learn)	Excluded (Learn)
Abi	9	100%	0%	67%	33%	0%	0%	0%	78%	0%
Tim	10	90%	0%	40%	50%	10%	0%	0%	90%	0%
Pat	15	80%	0%	27%	53%	20%	0%	0%	80%	0%
Women	12	92%	0%	50%	42%	8%	0%	0%	83%	0%
Men	22	86%	0%	36%	50%	14%	0%	0%	82%	0%
Overall	34	88%	0%	41%	47%	12%	0%	0%	82%	0%

Student quotes help explain how learning and discussing cognitive styles made them feel included. One participant who identified as having all five Abi facet values mentioned that identifying their facet values made them:

> "feel much more confident" and helped them "point out the benefits of [their] caution [and] validate [their facet values to themselves] and amongst [their] peers"

Another participant mentioned meta-cognitive benefits:

> "Identifying my facet values helped me [understand which features of technology] are most helpful [for my learning]."

As Table 2 on page 9 shows, what made students most often feel *very* included was interacting with their teammates (62% felt very included). In contrast, interactions with classmates outside of their team was what made the highest percentage of students feel excluded (18%; see Table 2 for more details), especially those identifying as Abi, Pat, and women. Considering that students felt included by discussing cognitive styles (which happened within teams but not outside of teams) suggests the cognitive styles content helped create a "safe space" within teams where students felt included and had the opportunity to help others feel included.

For example, students spoke positively about finding out they had cognitive similarities with their new teammates:

> "...excited to work on a team with a fellow Abi...[anticipating] running through the whole process [from] start to finish"

Students also expressed that the cognitive styles content helped their teammates be inclusive:

> "[My teammates understand that we] tend to work differently [and thus we were] less demanding on each other"
>
> [my team understands that I'm not] being lazy...some people just aren't really tinkerers"

Table 2. *Aggregate team inclusion/exclusion results (n=34)*

Student response about whether they felt included by classmates...							
	n	Team			Non-team		
		Included	Neither	Excluded	Included	Neither	Excluded
Abi	9	89%	11%	0%	45%	33%	22%
Tim	10	90%	0%	10%	40%	60%	0%
Pat	15	80%	7%	13%	27%	46%	27%
Women	12	66%	17%	17%	17%	50%	33%
Men	22	95%	0%	5%	45%	45%	10%
Overall	34	85%	6%	9%	35%	47%	18%

In addition, students noticed themselves becoming more inclusive to teammates over time, as they absorbed the cognitive styles content:

> "...the biggest change in my interactions happened in sprint 4 where I became more understanding of teammates that tend to tinker more and not gather information before taking a forward step"

While these inclusion results are encouraging, some students still felt excluded by some aspects of the course. One participant mentioned in the post-questionnaire,

> "I would have appreciated having another female in my group."

Another student similarly expressed,

> "I'm 37, female, and I have a disability. It seems like most of my classmates are younger males."

This indicates that while students felt included by their cognitive similarities with other students, some students with underrepresented identities would have still preferred having more classmates that shared those identities.

Positive team dynamics
We anticipated that the cognitive styles team discussion could be an ice-breaker to help students get to know and accept each other, but were surprised to observe how these effects were integrated into how student teams operated. For these students, cognitive styles seeped into the fabric of teamwork itself.

Cognitive styles gave teams new ways to frame design discussions. Students could go beyond stating their personal opinions about designs, instead resting their reasoning on cognitive styles, which gave their team interactions structure and direction:

> "With my teammates, the cognitive styles helped guide our discussions about how features should look or work."

Being able to justify design directions through cognitive styles also helped some teams avoid conflict:

> "We never had a debate about whether such focus [on providing feedback to users] was necessary...definitely because of the discussion we had on cognitive styles."

Students also expressed that the cognitive styles content helped with avoiding interpersonal conflict. One participant, who identified as being task-motivated (as opposed to motivated by tech interest), mentioned being resistant to learning new technologies, which could potentially create conflict if teammates expected them to eagerly learn new technologies. They found that:

> "the cognitive styles discussion ... helped [their teammates] interact with [them about their resistance]"

Similarly, another participant mentioned,

> "...[cognitive styles] introduced language that gave us the confidence to admit when we were in an area that felt overwhelming or something came easy to us"

Lastly, students began to see value in having a diverse team. Some students saw their teammates as specializing in different cognitive styles, which could help the whole team understand users with those same styles:

> "[cognitive styles] made it easier to understand...[which teammate] to turn to for help"

> "[If we were] looking to improve [the team's] project with respect to a Tim-type user, we already had an understanding of which teammates could relate to that user the most."

Students also saw how having a cognitively diverse team led to the team creating better software:

> "[The cognitive styles curriculum] was helpful in the group...we had each cognitive style reflected...This resulted in an overall more usable web app than if it were developed by...people all of the same cognitive style."

Teammates co-building a new understanding of their users
Using their new language of cognitive styles, teammates were able to co-discover nuanced perspectives about software users. In this section, we analyzed a conversation from a discussion board between two teammates who found consensus rejecting a black-and-white view of users—including while viewing themselves as users.

> **Student 1 (identified as a white man with mostly Tim facet values)**: "I typically think (thought?) in terms of a simple dichotomy of those who are good with tech and those who

aren't. As a teacher and someone who has worked in tech support on a school campus, I have definitely fallen into this simplistic view. I have gotten frustrated with colleagues in the past who couldn't just pick up a new tech tool be it Zoom, Google Drive, or any other ed-tech software. Now I see that I probably was being unfair, unreasonable, and probably inaccurate in my assessment of others. It's much more complicated and nuanced than just those who can and those who can't. The more I reflect on the material, the more I appreciate the adoption of these personas that specifically ignore age and gender. Side note: I have always felt uncomfortable with the idea of my students and younger generations as 'digital natives', and I think this exploration helped to solidify just why. I am excited to see where we as a group can take our software as we use these personas to guide our UI/UX."

> **Student 2 (identified as white man with mostly Tim facet values)**. **Response to Student 1:** "I agree that we sometimes get too focused on 'tech-literate' vs 'tech-illiterate.' It is not as simple as that and sometimes apps that we use and see as relatively simple can be obtuse in ways we don't perceive, even to those that are 'tech-literate' with everything else. Using myself as an example, I consider myself to be mostly 'tech-literate', but the first time I was introduced to macOS for work I was lost. Coming from a PC background, the file navigation, app installation, etc. all seemed incredibly unintuitive and at first glance you would think I'd never used a computer before haha."

In exploring the dichotomy of "tech-literate" and "tech-illiterate" people, both students were coming to realize that these dichotomies are simplistic and unfair and that they don't represent reality. These types of acknowledgements, especially from students who demographically fit the identity of many CS students (white, man), could help explain why students felt so included by discussing cognitive styles with their teammates.

Honoring user diversity
Students' understanding of cognitive styles followed through to their feelings about users. Students recognized that they were different from their users and that that has implications for the software design process. One participant reflected that,

> "if you do not fit [the user's] cognitive type, then you may not fully understand how they interpret [a feature]."

They also began feeling responsible for user experiences in software, such as when one participant mentioned,

> "That's not right! I felt a sense of responsibility to users like these"

and another decided,

> "I will now be more careful to incorporate features that allow you to undo actions."

Students also showed signs of becoming more empathetic toward users:

> "[when I see others] struggle with technology, especially in this context of the pandemic, I will view them with more compassion"

Conclusion
This Ecampus Research Fellows project resulted in promising evidence that GenderMag inclusive design methods, which were created for improving software inclusivity, can also improve the inclusivity climate of the online CS classroom when taught to students. Furthermore, the curriculum can prompt students to actively build the climate by adjusting how they view and communicate with their classmates. After integrating GenderMag inclusive design

curriculum into two online CS courses, we observed several positive results, including the following:

- Students **felt included** by learning and discussing cognitive styles and did not feel excluded by it.
- Students used the language of cognitive styles to **behave inclusively** toward their teammates, to discuss their strengths and weaknesses with teammates and to co-discover new ways of understanding users.
- Students wove cognitive styles throughout their **team practices** in positive ways.
- Students reported **feeling responsible** for their users' experience of software.

The larger study was conducted within only two junior-level CS courses and involved teaching only a subset of possible GenderMag topics, so there are several potential avenues of future research. For example, if GenderMag topics were incorporated throughout an online CS degree program, we might see changes in how included students feel outside of teams or in their major overall. Also, since students who identify as women often leave CS during the intro-level courses, it would be interesting to see if incorporating GenderMag at this level affects retention. As a third avenue, teaching the GenderMag Walkthrough activity to online students might result in even stronger inclusivity benefits, as the Walkthrough involves "channeling" the GenderMag personas (Burnett et al. 2016), which might further enhance online students' empathy toward their users and classmates. Finally, some GenderMag materials (e.g., a team ice-breaker about cognitive styles) could potentially be taught in courses outside of CS.

Our GenderMag course materials are freely available in editable formats within our OERCommons community.

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About the Research Unit at Oregon State Ecampus

Vision
The Ecampus Research Unit strives to be leaders in the field of online higher education research through contributing new knowledge to the field, advancing research literacy, building researcher communities and guiding national conversations around actionable research in online teaching and learning.

Mission
The Ecampus Research Unit responds to and forecasts the needs and challenges of the online education field through conducting original research; fostering strategic collaborations; and creating evidence-based resources and tools that contribute to effective online teaching, learning and program administration.

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