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# Online Professional Development for Computer Science Teachers: Gender-Inclusive Instructional Design Strategies

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## ABSTRACT

Computer science (CS) education is plagued by a gender divide, with few girls and women participating in this high-status discipline. A proven strategy to broaden participation for girls and other underrepresented students interested in CS is the availability of teacher preparation that requires classroom teachers to grow their knowledge of CS content as well as the pedagogical practices that enhance inclusive learning opportunities for historically underrepresented students. This case study describes the design and impact of an Online Professional Development (PD) for CS teachers, a year-long PD program aimed at broadening participation in the United States. Using survey and observation data from more than 200 participants over three years in PD settings, this paper examines how the design of an online learning community model of PD provides an inclusive venue for teachers to examine their belief systems, develop inclusive pedagogical practices, and collectively transform the culture of CS classrooms to places that support all learners. Findings suggest that purposeful facilitation creates a transformative culture of "shared experience" whereby facilitators and groups of teachers engage in collaborative lesson planning and debriefing discussions, in both synchronous and asynchronous sessions. This case study can inform other online PD efforts aimed at broadening participation in computing.

## KEYWORDS

Gender, Computer Science, Online Professional Development, Learning Community, Mentoring, Online Facilitation, Broadening Participation

# Online Professional Development for Computer Science Teachers: Gender-Inclusive Instructional Design Strategies

## INTRODUCTION

Women and girls are sorely underrepresented in computing. Computer science (CS) education has been perpetually plagued by gender discrepancies in participation; in the United States, CS participation for decades has hovered around 20% for girls in secondary and college CS courses (College Board, 2016; Taubee, 2017). In the United Kingdom, only 9% of girls' schools offer computing at A-level, compared with 44% of boys' schools, and 25% of mixed-sex schools and colleges (Kendall, 2017). School experiences are important for engaging girls in computing, and *teachers* are the key resource for providing these experiences. Research suggests that social opportunities and encouragement, often from a teacher or other educator, has a tremendous influence on girls' decisions to pursue computing (Google, 2014).

Studies have shown that boys often arrive at school with more extensive experience with computing through informal experiences such as robotics, computer camp, or coding with a male relative. Aware of these experiences, educators can mistake boys' *preparatory privilege* with actual aptitude and interest in learning about CS. Since CS is typically an elective course, guidance counselors and teachers often tap into their biases around who "belongs" in CS to select which students to enroll, using preparatory privilege as a proxy. Thus, girls, who are less likely to be given these same earlier opportunities, are not steered towards CS courses, and do not receive the social encouragement that signals to them they belong in CS, further exacerbating societal stereotypes (Cheryan, Master, & Meltzoff, 2015). When girls do participate in CS courses, they often report a "chilly climate" and curriculum and pedagogy that fails to build on their knowledge or capture their interests (Goode, Estrella, & Margolis, 2006).

As Cheryan, Master, and Meltzoff argue (2015), broadening the representation of CS to include features that make a CS learning experience appealing to a variety of cultures or people with differing interests and ways of learning, including in online spaces, is required to draw more diversity into the field. Their research demonstrates stereotypical features associated with CS (technically oriented, singularly focused on technology, socially awkward, masculine, etc.), when depicted in educational spaces, had significant gender effects on girls and women's sense of ambient belonging in the field. When undergraduates were given a choice between participating in an online learning setting with stereotypical objects associated highly with CS majors, e.g. images of science fiction materials and stacks of soda cans, or one with non-stereotypical objects, only 18% of women, and 60% of men, chose the learning setting with more stereotypical objects. This "geek effect" (Kendall, 2017) resulted in women reporting a lower sense of "belonging" in the stereotypical environment - they didn't feel connected to the stereotypical objects or to the people they assumed existed in the environment. Men, on the other hand, reported an equal and sometimes greater sense of "belonging" in the stereotypical

environment. Ultimately, this research illustrates that the more women felt a CS learning environment was stereotypically masculine in nature, the less interest they had in participating in the environment. This study suggests that inclusive CS education must include more diverse representations of people, the work involved, and the values associated with this work.

In recent years, the "CS for All" movement has aimed to move CS from the peripheries of the school curriculum into the core, where all students can access this knowledge. Exploring Computer Science (ECS), the widely used introductory CS curriculum in the United States, has led an equity-based approach to instructional materials and PD in the United States since 2008 (Margolis, Goode, & Chapman, 2015). ECS's equity-based approach is crucial and attempts to level the playing field where boys and students from majority groups currently enjoy a benefit of greater access to quality CS education; while quality CS curriculum is good for all students, a CS curriculum lacking a focus on equity is *harmful* for all students – and it's particularly harmful for students from underrepresented groups. Beginning in Los Angeles, the ECS program initially grew through regional hubs, supporting teachers in a 2-year professional development (PD) program in large urban areas, including seven of the largest school districts in the country. Unlike other high school CS courses, ECS student enrollment reflects the racial demographics of school districts, and girls make up 46% of students (Margolis, Goode, & Chapman, 2015).

However, to meet the needs of schools outside urban areas, for three years ECS has supported a "National Teacher Cohort" to introduce the ECS course in schools from across the U.S. (Camp, Campos, Goode, & Astrachan, 2017). While each cohort of teachers met face-to-face for a week-long PD the summer before they began teaching the course, the typical ECS one-day face-to-face quarterly PDs are impractical when considering the travel time and cost for convening in a single location. To address this need, we created a set of four quarterly online PD "experiences" to support the development of teachers' content knowledge, inquiry-based instruction, and equity pedagogy in CS that supports learning for girls and other historically underrepresented students.

This case study examines how these online PD experiences support the goals of increasing gender diversity in CS education. Ultimately, we seek to address in this case study: *What features of online learning during the school year support teachers in developing inclusive teaching practices to support girls in CS learning?*

## METHODOLOGY

The participants of this case study are high school teachers who were implementing the ECS course for their first year while simultaneously participating in a series of four ECS online PD experiences. Three national cohorts of teachers participated in the online PD over the last three years, with a total of 200 participants from 34 states. Each cohort had already engaged in a week-long face-to-face PD where they met one another and learned together in a residential college setting. These cohorts were racially diverse and had significant proportions of female teachers, with cohorts comprised of 52%, 53%, and 67% women, across the three cohorts.

This case study draws from a sequential mixed-methods approach, gathering post-professional development participant surveys from each of the 4 quarterly PDs; observing individual and interactive participant comments and discussions across the 4 sessions; and observing facilitators' interactions online, and an in-person focus group with 7 facilitators at the end of year 3. The surveys focused on teachers' self-reported learning of content, inquiry, and equity issues, as well as their impressions of the online environment. Meanwhile, the observations allowed us to capture discussions over time amongst participants and facilitators. These data were coded based on themes of teachers' content development, teachers' instructional learning, and teachers' learning around equity and inclusion. Further, the online setting environment underwent an iterative series of changes and modifications based on initial analysis of this data to better support the needs of teachers.

## FINDINGS

Because teachers are the most important resource for students in providing inclusive learning opportunities in classroom settings, instilling an equity-lens for teaching CS, a field steeped with gendered stereotypes and patterns of participation, is essential when preparing teachers. The data in this study pointed to the importance of how design elements of this online learning experience shaped teachers' experiences and knowledge around inclusive CS education.

### Online PD Environment Description

The four quarterly online sessions in this case study were designed to prepare teachers to teach the final four units of the ECS curriculum: Web Design; Programming; Computing and Data Analysis; and Robotics. From beginning to end, each PD workshop took place across two weeks, with an estimated time of six hours of learning time for each participant. All sessions took place during the school year.

Initially, we elected to use the Moodle course management system to house the ECS online PD content. Moodle is an open-source course management system with extensive online learning functionality. Using Moodle allowed us to efficiently develop and facilitate the first year ECS online PD sessions. While teachers and facilitators had a relatively easy time participating in the initial online PD environment, over time, modifications were made to address frustrations with navigation, technical language, and what felt like a "forced" layout.

After two years of adapting the initial environment based on user feedback, we moved to a more custom environment designed in WordPress using the LearnDash plugin. The combination of these tools allowed us more flexibility in terms of customizing the entire look-and-feel, as well as much of the functionality, of the learning environment. Specifically, the highly customizable nature of the new environment allowed us to be more purposeful in creating a space that is structurally more welcoming to participants.

Using the Computing and Data Analysis PD session as an example, Figure 1 illustrates the layout and types of learning participants experience within each section of the online PD environment.

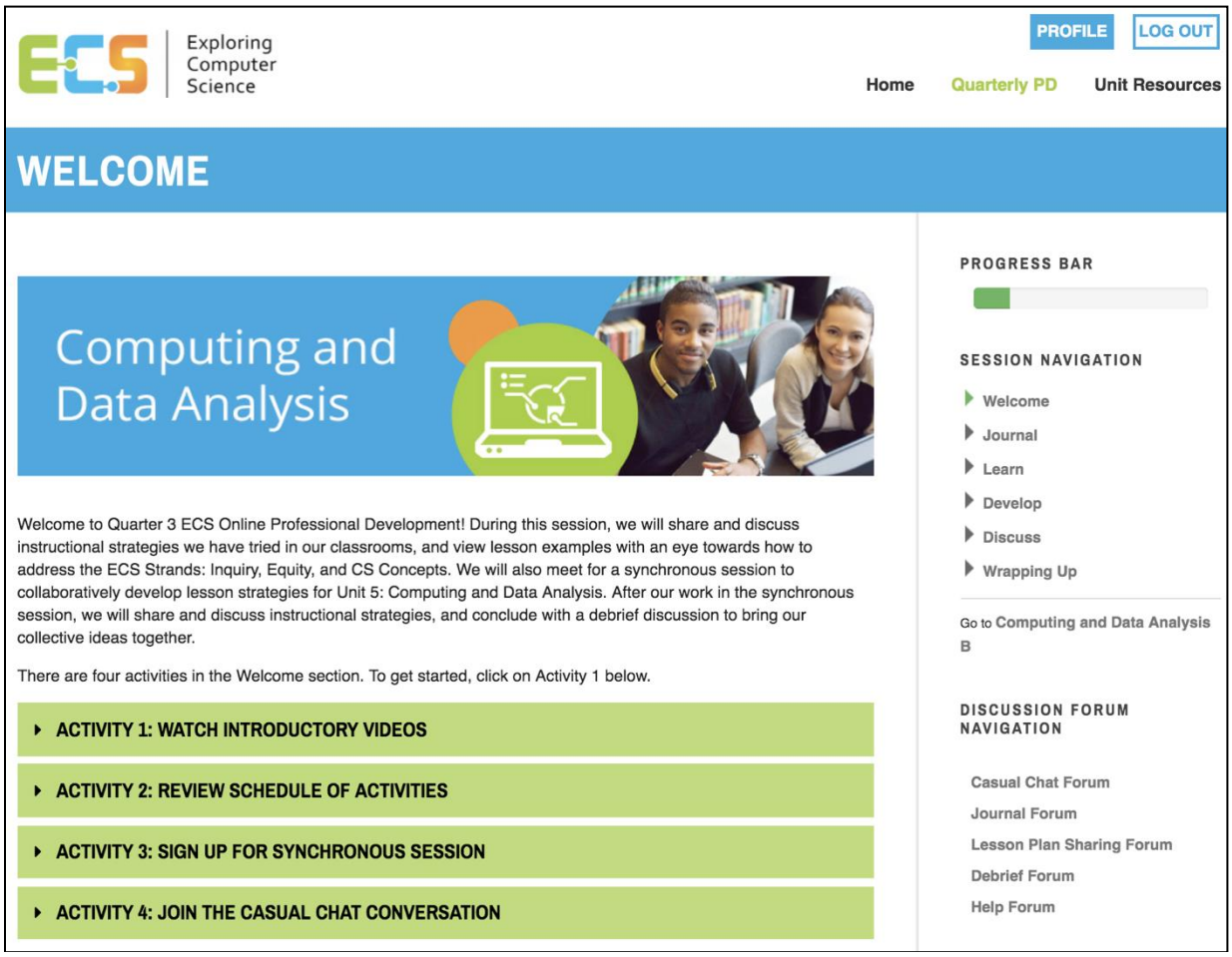


*Figure 1*: ECS Online PD Environment

Content is organized in the center of the screen in a collection of green accordion partitions, each of which drops down to display a particular activity. The Session Navigation bar on the right displays the progression of activities which build on each other both within each section (such as the Welcome section or the Journal section) and across the entire PD session.

The online PD design was an iterative process, with content and design adaptations taking place each quarter of each of the three years, based on participant and facilitator feedback. This design featured a Professional Learning Community (PLC) orientation to create an atmosphere that strengthens teachers' confidence and knowledge in inclusive CS pedagogy. PLCs are noted for engaging educators in a reflective process that asks participants to "dig deeply into learning" and expand their world views (Garrison, 2006). Further, we combined the use of self-guided online resources and teachers' desires (Wang & Chen, 2008) to collaborate on "planning, designing, and delivering instruction" (Fullan, 2005).

**Inclusive Design of Online PD Experience**

We found that modeling inclusive practices for teachers' online learning sparked ideas for teachers about similar structures for their own pedagogy with students. Creating a welcoming environment with a PLC atmosphere provided an *inclusive* environment for all teachers to engage in their own learning. The data suggests that several features of the learning environment were particularly notable for presenting an inclusive, non-stereotypical approach to CS PD. The table below summarizes these key design features embedded in both the environment and facilitation over the course of a PD session. Qualitative teacher comments are provided along with each of these design features to illustrate thematic remarks and reflections from online PD participants.

*ECS Online PD Design Features and Implementation Strategies*

| **Design Feature** | **PD Implementation** | **Teacher Reflections** |
|---|---|---|
| Welcoming, not Weeding | The online environment has an intuitive and organized design that ensures immediate, one-click access to each section and key functionality of the PD from the home page. The design is bright and colorful; images include people who are active and represent a variety of racial groups.<br><br>Beginning with the **Welcome** section, participants are introduced to the session goals, tasks, and expectations through both video and written materials; they select a day and time for the collaborative synchronous session; and they connect with facilitators and each other around a fun, relevant topic in the Casual Chat discussion forum. | "I liked that this was spread out more and gave us an opportunity to preview the lessons before we joined our synchronous sessions. This told me that you guys really did listen to our feedback from the first PD session. It helped with the facilitation and the pacing." |
| High-Touch Facilitation, not Self-Guided | Every section of the PD includes venues for dialogue and collaboration among colleagues and facilitators via threaded discussion forums, web-conferencing synchronous sessions, shared online documents, and ongoing supportive email.<br><br>Facilitators develop relationships with participants starting with a personal email to introduce the PD, set a welcoming tone, and invite active collaboration throughout PD session. If | "I think the facilitators is the big piece, the online facilitators. Because there's so much dialogue, and when we were going through it, we were like lost by ourselves, but with a facilitator keeping everyone together, that's how it works." |

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| | participants are absent from the PD for more than three days or if they need extra help, facilitators follow-up with individual emails or phone calls. Facilitators model empathy and the act of valuing all questions and problems that occur, ensuring responses to all participant concerns.<br><br>Facilitators operate with the goal of modeling inquiry-based learning and promoting it as a critical ECS instructional philosophy. In discussion forums, facilitators help participants think through each other's questions to come up with potential solutions and guide teachers in appreciating the value of "struggling through" a task. Facilitators highlight ideas contributed by participants, helping them make connections to each other's experiences, thus fostering *collective* intelligence and problem solving. | "I really appreciate all of the work the ECS team does in providing these PD sessions. They are all friendly and very supportive in their comments while also encouraging us to think deeper and focus on Equity and Inquiry when it is so easy to just think of CS Content." |
| Focused on Teaching, not Content | In the **Journal** section, participants reflect on their completion of an activity from the ECS curriculum, deepening their understanding of equity and inclusive instructional strategies - this reflection and subsequent dialogue among participants takes place in a discussion forum, guided by the facilitator. Participants next move to the **Learn** section where they experience ECS content *as learners* prior to planning a group lesson: unit materials, model lessons taught by ECS teachers, and resources targeted to their and their students' identified needs include reflective and interactive elements that prepare teachers to relate their learning experience with the activities to instructional strategies they'll use with their students. | "Discussions on strategies were beneficial to me. I am always looking for new ways to stimulate my students and ensure that everyone participates. Activities such as journals, think/pair/share, and notice/wonder were strategies that I will use in the future in many diverse ways". |
| Collaborative, not Individual | In the **Develop** section, participants come together in a synchronous session held in Adobe Connect, first as a whole | "Group collaboration helped me a ton. I was able to realize that my |

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| | group to discuss with facilitators the overarching goals for the session (which lesson they are focusing on and critical focus areas for equitable practice) and then moving to breakout rooms to work in groups of 3-4 where they use a collaborative Google doc and Adobe's voice and text chat tools to "remix" ECS lessons with collective instructional strategies to meet their students' needs.<br><br>At the conclusion of the Develop section, participants move to the **Discuss** section where one member of each small group posts their lesson strategies to the Lesson Plan Sharing Forum, while all participants review plans shared by others and discuss how the ideas support inquiry and equity-based teaching practices. This part of the PD is dynamic and highly participatory - teachers capitalize on each other's ideas for teaching the same lesson and obtain immediately applicable strategies to use in their own classroom, regularly reporting on the PD final survey that the lesson plan "remixing" and their own takeaways were the highlight of the session. | students are not the only under-served groups of students that are thriving in this curriculum."<br><br>"The discussions that my collaborative planning group had, both about the lesson and about our experiences with ECS so far, were the most powerful. I process information much better through discussion than reading and it was tremendously helpful to hear a variety of perspectives and experiences. It was also very helpful to hear that other people were having similar struggles and successes." |
| Teacher discourse, not Technical Jargon | A professional and conversational tone is emphasized in all language associated with the PD sessions. Each section title indicates what teachers will do during that portion of the PD and models the type of classroom structure and dialogue that ECS lessons promote. For example, rather than using a title such as "final survey", we included a "Wrapping Up" section to help teachers immediately feel the pulling together of their learning activities where we "invite" teachers to share feedback that impacts design iterations. | "One very unique part about this course is the PD's and the ECS for all teachers' forums create a national community for this subject. It is very exciting to be able to discuss the curriculum with teachers all around the country. It's like a huge Professional Learning Community." |

## DISCUSSION

Preparing teachers to teach "CS for All" is a formidable challenge for CS Education. Given the longstanding exclusion of women and people of color studying CS, preparing teachers with specific skills to present and teach through inclusive practices is essential for reaching goals of equity. In this case study, we found that an online environment that models pedagogy, nurtures the development of teachers, and fosters a collaborative approach to learning is particularly effective for teachers' skills and confidence in teaching for equity and inclusion. In particular, participants described the PD as responsive to the needs of teachers, they valued the relational, high-touch facilitation, and appreciated the use of teacher vocabulary, rather than technical jargon. In addition, we saw that this online setting encouraged participants to explore new concepts and teaching methods that were designed to be more inclusive for girls.

These findings extend the research of Cheryan, Master, and Meltzoff (2015) and showcases how the (re)design of an intentionally non-stereotypical environment for CS teacher PD can be inclusive and attentive to participants' sense of belonging. Not only were the aesthetics and instructional design devoid of more technical and masculine markers, but the high-touch facilitation and collaborative lesson-planning approach disrupted the stereotypical notion of the solitary nature of learning CS. Finally, it is not insignificant that the online PD program has also attracted a significant number of women CS teachers who had a space to engage in learning about CS content and pedagogy together. Given the dominance of men in this field historically, having women-majority cohorts in ECS has helped shift the perceptions around gender and who does CS. Since research suggests that having women teachers in STEM fields is correlated with higher rates of females who graduate from college with STEM majors (Bottia, 2015), building the cadre of women CS teachers further disrupts stereotypical notions of CS education that might prevent girls from pursuing the subject.

Based on lessons learned from this case study, some simple things others can do to replicate ECS's online PD model include the following:

1. Ensure that the PD program is overtly focused on equity - participants should represent traditionally underserved populations and cultural context should be woven throughout the learning experience.

2. The PD should be heavily facilitated by those with CS curriculum experience and experience in creating and sustaining a learning community online - this is "high-touch" interpersonal communication and relationship-building at the core.

3. Center the PD around shared/collaborative experiences where teachers come together to share specific instructional strategies for addressing the curriculum with their own students; teachers from different environments will learn from each other and the collective intelligence of the group will build skills not just in CS content but in equity-based teaching.

4. Design a simple online environment to house content; a homepage with clear navigation and an intuitive, linear content progression is key to ease of use. Course management systems offer many design options but they can also be hard to streamline. Remember that less is best.

5. Include multiple, ongoing ways to collaborate throughout the learning experience and actively facilitate dialogue among participants. For example, use threaded discussions because they are accessible at all times and allow for thinking time between comments; use Google documents or other tools for collaborative co-creation of lessons or instructional products; use web conferencing software with breakout room capability in order to have live meetings as a whole group and simultaneously allow small groups to collaborate in breakout rooms with facilitators on hand to drop in and provide guidance as needed; use a visual discussion tool like Padlet that allows a full view conversation including images and/or media.

6. Facilitators must stay in touch with participants - use email and phone to connect with individuals if they are absent, and offer reminders about deadlines while using a personal touch to communicate.

7. Understand that your PD is iterative - always focus on the user experience and feedback, making sure to regularly make both technical and content updates based on input and keep them informed of what you updated, acknowledging their contributions to the learning community.

This case study reveals that even online, relational approaches to teacher learning, within a highly-facilitated learning community that presents a non-stereotypical CS environment, are optimal for preparing teachers with the content, pedagogy, and orientation towards equity and inclusion that support girls in CS.

## CONCLUSION

Computer Science education efforts are expanding across the globe, and the pervasive concerns of equity and inclusion, alongside the need to prepare teachers to teach computing, are amongst the most significant challenges in bringing CS learning to all students. This case study demonstrates how online PD can address these challenges simultaneously – preparing teachers with a welcoming, collaborative environment where they themselves can engage in learning about CS that mirrors the inclusive practices that will support the learning of girls in their own classrooms.

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