Questioning the Why and the How: Collective transformative agency of experienced teachers co-designing a justice-oriented high school introductory computing program

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We report findings from qualitatively analyzing audio recordings and teacher-generated products from a two-day in-person collaborative design (co-design) workshop where nine experienced high school CS teachers revised parts of an existing introductory high school program towards justice. In response to our research question of how teachers demonstrated agency as co-designers, our analysis revealed that they collaboratively questioned the purpose, the "why," and the approach, the "how," and captured ideas in lesson templates and unit descriptions to transform future practice. We discuss co-design with teachers as openings to explore nuances of teachers' visions for equitable CS education. We highlight the foundational long standing relationships and politicized trust, and enabling features of the co-design space for equitable participation and joint creation of boundary objects to sustain ideas.

Introduction

Computing tools and solutions are increasingly penetrating our daily lives—from healthcare to criminal justice systems—while simultaneously shaping outcomes for individuals and communities. However, discriminatory outcomes for marginalized communities have forced fields of computing and computing education to question "what" makes up computing solutions. Underneath a "neutral" façade of technologies, the algorithms and datasets perpetuate and amplify historical harm to individuals with marginalized identities along race, sexuality, gender, ability, and socioeconomic status (Amrute, Singh, & Guzmán, 2022; Benjamin, 2019; Buolamwini, 2023; Costanza-Chock, 2020). Just as scholars demand the field of computing to investigate computing and its (dis)connections with multiple, intersectional social systems of oppression (e.g., Benjamin, 2019; Noble, 2018; Zuboff, 2019), similar calls have been made within computing education to teach CS towards creating a more just world (e.g., Kapor

Center, 2021; Ko et al., 2022; Kafai & Proctor, 2022). Societal biases and historical injustices have had implications for CS education—limited access to CS courses in high schools within under-resourced communities (Margolis et al., 2017), under-representation of students with marginalized racial and gender identities within CS classrooms across age groups (e.g., Ericson & McKlin, 2018; Gretter, Yadav, Sands, & Hambrusch, 2019) and exclusionary teaching practices that further keep marginalized students from pursuing CS (e.g., Ryoo, Goode, & Margolis, 2016) are just some examples of shadows of multidimensional and intersectional oppressive forces on CS education. More recently, with the uncovering of ways in which algorithms and datasets encode and encapsulate biases, calls for equitable and justice-oriented CS emphasize teaching CS concepts as aneutral, highlighting its connections to peoples' identities and communities and discussing the political implications of computing solutions for the marginalized, i.e., towards what ends computing education serves (Vakil, 2018).

While advocacy for justice-oriented computing education has shed light on "what" comprises computing education in terms of content taught, there is a need to equally engage with "how" we design the required curricular materials and teacher supports to achieve the set goals (e.g., Hu & Yadav, 2024; Ni et al., 2022; Brummelen & Lin, 2020). Pedagogical frameworks for pre-service CS teacher preparation programs (Ko et al., 2022), curricular materials (Kapor Center, 2021), and theoretical frameworks guiding these efforts (e.g., Kafai & Proctor, 2022; Madkins, Howard, & Freed, 2020; Yadav, Heath, & Hu, 2022) provide guidelines for the theoretical orientation and approaches for entailing design work. However, discussions about equitable, participatory approaches to designing justice-oriented CS programs, i.e., "how" we work towards these goals are only recent. Unlike traditional design efforts that involved small, mostly homogenous groups of designers hoping to inform teachers about the new

orientation within CS, participatory design methods draw one's attention to the composition of the design team, the power relationships between the team members, and the implications for designed products such as curricular materials and teacher preparation programs (e.g., Bang & Vossoughi, 2016; Philip, Martinez, Lopez, & Garcia, 2016; Voogt, Laferrie`re, Breuleux, Itow, Hickey, & McKenney, 2015). Such a shift in design processes implies a change in teachers' role in contributing to curricular design efforts with their wisdom from personal and professional experiences, what it means regarding CS teaching in classrooms, and how one can adopt it in their practices.

Co-design is one such participatory design approach that starts by recognizing the collective wisdom within teacher communities and how that can inform changes or reorientations (Bang & Vossoughi, 2016; DiSalvo, Yip, Bonsignore & Carl, 2017; Philip et al., 2016; Severance et al., 2016). More importantly, co-design empowers teachers to change their everyday professional practices and tools, such as curricular materials, that affect their practice. When designed to support teachers to bring in perspectives from their practice and learn and design as a part of a cyclical process, co-design has the potential to further teacher agency (Voogt et al., 2015) by inviting teachers to be active agents designing reforms (Severance et al., 2016). This role stands in contrast to the normative and deprofessionalized ways in which teachers are excluded from the educational design process (Philip et al., 2016; Santo, Yadav, & Phelps, 2024). Such an ontological and epistemological shift in how we perceive the role of teachers in the educational landscape has led to the uptake of co-design efforts while designing tools of consequence for teaching and learning spaces, such as educational software (Penuel, Roschelle, & Shechtman, 2007; Matuk, Gerard, Lim-Breitbart, & Linn, 2016), curricular lessons and programs (Ni et al., 2022; Brummelen & Lin, 2020), and even brainstorming ideas for classroom teaching (Jayathirtha, Chapman, & Goode, 2023). At

the same time, supporting agentic participation can lead to imagining transformative pedagogical approaches, cross existing boundaries and envision new disciplinary practices (Penuel, 2019). Although fairly recent in CS education design and research, co-designing with teachers has been explored as an opportunity to elevate teacher voices and perspectives within CS education (Ni et al., 2022; Brummelen & Lin, 2020; Jayathirtha et al., 2023), though explorations of teacher agentic participation are yet to be undertaken.

While studies examining co-design with teachers have highlighted the affordances of such an approach for teacher learning, professional growth, and effective uptake of curricular programs (Kelly et al., 2019; Kelter et al., 2021; Voogt et al., 2015), more recent studies have explored opportunities for teacher empowerment, and agency and solidarity development (Philip et al., 2016). Drawing from the Cultural Historical Activity Theory (CHAT), some of the recent work within teacher co-design efforts have articulated how teachers can demonstrate collective agency to disrupt the normative hierarchies and inequities in their immediate realities and envisioned new practices (Bang & Vossoughi, 2016; Engerström & Sannino, 2010; Philip et al., 2016). They emphasize the social, cultural, and historical nature of co-design work that leads to critiquing the status quo within learning contexts, instead of assimilating with the dominant ways within the practice. However, such efforts and entailing studies within CS are rare, although calls for envisioning justice-oriented CS imply challenging normative ways of knowing, doing, and being in CS teaching-learning spaces.

For this paper, we examined our ongoing co-design work with twelve experienced CS teachers from across the US, teaching Introduction to Computer Science (ICS, pseudonym)—an introductory high school CS program with a robust teacher community built over a decade of teacher professional development efforts

(anon., XXXX). In partnership with these teachers, we have revised the existing ICS program, curricular materials, and the teacher professional development (PD) to orient it towards justice while transforming CS teaching practices within and beyond their classrooms. For this paper, we particularly analyzed a phase of the co-design effort that involved nine in-service CS teachers (eight of the twelve and an additional local ICS teacher). They met at a two-day in-person co-design workshop during Summer 2023 after a year of brainstorming as they prepared to co-author curricular units the following year. We analyzed transcripts from audio recordings, pictures, and teacher-generated products qualitatively and inductively (Creswell & Creswell, 2017; Small & Calarco, 2022) to answer the research question: How did teachers demonstrate agency as co-designers? Our analysis revealed that teachers questioned the purpose (the "why") and the approach (the "how") of different aspects of the curricular materials, such as units, lessons, and activities. They collaboratively imagined new practices and created products and tools such as lesson templates and unit descriptions and overviews that concretized the revised ideas for future co-authoring of the revised justice-oriented CS program.

Theoretical Framework

Our work with teachers as co-designers of a justice-oriented curricular program is informed by existing work within two key areas of inquiry: co-designing with teachers as an equity stance and co-design spaces for teacher agency.

Co-designing with teachers as an equity stance

Engaging participants as co-designers is best understood through the CHAT framework (Bang & Vossoughi, 2016; Engeström, 2011; Engerström & Sannino, 2010; Severance et al., 2016) that emphasizes the social, cultural, and historical nature of the design

process. Design efforts such as curricular co-design have the potential to enable "partners arrive at deeper, shared understanding of problems and to design, test, and iterate on solutions to those problems" (p. 389, Penuel, 2019). Co-designing curricular materials has also been viewed as a context for teacher professional development and centering teachers in educational reform work (Voogt et al., 2015). When viewed as embedded in a communal and historical context, design teams should not only be diverse in terms of social and cultural positionalities, but the design spaces also make opportunities for participants to bring in critical historicity to disrupt the normative hierarchies shaping their activities and recognize the power relations between different participants and how they shape design efforts. Activities such as curricular co-design imply the expansion and transformation of the object, i.e., the curricular materials, by the actors within the activity (Engerström & Sannino, 2010) while co-design spaces make ideational resources accessible for participants, so they adopt them agentically to make meaningful and transformative changes to their living conditions. Co-design principally emphasizes on "role re-mediations [between co-designers with inherent power imbalance] and forms of disciplined subjectivity enacted during processes of partnering" to hold a productive space for meaningful co-designing that affords opportunities to disrupt the status quo by critical reflexivity and envision "wider forms of social and pedagogical imagination" (Bang & Vossoughi, 2016, p. 178). In case of CS education, existing inequities regarding access and participation, and dominant, neutral, and apolitical disciplinary perspectives can present contradictions that teachers will have to work with and transform as they chart new paths with curricular design efforts to transform future practice (Engerström & Sannino, 2010).

An equitable way to design curricular resources and PD programs is to co-design them with teachers, drawing from their classroom experiences and expertise

while closing gaps between the set categories and roles of "teachers," "researchers," and "designers" (Bang & Vossoughi, 2016). Emerging from the Scandinavian democratic movement of empowering workers to shape their working conditions, co-design implies involving individuals affected by the design in the design process (DiSalvo et al., 2017). Engaging teachers as co-designers is considered a special case of participatory design research where the participants, i.e., teachers, are included to inform the design of tools such as curricular materials that are of consequence for their professional lives (Philip et al., 2016). Co-designing with teachers should lead to newer forms of activities and relationships between themselves while supporting "alternative forms of learning and knowledge development, and contribute to the intellectual thriving and well-being of students, teachers, families, and communities" (Bang & Vossoughi, 2016, p. 175). While teachers can potentially bring in a wealth of experience and wisdom, design efforts barely consider their perspectives due to several constraints such as the perceived social value of the profession (Philip et al., 2016) and positionality of teachers in relation to educational design work (Philip et al., 2022). However, there is potential for rich engagements and design opportunities with teachers from diverse teaching-learning contexts if co-design spaces can be sensitive to teachers' needs within ever-changing local and political contexts (Voogt et al., 2015). Co-design efforts can lead to expansion of the object across multiple dimensions while opening questions of participant inclusion (social-spatial), future authoring for community (systemic-developmental), considering historicity in relation to the future (anticipatory-temporal), and locating power and responsibilities (moral-ideological) (Engerström & Sannino, 2010). Simultaneously, it has the potential to enable participants to collectively build and expand their capacities and exercise agency (Penuel, 2019).

Although recent within computing education, co-designing with teachers has

been adopted as a design approach towards equity and educational justice broadly across STEM education (e.g., Philip et al., 2022; Lin & Brummelen, 2021). However, most co-design efforts that have included teachers in design efforts have done so to create opportunities for teacher learning and a more comfortable adoption of researcher-designed artifacts (Kelter et al., 2021; Kelly et al., 2019; Penuel & Roschelle, 2006). Very few have approached it from a critical perspective discussed above, where co-design is explored as a design methodology to question and disrupt inequities within existing systems. Exceptions are approaches such as teacher solidarity co-design that specifically calls attention to the need to work towards educational justice and explicitly attends to the power relations that teachers navigate professionally and the relationships with communities and families they are enmeshed within while making room for mutual learning between teachers, researchers, and designers (Philip, Pham, Scott, & Cortez, 2022). Such work should not only include teachers for what they can contribute but also make a material difference against deprofessionalization of teachers by "highlighting teaching as a complex practice that requires growth over time" (Philip et al., 2016, p. 9).

Co-design spaces for teacher agency

Transformative agency, defined as collective action both to break away from current forms of activity and to develop "new concepts that may be used in other settings as frames for the design of locally appropriate new solutions" (Engeström, 2011, p. 606), becomes one of the significant aspects of co-designing with teachers for educational justice. This requires teachers to exercise agency at every step of the process as they analyze and question existing normative practices, envision and model alternatives in tangible ways, work with them to explore possibilities and limitations, capture the new model in concrete ways that can affect future practice, reflect on the process, and work towards creating stable new practices (Engerström & Sannino, 2010; Penuel, 2019).

Teachers will have to not only cross boundaries but also concretize new ideas into "boundary objects" that can continue to sustain these ideas and shape future practices (Engerström & Sannino, 2010). These steps, when embodied and enacted by participants in cyclical fashion, not only lead to the expansion of the object itself but also results in new forms of agency as demonstrated by the participants.

Attending to participants' agency draws our attention to the relationships between participants, or the subject-subject relations, and their implications for their role in re-mediations while demonstrating agency as co-designers (Bang & Vossoughi, 2016). Unlike the traditional approaches that focus on the actions and outcomes of individual co-designers, transformative agency when studied as a part of a relational process entails understanding the participants' joint activity and how emergent contradictions or disturbances make way for newer forms of activity, visions for the object of the activity, and overall expansion of the object. Such a focus on collaborative transformative agency will mean paying attention to interactions within groups, sometimes which can entail grappling with conflicting views, working towards resolving them, and capturing the solution in ways to establish and sustain newer practices (Sannino, 2010).

Previous, although limited, studies examining teacher agency within co-design settings have noted different ways in which teachers have demonstrated agency while co-designing curricular programs: developing new tools to support the design process, critiquing the variability between design groups, and recommending shifts in the design of co-design sessions (Severance et al., 2016). Secondary school science teachers, similar to other co-design efforts drawing from CHAT framework, were encouraged to resist inequities in their immediate contexts and turn them into resources for further engagement during co-design sessions. Teachers also adopted other resources and tools

that they had access to while engaging as co-designers and propelled into action that transformed their realities, while holding an equitable space for engagement and fostering ownership among teachers.

Furthermore, co-design work with teachers surfaces contradictions or "generative tensions" as teachers discuss ideas related to teaching and learning, while new forms of activity and envisioning may take the form of collective convergence, preparing to design products that embody the new imagination, or designed products at the end of the activity (Engerström, 2010). The co-design space will thus need to hold space for these tensions to emerge and have ways to collectively handle such contradictions in ways that will further expand the activity and turn these moments into opportunities for collective negotiation and dialogue (Bang & Vossoughi, 2016). And yet similar design studies within CS education is unheard of, although there has been increasing demand for transforming K-12 CS education to align with the vision for a just world.

Methodology

Positionality Statements

All three authors were facilitators of the co-design sessions analyzed for this paper. The first author identifies as a cis-woman researcher from South Asia. The second (Gina) and the third authors, identifying as White cis-women, were the original designers of the introductory computing program redesigned in this study. They launched ICS in 2009 as one of the first introductory high school programs with an explicit attention to access and participation inequities within CS education. Since then, they have facilitated several teacher PDs and facilitator workshops that have led to the development and sustenance of a teacher community of practice around the program consisting of high

CS teachers across the US and in Puerto Rico. Specific to this co-design effort, Gina facilitated teachers' PDs in partnership with and as a mentor for seven of the twelve co-design teachers in their first years of facilitating PDs. She had met each co-design teacher at least once in-person before this co-design work began in Fall 2022. As a curriculum designer and researcher, the third author had also developed a long-standing relationship with all the teachers teaching this introductory high school program. Both the curriculum designers met the co-design teachers regularly during the annual facilitator workshop, taking some of these relationships back over a decade (depending on the duration of teacher engagement with the program; more details below).

As the program was headed towards completing fifteen years, all three authors recognized the need for a major revision to keep up with increasing critical perspectives and shifting goals in the field of computing education. They secured the required funding in 2021 to revise the program in partnership with teachers within the community starting Fall 2022. All three authors were motivated by their teaching and learning experiences within computing to lead this co-design work. In particular, the original designers of the program were also high school CS teachers in the past, which motivated the team to co-design the program with teachers.

Context & Participants

ICS is an introductory program with six units and two optional units (see Figure 1), designed in 2009 to support high school students within under-resourced communities. The program has three key strands—equity, inquiry, and CS concepts—that shape how the lessons and activities are structured to support student-driven pedagogical practices and ensure conceptual learning through inquiry. Since the program's inception, the original designers of the program had revised the program to update resources and associated links in addition to co-creating additional optional units. Within the written

curriculum available online (version 9), each unit has a description that sets the direction followed by the overview chart that provides the sequence of lessons and activities (URL to the program website). The program comes with a two-year teacher PD consisting of two summer sessions and four quarterly sessions that has proven effective to support teachers before, during, and after a year of classroom teaching (anon., XXXX). Teachers read *Stuck in the Shallow End* (Margolis et al., 2008, 2017) and discuss CS education in relation to race and gender during the PD sessions, orienting them towards equitable vision for CS education in K-12 classrooms (anon., XXXX). Further, a few of these teachers facilitate PDs for new teachers and participate in a facilitator workshop annually, thereby having a more expansive experience teaching the program to students and teachers beyond their own classrooms (e.g., anon., XXXX). These teacher-facilitators have extended experience facilitating race-conscious conversations among CS teachers, at least twice every time they facilitate PD (anon., XXXX).

During Summer 2021, twelve of the teachers participating in the facilitator workshop volunteered to support the curricular revision work. Most teachers shared in their pre-co-design interviews how they were already making modifications to the program while teaching in their classrooms and viewed co-design work as an opportunity to let their teaching experiences inform the design process. The teachers came from across the U.S. and had varied professional and personal identities, demonstrating heterogeneity across gender, race, geographic location, and student demographics (see Table 1). During 2022-23, the co-designers met eight times to brainstorm potential curricular ideas based on the ongoing conversations about disciplinary connections with justice-related issues such as race, gender, etc. (see Figure 2). Each session involved the teachers and the designers going through pre-work, a

collection of articles and other materials, preparing synthesis cards, and participating in a 90-minute synchronous online session reflecting on potential connections with the curriculum (anon., XXXX). The first two authors summarized the brainstormed ideas to create a single document of ideas which identified common themes and specific suggestions for individual curricular units (see Figure 3 for examples).

During Summer 2023, eight of the twelve teachers were available for a two-day in-person co-design session held in a U.S. West coast city (four teachers had other personal reasons/commitments). Additionally, another experienced ICS teacher (Max) teaching at a local diverse public high school (see Table 1; also, a school with one of the highest number of students enrolled for Individualized Education Program (IEP), students identifying as coming from low-income households and multilingual families), joined the group. During the two days, the group along with the authors aimed to prepare for the next phase of the co-design work—of rewriting the curricular units and preparing materials for teacher PD for the upcoming year. Most of the preparation involved designing tools required for co-authoring lessons such as the unit and lesson templates and unit descriptions that shaped the entire revised program by reorienting the lessons and activities within the units. They further developed drafts of 2-3 new lessons as they prototyped the lesson templates and generated the unit overview charts to co-author lessons. In total, nine teachers worked as a group of three and three pairs, each group taking a curricular unit for redesign (see Table 2). Throughout, they modeled and practiced the revision process which involved three steps: revising, peer reviewing, and reflecting. Teachers had printed copies of the summary document from the year-long brainstorming and the curriculum being revised during the two-day session. The teachers went through the first day workshopping the unit and the lesson templates in addition to revising the unit overview charts and descriptions. In the spirit of co-design,

they were a part of designing the flow for the second day where they continued to revise the overview charts and reflect on the overall process as they planned the next phase of co-authoring lessons and activities (see Figure 4 for session breakups each day). The teachers continued to build on their joint work over the academic year 2023-24, working in groups and meeting as a whole group several times to develop new lessons and revised units, which led to the launch of ICS v.10 in Summer 2024.

Participant motivations

The co-design team was motivated by the recent push for justice-oriented K-12 CS education that draws from research on how carceral technologies shape everyday lives by aiding public surveillance and criminal justice systems (Amrute et al., 2022; Benjamin, 2019; Buolamwini, 2023; Costanza-Chock, 2020). We were particularly motivated by initiatives within computing education that explore intersections with justice-related issues to develop pedagogical approaches (Madkins et al., 2020), curricular resources (Ko et al., 2021; Washington, 2020), and frameworks for designing learning environments (Kapor Center, 2021; Kafai & Proctor, 2022). Across these efforts is a call from scholars to curb the neutral treatment of computing concepts and actively and critically engage with their connections with aspects such as individual sociocultural identities and their communities (Ko et al., 2022; Yadav et al., 2022). These scholars argue for pedagogical practices that acknowledge racism in computer science and enact anti-racist practices within classrooms by adopting inclusive pedagogical approaches that "actively and intentionally confront and dispel stereotypes and biases about the abilities and skills of students from groups marginalized in CS" (Kapor Center, 2021, p. 7). Such practices further equity within CS classrooms by inviting student voice, agency, and active participation in meaning-making (Ryoo et al., 2016). We are continuously informed by all the work during our two-year co-design

work, which started in 2022-23 with a series of brainstorming sessions, followed by co-authoring of the revised program during 2023-24, and the launch of the revised program in Summer 2024.

Data Collection and Analysis

For this manuscript, we focused on the data from the two-day in-person co-design session in Summer 2023. We audio recorded interactions both days at each group's table, took pictures to capture the process such as feedback teachers left for each other during gallery walks, and gathered teacher-generated products such as revised unit descriptions, overview charts, and unit and lesson templates for lesson authoring. Inspired from interaction analysis (Jordan & Henderson, 1995), we analyzed multimodal transcripts for understanding teacher agency, i.e., how teachers demonstrated agency as they reimagined the program. Teacher interviews before and after the year-long brainstorming sessions, in addition to previously conducted analysis (anon., XXXX, YYYY, ZZZZ), provided required background information to contextualize teachers' utterances in terms of their professional contexts and identities. As an effort towards achieving validity, we shared our interpretations from the analysis with the teachers and provided opportunities to surface any discrepancies or disagreements on an ongoing basis (Small & Calarco, 2022).

Drawing from the traditions of sociocultural theories and interaction analysis (Danish & Gresalfi, 2018; Jordan & Henderson, 1995) and in line with the sociocultural ways of viewing co-design work (Bang & Vossoughi, 2016), we viewed teacher co-designers as active agents within the ICS community and focused on the collaborative process in context as the unit of analysis to understand collective agency of teachers as they engaged as co-designers (Engerström, 2011). We gathered all the teacher-

generated products on a slide deck, with revisions highlighted, that were weaved into the iterative analysis of transcripts (see Tables 4 and 5 for examples).

We iteratively and inductively qualitatively analyzed the transcripts from audio recordings (Creswell & Creswell, 2017) while triangulating with other teacher-generated products in three phases: During the first phase, the first and the second authors independently read the session transcripts, one group at a time (~50 pages each group), commented the transcript with their thoughts, summarized their observations, and discussed them during weekly meetings to better understand teacher interactions that had led to the revisions, particularly paying attention to how teachers demonstrated agency as they challenged contradictions within their experiences with the program and envisioned newer forms of activities, as visible in the revised parts of the curricular material (Severance et al., 2016; see Table 3 for summaries of example episodes). During the second phase, the researchers consolidated notes from all four pairs to identify common patterns and generate themes (Creswell & Creswell, 2017). Two key themes emerged: teachers demonstrated agency by questioning (1.) the purpose and (2.) the approach, across the curricular program, units, lessons, and activities. The researchers reviewed all the episodes across the notes until no more distinct themes were emerging. Throughout, we relied on the longitudinal relationships that the second and third authors shared with the teachers to better understand teachers' utterances in context and develop accounts with palpable details–foundational for deep, qualitative work (Small & Calarco, 2022). During the third and final phase, the themes were shared with the third author and the co-design teachers during a subsequent whole group online meeting. The meeting room was open for teachers to bring in their perspectives and comment on them. All teachers agreed with the key themes, which not only validated and further deepened the analysis, but also enabled the analysis to inform

the ongoing curricular writing work by elevating the new directions and questions teachers had surfaced during the process. In the meetings that followed, we all adopted the "why" and "how" themes to continue to stay aligned with the redesign goals as we co-authored lessons and activities. Constant on-going engagement with teachers helped us follow-up with them during our analysis (Small & Calarco, 2022) and let that inform our current work of co-authoring curricular lessons and preparing for the teacher PD for the academic year 2024-25.

Findings

Teachers demonstrated collective agency as they questioned the purpose, "the why," of different aspects of the curricular program and interrogated the approach, "how" one can get there pedagogically in the curriculum. This required teachers to recognize and question contradictions within the program, envision newer forms of activities and model them within the curriculum, refine and reflect on it, and iterate this process until it consolidated steps towards new forms of practice in the form of revised tools for co-authoring the program (Engerström & Sannino, 2010). Teachers' shared vision towards supporting equitable CS learning, mostly emerging from their practice and prior preparation as ICS teacher-facilitators, guided these negotiations. While Table 3 provides the sub-themes and themes with examples, below we elaborate on specific exemplary episodes from the sessions to highlight how, in interaction, teachers demonstrated agency as co-designers as they not only revised aspects of the curricular program to transform their current routines but also to advocate for and strengthen their commitment to equitable pedagogical approaches.

Why are we teaching this: Questioning the purpose

Although the co-design teachers were teaching the program for at least five years and

some over ten years (see teaching experience column in Table 1), they took the opportunity of co-designing to question the purpose of different parts of the curriculum: from the overall unit to individual lessons and activities within the unit. Throughout, teachers drew from their practice and iteratively revisited the need for the program to be accessible for learners new to CS while providing them authentic opportunities to explore the connections between their cultural identities, communities, and computing. Teachers asked the "why" question as they reviewed the role of different units within the curriculum, revised the unit descriptions to center justice-related issues, and envisioned lesson revisions or new lessons to realize the new goals (see Table 3 for brief descriptions of specific episodes). Below we present two examples by providing a summary of the episode and further theorizing it to illuminate teachers' collective agency. Detailed transcripts accompanying each of the episodes are available for further reference (Tables 4 and 5) in the Appendix.

"When we talk about the [Web Design] unit"

Teachers and Gina, in interaction, distilled the "why" or the purpose of one of the curricular units. The two-day session began with a whole group discussion about the "future of the Web Design unit" (the third unit in the previous version of the curriculum as seen in Figure 1; see Table 4 for the episode transcript). Gina facilitated the session. She presented the brainstormed ideas from the year-long co-design session for the Web design unit (see at the top of Table 4), consisting of ideas to use website design as an opportunity to explore justice-related themes—although the original unit had lessons dedicated to learning to programmatically make webpages using HTML and CSS. Gina presented the mismatch as a contradiction and reminded teachers of the lack of time to attend to key emerging ideas such as data and Artificial Intelligence that they had

shared about earlier. She invited the teachers to reflect on the role of the unit within the program offering in light of these contradictions.

Drawing from experiences in schools and classrooms, teachers initially recollected the contributions of the unit broadly for sustaining the CS education ecology in their local contexts. For instance, veteran teacher-facilitator Floresa mentioned how "Web Design is one of the things you placed the weight on" when "selling" the program to school administrators. Along similar lines, Don, yet another senior teacher-facilitator shared that Web Design is "the first time that students had the opportunity to tell the computer to do something," which garnered significant support from his colleagues in the room. However, other teacher-facilitators in the room demonstrated agency as they surfaced tensions and proposed solutions. While agreeing to all the points raised, John, a novice teacher-facilitator subtly suggested finding a middle ground where important parts of the unit can be placed in other parts of the program while letting off the unit to make room for other emergent, central concepts in CS such as data and AI. Agreeing to Don's point about supporting teachers and students new to CS, John identified the crucial role the unit plays in "building self-esteem" and also alluded to potential ideas for revision "where you can like split things in between and dial things in so that your intent is better." Jennifer and Kerri, also novice teacher-facilitators, built on John's idea from their experiences and led the room to reflect on the lack of authenticity in terms of how tools around web design have changed since the curricular unit was first envisioned. At the end, teachers collectively distilled the key ideas of the Web Design unit—-enabling students to do CS and experiencing the design process—and decided to make place for it in other parts of the program.

Changing landscape within CS in the last decade required teachers to move away from a dedicated Web Design unit and instead make space for data practices and AI-related ideas within the program. However, such a shift within the curriculum had to be negotiated, especially since the current Web Design unit had already established teaching practices around it within the ICS community of teachers. Gina, through her facilitation, created the co-design space to be one where teacher-facilitators within the group such as John, Jennifer, and Kerri, could discuss issues from practice and arrive at a collective consensus while negotiating possible new activities with experienced teachers such as Floresa and Don. Teachers' wisdom from teaching the program and facilitating PDs was called to action as they were invited to candidly reflect on their experiences teaching the Web Design unit–an active way of creating a floor where teachers' and the designers' perspectives were equally valued, which enabled them to draw from their experiences teaching within classrooms and facilitating PDs. However, presenting the teachers with contradictions from practice, i.e., lack of time to bring in additional but important CS ideas and evolving tooling around web design in the last decade, stemming from Gina's observations within PDs for over a decade and recent teacher interviews, led teachers to consider the benefits of the unit in relation to what the unit actually means to their students. For instance, John highlighted how the unit was his students' "first time that they're like, 'Oh well, I'm a coder, I'm actually working with computers'" just as Kerri juxtaposed it with an equally pressing need to "prepare our kids for the pathways" that lead to students understanding of the roles of Data Analyst and Data Specialist. The group discussed their observations about the changing landscape of tools available for web design and distilled the key ideas of the Web Design unit while dissolving the overall unit itself in the program, significantly breaking away from their current routine in teaching the program. As visible in the transcript,

teachers, in interaction–built on the initial proposal of John, Jennifer, Kerri, and Floresa–imagined accommodating the new ways in which Web Design can be discussed within ICS classrooms to make room for the more recent conversations around data and AI within the unit. As Floresa summarized, "the design process [and the] feeling like you're a computer scientist, I think those are the things that we just have to make sure that we keep in whatever it is that we're going to do." The new solution implied dropping the Web Design unit in the revised version and instead integrating opportunities for students to experience web design processes in other units of the program.

"How do we emphasize [the sociocultural connections] in the description?"

Yet another way teachers asked the "why" question and further pushed the envelope while redesigning was by re-articulating the unit description—an introductory text that sets the vision for the rest of the unit and informs the lessons and the activities within them. Max, Kerri, and Taylor revised the Human-Computer Interaction unit description to "elevate [computers' and computing's] connections among social and economic contexts" (see Table 5 for the transcript and revised unit description). The revised unit descriptions served as "boundary objects" (Engerström & Sannino, 2010) that captured the new objectives envisioned by the co-design group and helped shape new activities for classrooms in the form of lessons and activities.

The Human-Computer Interaction unit is the very first unit in the year-long ICS program that will significantly shape classroom conversations and culture around understanding the role of computing. And yet, the unit description in the previous version of the program was limited in surfacing critical perspectives about computing as it described the role of computing in neutral ways, as supporting students to gain "an

appreciation for the many ways in which computer-enabled innovations have had an impact on society, as well as the many fields in which they are used." During the co-design session, the group negotiated how these connections between computing and social and economic context, initially only presented at the end of the description, "deserve their own [sic] more clearer sentences." As seen in the interaction between Max, Taylor, and Kerri, they considered the original description in relation to their goal of highlighting the historical, social, and cultural connections, and collaboratively arrived at a revised description by gathering feedback from the larger co-design group during the gallery walk, and revising the text to accentuate these connections. The group, after elaborate negotiation, left questions for the broader teacher group to respond to before revising the unit flow. Based on further questions received from the group, Taylor and Kerri decided to revise the sentences to move away from "talking [only] about positive" aspects of computing and instead present a balanced view of computing and its societal impact.

Unlike the normative ways of engaging with computing as devoid of any connections with people, culture, and societies, teachers here envisioned new forms of activities at the intersection of CS and justice movements as they identified the skewed narrative in the Human-Computer Interaction unit in the previous version of the program. And the unit descriptions served as boundary objects that helped teacher co-designers to imagine new activities within CS classrooms beyond the normative confines. The new lessons and activities that speak to the intersections between computing, people, communities, and societies that emerged in the revised unit started with Max, Taylor, and Kerri revising the unit description during the in-person co-design meeting. Max and Taylor noticed the need to forefront these connections in the unit description and they sought to open this discussion for the larger group by asking the

question, “How do we emphasize [the sociocultural] connections in the unit description?” to other co-design teachers to respond to during the Gallery walk and gather views from the rest of the community. A gallery walk provided a space for teachers to informally review each other’s redesign processes in the making and add their perspectives. All the three authors and the teachers participated jointly as everyone in the room went around with sticky notes to leave comments on others’ work, opening the room for equitable participation and organic surfacing of joint concerns of practice. In this case, teachers outside the small group elevated the need to include justice-related issues within the unit by asking questions such as “What about the impact of AI on societies? Algorithmic bias?” These questions further propelled Kerri and Taylor to review the unit description, this time with a critical lens and include perspectives from all the teachers in the room. Taylor, reading out the text, identified how the current language made “it sounds like it's only talking about *positive*” implications of technology on societies. Kerri and Taylor instead decided to revise the language to emphasize how “computer enabled innovations have had both a positive and negative impact on society” and highlight concerns of bias and justice. While Taylor revised the description text to reflect this discussion, the introductory text represented the emerging ideas, serving as a boundary object for teachers to reimagine the unit, and shaped the group’s future work. This was evident in how the group later included new lessons and revised a few old lessons to provide opportunities for students to examine computing and its implications on ecological justice and individuals from marginalized communities. Overall, with the revision of unit description, teachers collectively reoriented the unit to tighten connections between computing, people, communities, and societies.

How do we teach this: Negotiating the pedagogical approach

Teachers not only oriented the units to serve expansive roles and embody revised vision for the program, but they also discussed pedagogical practices that help realize the ideas embedded in the lessons and activities, getting to "how we teach" towards the said goals. Debates and discussions related to teaching practice surfaced when teachers revised the unit and the lesson templates that would serve as tools that will continue to animate shared ideas and enable future lesson authoring by including details that are of significance to support equitable teaching practices. Further, they constantly negotiated how their curricular revisions would still allow for inquiry-driven pedagogy that teachers identified as an important aspect of their teaching practice within ICS.

"*I don't want to modify, I only want to accommodate*"

Lesson templates are key tools that shape future lesson authoring by signaling aspects of the lesson that are important for teachers to attend to. These templates guide lesson-writing for the entire redesign project and serve as tools that capture the shared vision for the revised program. Teachers grappled with the historical challenge in CS classrooms of inequitable participation, where students with preparatory privileges excel in CS classes which create exclusionary environments for students from marginalized backgrounds (Margolis et al., 2017). As teachers discussed the pedagogical strategies that they describe in the curriculum, they constantly grappled with practices that may further inequity within classrooms and called for changes in the curricular structures to address them.

During this episode (see Table 6 for transcript), teachers discussed their suggestions for revising the lesson template in order to highlight parts of the lessons that

they thought were significant to their practice while teaching a justice-oriented CS program. Their suggestions included ideas such as providing teachers a space within the lesson to reflect on their experience teaching it, highlighting key ideas and concepts within the lesson along with connections across units, and most contentiously having a section for "differentiated instruction" to attend to different student needs in a class.

Kerri, Taylor, and Max, in their small group, had discussed the need for a section called "extensions and enhancements," as a way to "have teaching and learning strategies, if we're wanting to add another extension" (Taylor). Teachers saw this as a place within every lesson to provide scaffolds for students "who are going ahead" in the lesson (Kerri) by "giving them something slightly different" (Taylor). This was similar to what Libbyada and Don discussed in their group as "modifications" to accommodate for how "everybody's not going to learn at the same level." However, as the group suggested addition of this section among the whole group, Floresa and Maria, two veteran female teacher-facilitators teaching in schools with majority Black students immediately questioned the whole group about the role of "extensions and enhancements" section by surfacing its potential to inadvertently further inequities within CS classrooms.

Maria started to push back at the suggestions by pointing at the frustration at words such as "modification and accommodation, and which should be used and debates on like legally could-be-used." Floresa, building on this, framed the tension as a question for the group by asking: "Are you changing that objective for certain students? Or are you changing the way in which you present that activity for certain students?" This push back garnered attention and support from many others in the room while Libbyada responded to the friendly nudge with an agreement. Just as Floresa

highlighted "*I don't want to modify, I only want to accommodate,*" Libbyada exclaimed "Accommodate!" At the end, Extensions and Enhancements no longer was included in the lesson template that guided co-authoring of lessons. Overall, teachers surfaced tensions within teaching practices that can potentially perpetuate stereotypes and biases about who can succeed or who cannot. They, in questioning their colleagues and holding them accountable for clarifications, pushed boundaries to center equitable teaching practices. Further, their commitment informed designing of tools such as lesson templates that continued to shape curricular materials and suggested teaching practices. While teachers were intentional about elevating justice connections, they wanted to ensure that the revised curriculum would continue to support equitable teaching practices.

Computer science classrooms have been notorious in reflecting historical inequities across race and gender, in how students from marginalized backgrounds are perceived within these spaces with a deficit mindset (Kapor Center, 2021; Madkins et al., 2021; Margolis et al., 2017). A deeper engagement regarding the role of the proposed "extensions and enhancements" section within the lesson template is evidence of how the teachers' advocacy for equitable teaching practices ensured that these sections are more for accommodating different learner needs as opposed to modifying lessons to match perceived capabilities of students. Teachers, in a collaborative effort to have a template that works for all, re-negotiated the role of this section of the template as they called for collective thinking and planning for the template. In the process, the teachers were shaping the design of future lessons and their orientations, re-mediating the roles with the original program designers. Although the discussion started with Floresa and Maria wanting to "hold all my students to the same standard level," the pair soon started garnering support from other colleagues in the room, Libbyada and Kerri,

that this introductory program should support "every student [was] gonna have somewhere that they can get" (Floresa). The group further agreed that the program "is written that way" and that the revised version of the written program should ensure that it enables teaching practices to "accommodate" all students instead of creating different lessons for perceived high- and low-achieving students. This interaction between teachers led to the new lesson template that embodied this commitment and shaped future practices within the program by orienting lessons and activities to be mindfully accommodative of diverse student needs.

"It's not just lecturing"

Once the teachers revised the lesson template, they further embedded their vision for equitable teaching within CS classrooms in concrete steps for future teacher moves by revising lessons—yet another product that captured the objective of the redesign. Teachers actualized their vision for equitable teaching practices as they designed lessons. During these occasions of envisioning new lessons, on multiple occasions, teachers were noted revising existing lessons to support and further equitable teaching practices. For instance, teachers were constantly mindful of supporting student-driven activities while revising lessons by providing opportunities for students to make meaning and learn as a community.

As seen in one of the episodes when Kerri in the Human-Computer Interaction group proposed a lesson on "what is the internet," (see Table 7), Taylor, Max, and Kerri discussed the pedagogical approach to ensure that the activity would support student agency by enabling them to participate as active meaning-makers in the process. As the group examined the existing unit overview chart, Kerri paused at the "How the Internet works" lesson and asked the small group if they should add another lesson to "teach

about the internet and networks, like the layers and stuff." As Taylor probed for further details about the lesson to "make sure that there's still [a sense of] collaborative community" as learners engage in the lesson, Kerri explained how she teaches about "the application layer and all the way down to the Ethernet layer of how the Hello messages like save." With further push back from Taylor, Kerri further elaborated on the pedagogical practice of "acting it out because it is all student-driven activities. *It's not just lecturing*."

Further, during the gallery walk, John and Floresa from the broader co-design teacher group probed Kerri along similar lines as Floresa asked what the group was hoping students to get out of this lesson, especially if we have to teach "like how we never give the definition for what is a computer" in an earlier lesson within the same unit. Kerri, in providing further details about the Unplugged activity that she facilitated, hinted at Taylor's earlier apprehension about it being a lecture-based lesson while assuring that she is committed to the lesson not being "a lecture." This interaction about student-driven teaching practices led to Kerri explicitly including an Unplugged activity for learners in the revised version of the program where learners collaboratively enact the different layers of the internet and learn about data movement within the network as a community. Similar orientation towards supporting student-driven pedagogy was visible in how another new lesson envisioned as a part of the revised Unit 1, also primarily authored by Kerri, involved collaboratively students working in jigsaw arrangement as they led inquiries about natural mineral life cycle, from extraction to manufacturing, and its connections to computer hardware.

Supporting the development of student agency and identities within the discipline by providing opportunities to experience learning within a community is key

to holding equitable learning spaces within computing (Kapor Center, 2021; Madkins et al., 2021; Ryoo et al., 2016). Pedagogical practices that support student-driven, inquiry-based teaching have been discussed as ways of realizing equitable teaching-learning spaces. In this episode, teachers, both in the small group and as a large group, were holding each other accountable to similar practices as they clarified the pedagogical approach of newly proposed lessons. Kerri constantly has to clarify while her colleagues are nudging her to ensure that the lesson will still be student-driven and inquiry-based, without making the definitions the central aspect of learning within this lesson. In addition, as visible in this episode and across, teachers gently nudged each other, to work towards the shared vision they had for the revised program. Structures such as Gallery walk allowed for such friendly nudges through constructive feedback, without denting the relationships. As a culminating artifact, revised lessons that were workshopped during the co-design sessions served as objects that captured collective vision for equitable teaching practices within the community. Furthermore, the co-design space—with all the opportunities for teachers in question, push boundaries, draw from experiences, imagine new teaching opportunities, and capture the same in shared objects and tools—surfaced further nuances of the relationship between equitable teacher practices and curricular materials within CS classrooms.

Conclusions & Reflections

Overall, teachers demonstrated collective agency as co-designers as they critiqued the existing program in terms of the purpose or towards what ends the content was presented to classrooms and how one needs to teach it, being mindful of equity goals within CS classrooms. Creating products such as unit descriptions and imagining future lessons played a significant role in actualizing and sustaining ideas to transform practice. Such an approach to curricular design was neither top-down nor product-

driven. Just as Bang and Vossoughi (2016) recognized, teachers approached co-design from their practices and wrestled with how to support the needs of other ICS teachers and their students. Co-designing curricular materials with teachers served as a powerful context to explore nuances of teachers' visions for equitable CS education. Revising an existing program requires teachers to critically examine the program and related practices and surface tensions that might otherwise miss one's attention.

The concrete goal of realizing a revised program for the extended community meant that teachers had to build on their critiques, negotiate and arrive at a shared vision, and create products to realize the renewed goals. As visible in the episodes above, the multi-step and extended co-design process, which involved iterative rounds of reimagining the object and expanding it (Engerström & Sannino, 2010) made visible nuances of teachers' perspectives on equitable CS education and the different dimensions to it—attending to both the "what" and the "how" of it. Designing a justice-oriented CS program involves content, pedagogy, and pedagogical approaches. Involving teachers as co-designers helped pay equal attention to this critical aspect of supporting teaching, just as several frameworks call for such attention (e.g., Ko et al., 2022; Madkins et al., 2021). Despite increasing calls for anti-racist classroom practices and pedagogies, these need to be built on as we continue to question the "what" of CS education–the weaving of CS concepts with justice issues should be balanced with equitable pedagogical practices that continue to be inviting and inclusive of students from marginalized communities. While changes in how teachers discuss computing concepts in relation to people and communities may support the participation of students from marginalized identities, ensuring they sustain their participation may require us not to lose focus on equitable teaching practices. The central role these equitable pedagogical practices played in co-design teachers' contribution in this study

emphasizes the need to attend to them in tandem with transforming the discipline.

Further, the co-design experience allows us to reflect on ways of supporting teachers to participate as agentic co-designers of a justice-oriented program. It highlights the critical role of longstanding relationships and politicized trust among teachers (Vakil & de Royston, 2019), the need to design spaces for equitable participation, and creating boundary objects to capture and sustain ideas generated from the co-design work. Critically examining a curricular program and teacher practices requires teachers to be conscious of the different axes of oppression and their manifestations in CS classrooms (e.g., Margolis et al., 2017; Kafai & Proctor, 2021). Interactions among teachers as they revised the program centered around attending to computing's intersections with identities, communities, and society. Further, as they concretely imagined new lessons and student activities, they had to continuously pay attention to keeping their CS classrooms inclusive and transformative. All of the work, in summary, meant that teachers had to enable their colleagues to surface tensions within CS teaching and learning and, at the same time, challenge practices that may potentially perpetuate or amplify exclusionary practices. A safe and brave space for teachers to engage with these tensions required that teachers knew one another, trusted each other to work on contentious issues, and arrived at a consensus with room for mutual respect and opportunities to learn.

Our findings highlighted the relational nature of working with teachers while co-designing curricular materials. The gentle nudges and friendly critiques (they all continue to work with the same partners as they write the lessons) came from teachers knowing each other from previous PD experiences and being a part of the ICS community (see Table 1). The relational space, already there, was further strengthened during the year-long brainstorming session before meeting for this two-day in-person

co-design session. From our previous analysis of teacher interviews, we knew there was a politicized trust among these teachers, stemming from their longitudinal engagement with race- and gender-related conversations within CS education (anon., XXXX). The ICS program provided a common orientation/stance and a robust teacher community, which is visible in the teachers' shared advocacy for equitable teaching practices and an extensive part of their preparation to be teaching ICS and facilitating ICS PDs (anon., XXXX). It supported extended community development among teachers that further supported the co-design process. Our related analysis of post-session interviews and a co-design brainstorming session highlighted how teachers felt personal growth as they reflected on their social and cultural identities in relation to CS teaching (anon., XXXX, YYYY). Furthermore, the continued ongoing work of co-authoring the lessons continues to strengthen the relationships among teachers and between teachers and the authors of this paper. Future work should investigate what this relationality means for teachers' growth and community growth around the justice-oriented introductory CS program.

Furthermore, another significant aspect of designing the co-design space was to have several opportunities embedded for teachers to capture generated ideas in forms that can concretely have implications for community practice. In the context of curricular co-design, revising unit descriptions and lessons provided teachers with specific, tangible ideas to work with and opportunities to re-orient the program and connected teaching practices as they revised these products. These products continued to serve as boundary objects during the rest of the co-design process as teachers revisited and revised these products as they worked on the curricular units. In keeping the ideas alive, the unit description texts and lesson templates spotlighted the key ideas from the co-design work and led to developing new lessons within the program as the

co-design work continued beyond the in-person meeting.

Despite promising findings, our data collection and analysis processes are not without limitations. For one, we audio-recorded the sessions instead of videorecording to be less intrusive and to decenter the research aspect of the work. Video data would have provided more nuances in terms of gestures and teachers' spatial positioning, which would have added another layer to understanding teachers' participation and their agency during the co-design process. Second, only two of us did an in-depth analysis of the data collected, although the process could have benefited from multiple, diverse perspectives earlier in the process. Since we went with a depth-first approach to this analysis, we depended on the familiarity of the context and the extended relationships of the authors with the teacher community to deepen the study, which made it very challenging to involve someone without that background to contribute to the analysis in a reasonable time meaningfully. Third, while this data did not speak to the entire co-design process, our future work will discuss the final revised program, how these teachers continued co-authoring lessons, and what it meant to their agency and empowerment. Fourth, all of the findings presented in this paper were very specific to the study context. The teachers had a shared background of being ICS teachers, going through PDs, and facilitating PDs where CS teaching and learning were always discussed as connected to race and gender disparities. Also, these teacher-facilitators also knew each other, as did the second and the third authors, some of whom date back to a decade. As the teachers shared in earlier interviews, such long-standing relations and shared professional contexts led the group to develop politicized trust (anon., XXXX, YYYY). More work is needed to understand how these findings may relate to a co-design study with a group of teachers who may not have similar shared understanding and relationships.

Realizing a justice-centered CS program requires dealing with many tensions and contradictions as we challenge the normative ways of teaching and learning CS and instead emphasize a vision of teaching towards justice. Designing justice-oriented lessons without centrally involving teachers in the co-design process is a contradiction in itself. Despite all the frameworks proposing transformative CS education, there is a need to more expansively imagine the role of teachers in designing the required curricular materials and teacher support. This trend is despite the theoretical frameworks calling for synergy between curricular products, their aims, and teachers' practices (e.g., Kapor Center, 2021). Involving teachers in the design process brings these contradictions to the fore as they draw extensively from their experience teaching the program across different student groups and potentially facilitating PDs for teachers new to the program. Such partnerships will also illuminate the potential challenges for the adoption of justice-centered CS programs that may emerge within changing political contexts (Santo et al., 2024). As we continue engaging with the co-design teachers, we will study what such participation means for teachers' professional growth and adopting justice-oriented CS programs within their teaching contexts. With the co-design teachers spread across diverse geographical and political contexts across the US (see Table 1), studying classroom implementation of the revised program will shed light on potential modifications and local adaptations teachers may undertake to suit their and their students' needs better.

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Table 1. Co-design teacher details (first nine participated in the in-person two-day co-design session analyzed for this paper).

Teacher name*	Racial & gender identities	ICS teaching experience (years)	ICS facilitating experience (years)	U.S. geographical location	Student racial composition in descending order^
Don	White, male	11	11	Midwest urban	South Asian, Latinx, Black, and White
Floresa	Black, female	11	7	West coast urban	Mostly Black
Maria	Black, female	10	5	Midwest urban	Black, Latinx, White
Taylor	White, female	5	2	Midwest urban	Latinx, Black, White
Libbyada	Black, female	5	1	South rural	Black, Latinx
Kerri	White, female	3	1	East coast suburban	White, Black
Jennifer	White, female	5	0	Midwest urban	All Black
John	White, male	8	0	West coast suburban	Latinx, Black, White, Polynesian
Max	White, trans-male	7	0	West coast urban	White, Latinx, Black, Asian, Native American
Elaine	White, female	11	8	East coast suburban	Mostly White, under 10% marginalized communities
Kristi	White, female	7	6	East coast urban	Latinx, Black, Asian
Tangela	Black, female	5	4	South rural	Black, White, Asian Indian
Taghrid	Middle-eastern, female	5	2	West coast suburban	White, Latinx

* as preferred by the teachers; ^ as described by the teachers

Table 2. Teacher pairs and a group that worked on revising specific ICS units.

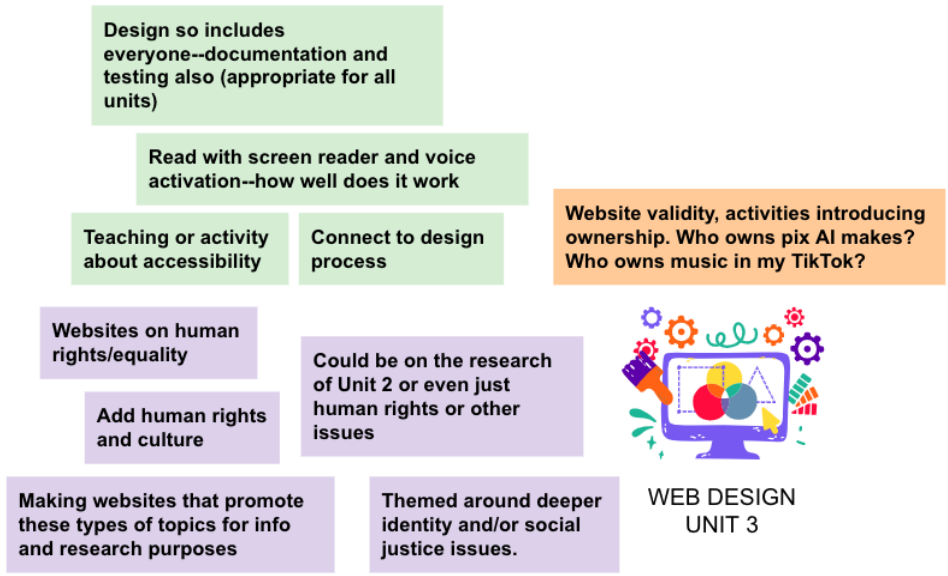
Units	Human-Computer Interaction	Problem-solving	Programming	Data and Computing
Teachers	Kerri, Max, & Taylor	Floresa & John	Maria & Jennifer	Libbyada & Don

Table 3. Emergent themes, sub-themes, and example episode descriptions across different granular levels of the curriculum.

Theme	Sub-themes	Examples
"The Why?:" Questioning the purpose	Unit-level: Interrogating the need/purpose for an existing unit	[1] Discussing the appropriateness of the Web Design unit within the program, given changes in the tools used over the last decade [2] Don and John had a discussion about the role of Problem Solving unit, debating between providing students with an array of "algorithms" versus introducing to the process of Problem Solving and to algorithms as "tools" to solving problems
	Unit-level: Revising unit descriptions to set new goals and orientations	[1] Including justice-oriented themes as potential areas of exploration while students learn within the Data and Computing unit [2] Revising Human-Computer Interaction unit revised to include an emphasis on the "connections among the social, economic, and the cultural contexts, including the impact computing has on social justice and equity"
	Lesson-level: Envisioning new lessons while revising the unit overview charts	[1] Revising existing lessons to infuse justice-oriented conversations, like the computer buying project lesson in Human-Computer Interaction unit revised to engage students about ecological sustainability [2] Introducing new lessons and supporting lessons with themes that provide better contextual scaffolds for learning CS concepts, like the themes around learning programming concepts within the Programming unit or the introduction of a new lesson to investigate the "good and the bad" influences of technology at the end of the Human-Computer Interaction unit
"The How?:" Questioning the approach	Program-level: Negotiating the significance and the role of different aspects of unit and lesson templates	[1] While redesigning the unit and lesson templates, Floresa and Maria pushed back against the role of "enrichments and enhancements" extensions for lessons, the idea of providing enriched opportunities for some while others missing on it, inadvertently creating tiers of

		the curriculum for different student groups based on teachers' perceptions [2] A whole group discussion, triggered by Taylor, Max, and Kerri's suggestion of providing a vocabulary list for lessons to not only support multilingual learners but also to clarify meanings of words specific to CS for novice learners
	Unit-level: Discussing the pedagogical role of a unit within the program	[1] Taylor, Kerri, and Max discussing the role of the Human-Computer Interaction unit as a foundational unit within the program and its implications for how lessons in the unit should support community building within classrooms [2] Floresa and John identifying the need for re-organizing the different lessons within the Problem Solving unit in order to emphasize the "iterative" problem-solving process throughout
	Lesson-level: Advocating for student-driven methods of inquiry within lessons and activities	[1] Maria included several lessons with the Programming unit to engage students to think more closely about "the meanings of their names" and their "cultural" significance [2] Kerri and Taylor discussed a pedagogical approach to a potential lesson on "How does the Internet work?," without making it about knowing the definitions of different layers that make a network work

Table 4. Transcript of the whole group negotiating the placement of the Web design unit within the revised version of the program.



Gina: So, as we looked at this, we said, maybe some of these things could go in other places, maybe we don't need to have this full unit devoted to web design…. What you think would be gained and what you think might be lost if we were to get rid of the web design unit?

[teachers discuss at their tables for ~10 minutes]

Floresa: We are all up in arms over here [everyone laughs] I think, for me, one of the things that now I'm saying is that it's like, when you're talking to administrators, when you're like, selling the course, right, Web Design is one of the things you placed the weight on, but, I mean, we went back and forth [some laughs].

Kerri: We talked about the ability to be creative.

Don: [Just as] You mentioned, one of the things I think—that's the first time that students had the opportunity to tell the computer to do something.

[some "hmm," "that's true," "agree" indicating agreements in the room]

Gina: Okay

Max: Think for me, this, this becomes the thing that when people don't have time for this, I feel like this is when people don't have a full year to teach ICS. Like the people who have a full year, I don't feel that this is a problem. [some agreements in the room] But I'm often in these kinds of tricky scenarios where people are like, well, in my school, I can only do this for a term or a half a year. ["hmm," agreement in the room] So then I feel like the curriculum should just reflect the year. And then if people need to pull something out, then they decide what they pull out. That's just kind of my bigger, bigger picture.

Kerri: Depending on what else is in your school, right, if they offer web design class, you know?

["absolutely," "right," agreement in the room]

Max: So, I pull that out, because I'm only allowed to teach half a year. And I teach a web design class. So, I do like a brief intro. And then I say, we'll come back, and we'll like, dig in.

Gina: [connecting back to the original intention of the program] Well, that's what we recommend if people actually are doing a semester course that's not a block. Yeah, right. And we always have said, units one, two and four.

Maria: [supporting Max's earlier point but slightly pushing back on Gina] It depends on the community, because in Chicago, that web introduces a lot of our students to prepare them for their second class, which is web design.

Don: One of the things that just came to mind, and I'd like some feedback from some thoughts from other people in here. [soliciting feedback as a way to keep the conversation open] And in Chicago, we have a large number of teachers that come from other disciplines. And so I'm wondering like, is this unit the first experience for teachers where they can start to identify as a computer science teacher, because there's syntax and coding so and so does mastering this or teaching it for the first time successfully, like really encourage teachers to start to identify that way, maybe pursue more learning? [Maria, from the same school district agrees] You know, I don't know.

John: Right. I like to add on to that, and that, I see that happening with my students, that that's the first time that they're like, Oh, well, I'm a coder, I'm actually working with computers. And so it builds their self-esteem. So, I know that it's happening in that side. But I like the idea that what you're thinking about with it also for the instructors, especially since we are trying to reach out in different directions. And secondly, it's we always have this as well as or instead of, and there's also this in between where you can like split things in between and dial things in so that your intent is better. You don't have to throw the whole thing out.

Gina: What I'm hearing is that there's some things about the web design unit that are really important. We also heard that there are things about data that are really important and nobody's teaching. [unanimous agreement in the room] there's no AI in the curriculum, and everybody wanted AI in the curriculum. [agreement again]

Kerri: [agreeing with Gina] That is true, though. Like, if you want to be a web design person, you can go to your school and learn it. But these data jobs are like, that's what's in computer science right now. Data analyst, data specialist. Yeah, I mean, I feel like I would like to prepare our kids for that pathway.

Gina: I'm also gonna bring up something that I don't know if you've encountered in your settings, but I've encountered a lot during PD and other places—because there are so many tools now in web design, that a lot of people aren't even teaching the HTML and CSS, which is the thing that makes you feel like you're a computer scientist, right?

[agreement in the room]

Gina: So, I hear you the design part, which I think is really, we all agree is important. And we want to sprinkle that more everywhere. I hear something about being on the computer sooner and designing, right?

[some pause in the room]

Jennifer: Maybe you could integrate it into the other units. So like Don said, this is the first time that they feel like they're coding right? The first time they get to put something into a computer. But we know they can put something into the computer in the [human-computer interaction] unit, when they are learning input and output. So could it be integrated into the other units a little bit so that you'd be like, you're doing computer science the whole time.

Don: I see the opportunity for creativity in Unit Five in the data unit, because there's a lot that can be done with data visualization, and how impactful that can be. And there's a lot of resources and the opportunity for students to get to that higher level of learning my discovery and telling stories based on a variety of different data collections.

Gina: Jennifer mentioned it herself, right. To the notion of sprinkling these things in throughout. Why not data and AI is unit three to get it to creativity, bring some things in early right. Is that palatable?

John: [jumping in instantly] I do that already. I've looked at all the units and it's that data, really a kind of a strand that's going through all of it. And it's kind of being scaffold, I kind of scaffold it...

Kerri: [building on John's idea] When you do human computer interaction, there's a spot to say—this is how some professionals interact with computers. Hey, this is what scientists do, they use simulators, hey, this is what office people do, they use Excel data, like you could put it in that unit, because that's how humans interact with computers. And I love that part.

Gina: And, you know, I mean, going back to my tools issue, right? If they're not actually coding, you can throw in, you know, some Web Design piece using a tool that absolutely they would most more likely use than creating themselves anyway, right?

Don: Could we think of using a web design tool and offering that as another opportunity for a way to students to express their ideas?

Gina: That's what I am suggesting

Don: Creating slides, posters, and now, web page will be..

[Gina called out Flo for being silent and asked to share]

Floresa: I think, what I hear when *we* [emphasized] talk, when we talk about [the Web Design] Unit, when we talk about the design process, when we talk about feeling like you're a computer scientist, I think those are the things that we just have to make sure that we keep in whatever it is that we're going to do. [agreement in the room] Because that is what you know, what I think is what ICS is. And then also, the tools thing is something that we talked about here as well, like, I think sometimes teachers might even or students might not even buy into the unit as much because they feel I can just go here and drop some things and have a website, why would I want to spend the next five weeks of this class?

Table 5. Transcript from the episode where the Human-Computer Interaction unit description was revised to elevate connections between computing, people's identities, cultures, and communities.

UNIT 1 – Description

Original: In this unit students are introduced to the concepts of computer and computing while investigating the major components of computers and the suitability of these components for particular applications. Students will experiment with internet search techniques, explore a variety of websites and web applications and discuss issues of privacy and security. Fundamental notions of Human Computer Interaction (HCI) and ergonomics are introduced. Students will learn that "intelligent" machine behavior is not "magic" but is based on algorithms applied to useful representations of information, including large data sets. Students will learn the characteristics that make certain tasks easy or difficult for computers, and how these differ from those that humans characteristically find easy or difficult. Students will gain an appreciation for the many ways in which computing-enabled innovations have had an impact on society, as well as for the many different fields in which they are used. Connections among social, economic and cultural contexts will be discussed.

Revised (highlighted): In this unit, students are introduced to the concepts of computer and computing while investigating the major components of computers, their origins, and the suitability of these components for particular applications. Students experiment with internet search techniques, explore a variety of websites and web applications, and discuss data and issues of privacy and security. Fundamental notions of Human Computer Interactions (HCI) and sociology are introduced. Students will learn that "intelligent" machine behavior is not "magic" but is based on algorithms applied to useful representations of information, including large data sets. They will learn the characteristics that make certain tasks easy or difficult for computers, and how these differ from those that humans characteristically find easy or difficult. Students will gain a better understanding of the many ways in which computing-enabled innovations impact society and determine if the effects have been more positive or negative. Connections among social, economic, and cultural contexts will be discussed, including the impact computing has on social justice and equity.

Taylor: Okay, the description. [reads out the description as in the previous version of the unit, they briefly discuss different parts of it, comparing what each of them do in their classrooms]

Max: I was thinking about like the, the, the weight of some of these like connections among social economic and cultural contexts are you want to discuss versus like, components and yeah, like what should be elevated to this sort of synopsis of the unit? Where does this talk about like culturally situated? Is that just the last sentence?

Taylor: I think that's just the last sentence and I think it's also

Max: I feel that those deserve their own more clearer sentences.

Taylor: Yeah.

Max: Like, why are we looking at, like, where's the sentence around how historically data has been used to… [thinking]

Taylor: Do you think that's what they were trying to do with that ergonomics or no? Probably not, right?

Max: Well, just thinking about things like algorithmic bias or like some of the things they're going to look at.

Taylor: Yeah.

Max: It's not really clear here.

Taylor: That that could be a question for us was how do we elevate?

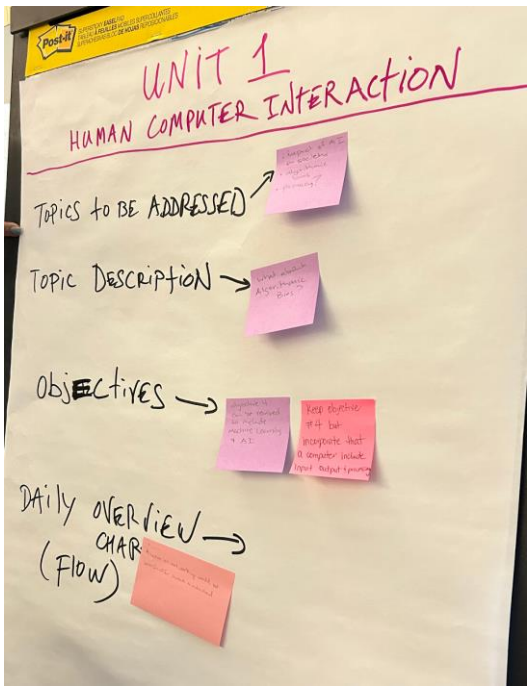
Max: We don't have to have a solution but yeah, this is missing.

Taylor: Our question, yeah.

Max: So, one was the suitability of the components, right, I'm just putting it as a question mark. What is the function of the culturally situated design tools, like motivation? Okay, what are students getting out of that piece, and then maybe a more explicit social justice orientation connection….

[they placed a question "How do we emphasize this in the description?," pointing at the last sentence, for others to respond during the Gallery walk]

[after the Gallery walk, reviewing peer feedback and revising the overview description]



Kerri: [reading from a post-it note] This question says, What about the impact? Isn't that like societal impacts [already in the description]? Or should we put something more specific?... We didn't actually change the paragraph that much [pointing at the unit description]

Taylor: We didn't [change], we just added two questions to it. [pause] So I think the last two sentences could be changed to incorporate some of that. Because it says: [reads out] students will gain an appreciation for the many ways in which computing enabled innovations have had an impact on society, as well as for the many different fields in which they are used. connections among social economic and cultural context will be discussed. So that the phrasing it currently has what's like, well gain an appreciation for the many ways… like that makes it sound like it's only talking about *positive*

Kerri: Maybe we should say something about the word *justice* in there.

Taylor: Yeah, I think we could probably add *justice*

Kerri: Yeah, I hear that [a long pause].

Taylor: because we could do like students will gain an understanding for the many ways in which computer enabled innovations have had both a positive and negative impact on society, including

Kerri: Including *bias* [emphasized], *justice, or*.

Taylor: Should I go and change that part then?

Kerri: Yeah. [Taylor revised the unit description to include the new sentences, as seen above]

Table 6. Transcript for how the role of the "extensions and enhancements" section of the lesson template was negotiated.

Kerri: We talked about scaffolding and like I did, I was working on it from curriculum, and we put things in for like, this wasn't there was a special ed liaison, like helping us. And so there was, we thought we should have a differentiation part of each lesson where you can scaffold it and make it like these are for kids that are going ahead. These are kids that might need help. And everyone understands the word differentiation. So there could be a section on the lesson template for that.

Taylor: We used the word, extensions and enhancements. So if you need to take it a step further, for some kiddos or give them something slightly different, it's kind of already built in a little bit more.

….

Libbyada: Just a thought, Well, we talked about modification… if we needed to modify something like for lower learners, where could we indicate that like, Okay, so the entire lesson is for me, but isn't it. For those that need that modification? Where is there, like everybody's not going to learn at that level. So I need to revise and improvise it, would that be a component?

Maria: The whole thing about the word modification and accommodation, and which should be used and debates on like legally could-be-used, those kinds of words..

Floresa: So that's what I wanted to ask, so, when you were saying modify for lower learn… hmmm. Like, I'm trying to figure out like, if the objective of the lesson is that students can count forward and backward in binary. Are you changing that objective for certain students? Or are you changing the way in which you present that activity for certain students? [agreement in the room]

Floresa: Right, because I don't want us to change the activity, right?

Libbyada: Hmm.. right!

Floresa: Because *I don't want to modify, I only want to accommodate* [emphasis]

Libbyada: Accommodate!

Floresa: But as a teacher, in my mind, they all mean the same thing to me. [agreement in the rool] I'm gonna hold all my students to the same standard level, I'm just making, you know, differences and how they get there. And so that's just I just want us to think about, you know, when we're talking about these lessons, right? We don't, right, it's a very introductory, exploratory curriculum. So, I feel like every student is gonna have somewhere that they can get.

Kerri: Yeah, it's written that way. Yeah.

Floresa: That's what I just us to.. [calling for collective thinking]

Kerri: [reflecting on her classroom practice] Right, maybe we think about it, maybe we don't do a lot of accommodations in this actual [program]. I do less in this class than any other class I teach. Maybe it's already there. Like, the way we wrote it. [a lot of agreement, "right," "yeah," "hmmm" in the room] It's accessible to anyone. You put it down and all four kids can do something [in a group work]. [agreement in the room]

Table 7. Transcript from how Kerri, Max, and Taylor navigated the potential misunderstanding of the pedagogical approach while revising the lesson on "how the internet works."

[in small group discussion]

Kerri: [discussing the individual lessons within the Human-Computer Interaction unit] Do you think we should add? I always teach about the internet and networks, like the layers and stuff. Do you guys ever teach that?

Taylor: What do you mean by layers?

Kerri: Like the application layer and all the way down to the Ethernet layer of how the Hello messages like save, I do like a reenactment of like you send an email to me like what all a part of it goes through to get to me.

[Max and Kerri have a conversation about the lessons they teach to communicate fundamentals of the internet]

Taylor: [raises concern about the potential lecture-based pedagogy] I think and I don't know, because I missed the first part of this. But like, if we go back to the original

purpose, I mean, at mine, it's also supposed to be about, like, community building. So, to tie that.. I don't know. Because I think that was the way it was originally created. Was that like the community building was like, built in. So that would be the only question I have about jumping in like, and I'm not saying like what you're saying is like super technical, but like making sure that there's still like, that collaborative community.

Kerri: You're acting it out because it is all student-driven activities. It's not just lecturing.

Taylor: Okay. The first few [activities] to have like, a lot of like, there's a little bit more like, self choice.

Kerri: What's by self choice?

Taylor: Well, you come up with your own definition, right? And then like, you come up with it as a class and like so it's not so much of like me telling anyone if we look at the hardware, like it's a jigsaw, and then scavenger hunt, it's like how you learned and how you did it. So that would be my only, like, concern is making sure that like however we go about writing that lesson is still taking in like that collaborative stuff.

Kerri: I think it's because I use CS Unplugged activity. there's a networking fun activity. They figure out how like blockages come, but you don't say anything. Just figure it out. Yeah, have like two objects and passing them around so that they get the write up. It's fun. But yeah, don't you mean like, you don't want someone lecturing up there? Yeah, yeah, I don't think it's just like anything like you say a little bit and then they do the rest or they do it first and then you explain it after that. I have that we could just put it in there if everyone else doesn't want it. I mean, that's but like, we're not the only people who do that…

Max: I think it's just fun to have them stand and have a string that they hold

Kerri: I have the addresses along the way. As you can see a network isn't know how that works. They should know.

Max: Is kind of like part of the community, the community thing that we're anyway.

Kerri: She was afraid that we're like, just giving away, but yeah, good thing is it's not like that.

Taylor: Yeah.

[Floresa and John visited the group as a part of structured peer review of the overview chart]

Floresa: [in discussion with John] So I liked that they added that oh, how does the Internet work? That's a big question. Yeah. What are we expecting in unit one?

[they leave a comment on their overview chart asking for clarification]

Taylor: [reading out the comments] Lots of good additions, especially things we talked about during the year. And then one was how does the Internet work is a big question, what is the answer in unit one? Like you're ready to… [everybody laughs]

John: The question what that means that needs to be your prompt needs to be dialed in more. So where are you? So, we understand where you're going with it. Because, you know, it's a big thing. Talking about like, what?

Floresa: You know, like how we never give the definition for what is a computer, And we never really, yeah, definition right? Like, I just think that asked him something like, how does the Internet work? Is being right, and this is unit one if you've never taken this class, and then you're trying to answer that question. That just seems like a lot.

Kerri: There's like a lot of unplugged activities that show internet networks, and they like discover it as they're doing it. But it's not going to be detailed.
Floresa: That's what I am saying, I wonder what are those couple of things..
Kerri: It's very simple, just layers..
Max: I think, in my level, it's computers that are connected when we talk about like, three connections, which is, you know, wire wireless, Bluetooth, and in like, what is it allowed? So it's kind of because we're already taking them into this world, where the reason they can do these things is because computers are Yeah, I mean, it doesn't have to be
Kerri: We have to talk about that one. Because [Taylor] was wary of like, it becoming a lecturing class, right. But I don't do that. And my, but she hasn't taught that in her class. But when I teach it, I don't do a lecture. But yeah, we have we just put that in to see what people thought. So that's not the same thing. Like it can't be too difficult. It can't be like a lecture.

Figure 1. The curricular composition of the ICS program, with six core and two optional units (as taken from the program website).

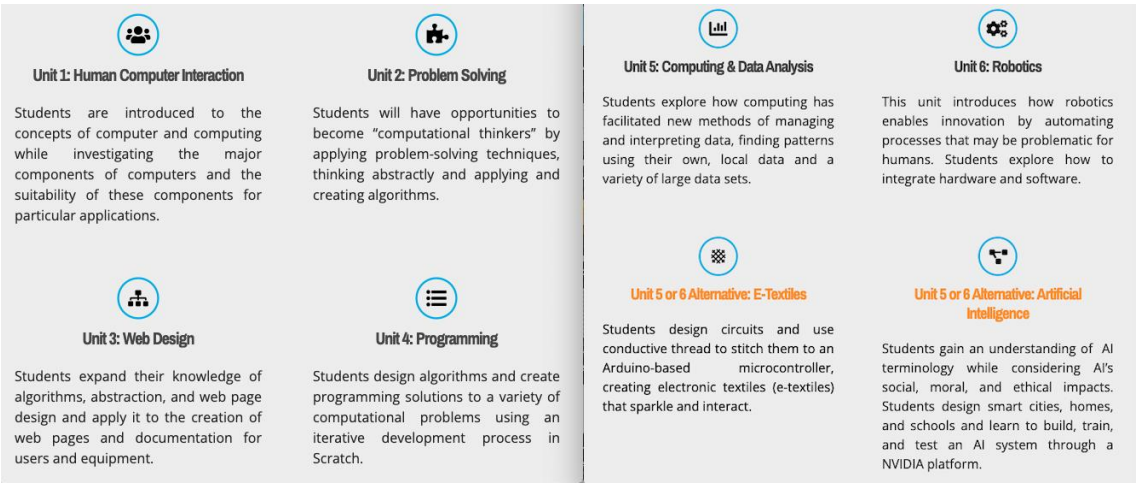


Figure 2. Co-design session series showing a subset of pre-work materials

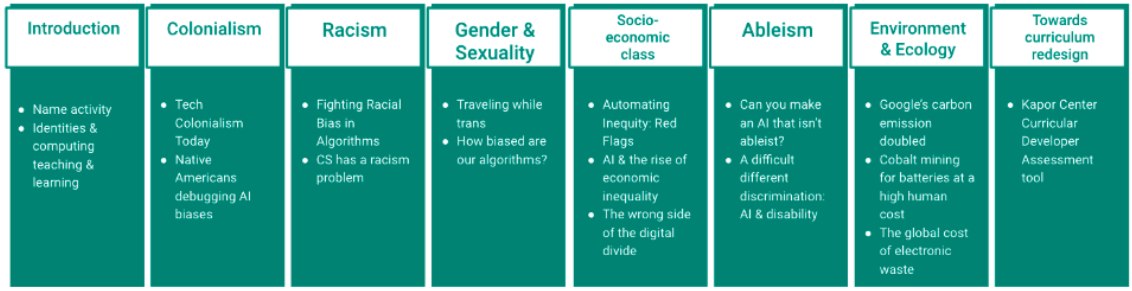


Figure 3. Visual summary of the brainstorm ideas generated at the end of year-long co-design sessions, overarching themes for the entire program (above) and for the data and computing unit (below).

Figure 4. Visualization of the activities during the two-day co-design session.