Queering Computing and Computing Education

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Summary

Technological imaginaries underpinning computing and technoscientific practices and pedagogies are predominantly entrenched in masculine, imperialist, and militaristic ideologies. A critical, intersectional queer and trans phenomenological analysis of computing education can offer an essential epistemological and axiological reimagining by centering the analysis of gender and sexuality through the lens of marginalized people's experiences (queer, trans, and intersecting marginalities). It analyzes how systems of domination and liberation occur through relationships between objects, people, and their environments and how these systems of power multiply in effect when people are situated at multiple axes of oppression (such as gender, sexuality, race, and disability).

Complexity, heterogeneity, and fluidity are at the core of queer and trans imaginaries and are essential for challenging the assumed naturalness of biological categories that underpin much of the cisheteronormative harm and violence in K-16 education, STEM disciplinary practices, and technological innovations. This chapter illustrates how foregrounding complexity, heterogeneity, and fluidity can help us critique, construct and transform computational objects, worlds, and learning environments so that queer and trans perspectives, narratives, and experiences are centered and valued. In doing so, ambiguity, fluidity, and body becoming are centered in virtual spaces, thereby offering emancipatory possibilities for supporting critical literacies of gender and sexuality. From a methodological perspective, this chapter argues for adopting methodological approaches rooted in *active solidarity with* queer and trans people and a commitment to *listening to* intersectional experiences of gender and sexuality-based marginalization and resilience.

Diving deeper into computational worlds and practices, this chapter argues that researchers must pay immediate attention to the area of carceral technologies, including algorithmic bias, from queer and trans intersectional perspectives. This focus of research attention is necessary because computing scholars and educators have identified data science (more broadly) and algorithmic bias (in particular) as an essential domain for furthering education research and practice.

Histories of erasure, exclusion, and violence on queer and trans people, both by technologies and as part of the computing profession, are enacted on individual people and reflected in societal biases that inform and shape public experiences of computing and technologies. Overall, this chapter argues that queering computing education and computing education research requires a deep, critical awareness of a multifaceted problem: the historical and ongoing hegemonic, masculine control over programming; the limitations to representation by code that a computer can recognize; the possibilities to queer code and computer architectures; the technological regulation of identity and bodies; and the limits and affordances of technological representation of gender and sexual identity. It is not enough to teach all kids to code if we are not addressing the societal context of coding, the dominant cultures of the technology workforce they might join, and the everyday disciplining interactions with technology that shape who we can become.

Keywords

Computing; Computing Education; Queer Theory; Gender; Sexuality; Technology; Design; Computer Science; Human-Computer Interaction; Game Studies

Introduction

In this article, my goal is to center queer and trans perspectives as an essential counterpoint to the largely heteronormative body of technoscientific scholarship. I examine historical and ongoing relationships between computing education and *queering*, an act of *reorientation* of computing objects, practices, and disciplinarity away from cisheteropartriarchal hegemonies, particularly in the context of computing in education. I argue that a critical, intersectional queer and trans phenomenological analysis of computing, and computing in education, can offer an essential epistemological and axiological counterpoint to masculinist, militaristic, and intersectionally oppressive, carceral technologies. By centering the analysis of gender and sexuality through the lens of marginalized people's experiences (queer, trans, and intersecting marginalities) and building on the queer, trans, and intersectional theories, the critical phenomenological approach I propose here illustrates how systems of domination, as well as resistance to and liberation from such systems, might occur through relationships between objects, people, and their environments in the context of computing and computing in education.

Recent reviews and critiques have revealed that globally, the focus of technoscientific education research writ large – i.e., STEM education research – have primarily been shaped by U.S. discourses of national security and national economic growth and productivity priorities (Philip & Sengupta, 2020; Takeuchi et al., 2020). These discourses are also intertwined with oppressive ideologies and professional practices in the realm of computing (Philip & Sengupta, 2020). These oppressive ideologies are cisheteropatriarchal, ableist, colonial, imperialist, and racist and are central to the functioning of Western, nationalist militarism and economic growth. In turn, these ideologies position specific forms of experiences and lives as more valuable than others, further perpetuating historical and systemic forms of marginalization (Takeuchi et al., 2020). In a similar vein, while offering a critical and historically grounded review of a necessarily heterogeneous body of the literature that cuts across computer science, queer and trans theories, and queer game studies and beyond, this article also calls for a reorientation of epistemologies and design approaches that underpin technological imaginaries in the realm of computing education away from cisheteropatriarchy and masculinity, and towards an intersectional *queering* of computing education.

I outline a framing of critical queer and trans phenomenology to guide this approach. The goal of a phenomenological account is to foreground *experience* beyond socially pre-determined categories (Merleau-Ponty, 1966). A critical phenomenological approach centers marginalized experiences of oppression, restraint, erasure, and silencing by normative and disciplinary forces (Ahmed, 2006; Bettcher, 2020; Salamon, 2010; Young, 1980). I present challenges and possibilities associated with enacting such reorientation while identifying the need for solidarity with and listening to queer, trans, and intersectional voices. I also identify areas that need immediate attention to challenge the systemic violence and oppression deeply interwoven in technological imaginaries.

Framing Queering within Critical Queer and Trans Phenomenology

Queer and trans theories developed in the 1990s within a milieu of critical responses to women's studies and feminist theories, and epistemological heterogeneity is a key facet of the field. Rather than adhering to a single perspective, construct, or theoretical frame, the fields of queer and trans studies reflect the myriad of ways in which the assumed naturalness of the gender binary, the biological body, and cisheteropatriarchal relationships have shaped our

experiences, institutions, and theories. For example, a proliferation of language exists to describe the assumed naturalness of the gender binary and how it is reinforced through heterosexuality (since the 1980s), including Judith Butler's (2006/1990) heterosexual matrix, Adrienne Rich's (1980) compulsory heterosexuality, Monique Wittig's (1980) heterosexual contract, and Michael Warner's heteronormativity (1991). Trans studies grew in the mid-1990s as a field where trans people theorized their own lives and countered the pathologizing writings about them (Stone, 2006/1991; Stryker, 2006). Transgender studies have challenged gay and lesbian studies and queer theorists on many fronts, notably expanding theories of the body and embodiment (Prosser, 1998; Rubin, 1998; Salamon, 2010), liminality (Bettcher, 2020), and theories of becoming (Lane, 2009). Furthermore, many of the ontological challenges and epistemological expansions that shaped trans, gay, lesbian, and queer studies are grounded in intersectional approaches addressing gender, sexuality, race, ethnicity, and class; however, intersectional approaches have also been marginalized within the field (Anzaldúa, 2009/1991; Combahee River Collective, 2014/1978; Crenshaw, 1990; Davis, 1983; Roen, 2001).

Despite queer theoretical approaches to education being taken up more generally since the mid-1990s in education research (Britzman, 1995; Pinar, 1998; Sumara & Davis, 1999), education research in STEM disciplines has largely been rooted in cisheteropatriarchal perspectives (Fifield and Letts, 2014). This framing is evidenced, for example, in the cisheteronormative and binary representation of bodies and sexuality in K—12 biology textbooks and science classrooms (Bazzul and Sykes, 2011; Snyder and Broadway, 2004). Cisnormativity and heteronormativity, or the combined cisheteronormativity, refers to the assumed naturalness of binary gender, alignment with the gender one is assigned at birth, and heterosexuality, and the implicit or explicit belief that society should be organized by these gender and sexuality norms. Even more broadly, marginalized immigrant students are disciplined and silenced through normative expectations about bodily comportment in mathematics classrooms (Takeuchi and Dadkhahfard, 2019). Queering offers a critical phenomenological resistance to such forms of disciplined erasures and oppressions. Queer theory goes beyond the mere inclusion of different identities to interrogate regimes of normativity in classrooms (Rands, 2009) and can fundamentally question what counts as knowledge and knowing in technoscientific education (Takeuchi and Dadkhahfard, 2019).

The work of reorienting oneself involves an active and continual resistance to the normative forces that impose docility. A phenomenology of reorientation attends to experiences of recognizing normative forces and orienting oneself with counter-hegemonic and non-normative actions and people. For example, Ahmed (2006) explains how "compulsory heterosexuality diminishes the very capacity of bodies to reach what is off the straight line" (Ahmed, 2006, p. 67). Those who go "off the straight line," she says, travel a new path of repeated actions that tend their bodies towards queerness, "often in the face of hostility and discrimination, to gather such tendencies into a sustainable form" (Ahmed, 2006, p. 78). Ahmed (2006) describes disorientation as the "feelings that gather when we lose our sense of who it is that we are" that results from "encountering the world differently" (p. 20). This is aligned with Butler's (2006/1990) notions of the heterosexual matrix and compulsory heterosexuality, which also argue that society's normative expectations marginalize queer and trans bodies, desires, and experiences.

Ahmed (2006) argues for disorientation as a path forward for queer phenomenology because the simple act of queer presence disorients straight paths. However, I

argue that pedagogical approaches in computing education need to be focused on *reorienting* both computing and computing education. Phenomenologically, this involves recognizing and resisting the normative enforcements within disciplinary spaces and enforced through disciplinary expectations and practices that effectively make us "docile" (Foucault, 1995/1975; Takeuchi and Dadkhahfard, 2019; Takeuchi et al., 2020). The work of reorientation should be central to the experience of learning, and following Crenshaw (1990), I further posit that this should not be framed as a political act that relies on identity politics. One's identity as lesbian, gay, transgender, straight, or cisgender should not be the sole basis for pedagogical design. As our work (Paré et al., 2020) shows, systemic forms of oppression that are ubiquitous in our experiences can be illustrated in ways that both embody and connect with peoples' personal experiences, without necessarily making them feel the sense of a loss of self. While one could argue that this is an act of disorienting the discipline of computing, I believe that this is, instead, an act of reorienting normative computing practices (e.g., the use of a well-known algorithm) toward queerness. That is, learning computing is a phenomenological move of continual action that orients the discipline of computing in ways that are aligned with queer and trans notions of liberation and solidarity.

Within the broader field of education research within and across STEM disciplines (including computer science), queer and trans perspectives in computing education have received little, if any, attention. This chapter proposes a critical phenomenological approach for framing computing education research grounded in intersectional queer and trans scholarship. My goal is to center an intersectional analysis of gender and sexuality through the lens of marginalized people's experiences at the heart of computing education. Computing is commonly viewed as a complex practice that involves the design of multi-layered, computational objects and human-computer systems and networks. The critical phenomenological approach to computing that I propose offers an analysis of how systems of domination (Collins, 1990) occur through relationships between (computational) objects, people, and their environments. Additionally, I look at how these systems of power multiply in effect when people are situated intersectionally (Crenshaw, 1990), i.e., at multiple axes of oppression (such as gender, sexuality, race, disability). I also argue that naming, addressing, and ameliorating these forms of oppression and violence can happen through *queering* computing and computing education.

Queering computing education is not merely a matter of adding some missing context to the more technical elements of computing education. Instead, it is a fundamental questioning of the epistemological and axiological assumptions that shape what we take for granted as *authentic* computing education. *The authenticity I seek necessitates a political reorientation of computing and computing education toward intersectional, queer, and trans perspectives in thought and action with marginalized people in the struggle for liberation.* This political reorientation involves unsilencing and acknowledging computing histories of cisheteropatriarchal violence toward queer and trans people and perspectives and examining how queer and trans theories can reimagine computing practices and computing education research as I explain next.

Cisheteropatriarchal Violence and Normativity: A Brief Historical Look at Computing

The history of gender in computing is far from simple, though, especially since cisgender women, queer and trans people have been intricately involved in shaping what we know in the early 21st century as computer science. The earliest

"computers" near the turn of the twentieth century were women, who were employed in positions that involved doing the work of calculating or *computing* (Barkley Fritz, 1996; Hicks, 2017; Shetterly, 2016). Barkley Fritz (1996) and Hicks (2017) show how women's careers as programmers were positioned by their male managers as low-skilled labour, thus under-valuing their contributions. Programming became more prestigious and lucrative as higher-ranking jobs were turned over to men, and eventually, the field of computing became overtly dominated by men, thus solidifying computing within a hegemonic, masculine culture (Chun, 2004; Ensmenger, 2015; Hicks, 2017). Computing's early queer and trans history also reveals the ways that computing was not always a domain held by cisgender, straight men. For example, Alan Turing, an early pioneer of computing, was a gay British mathematician whose work in cryptography was instrumental in WWII and whose insights spurred the emergence of artificial intelligence, computing, and mathematical biology (Voss, 2013). Lynn Conway, a computer scientist, electrical engineering scholar, and transgender activist, made foundational contributions to computer architecture through inventions such as scalable design rules for VLSI chip design (Computer History Museum, 2020).

However, both Turing and Conway faced societal bigotry that impacted their lives and careers. Turing was convicted of Gross Indecency in 1952 for being gay, and the State forced him to take estrogen hormones. He died by suicide in 1954 and was only exonerated posthumously in 2013 (BBC, December 2013). Conway was fired from her job at Xerox PARC in 1968 when she notified Human Resources that she was undergoing gender transition and hoped to do so quietly while maintaining her job (Conway, 2012). IBM delivered a formal apology to Lynn Conway 52 years later (Cramer, November 2020). This history of systemic oppression reminds us that the contributions of gender and sexually marginalized people were not welcomed in the professional worlds of computing. Despite making groundbreaking contributions, they were removed and inflicted with physical or financial violence by the State or their institution. Therefore, the oppression of queer and trans people in computing has not only been discursive or symbolic; it also takes the form of displacement and violence.

Not surprisingly, the current dominant culture of computing has been critiqued as cis-male-dominated and masculinist, arising out of the 1960s and 1970s university computer labs. These labs were necessary gathering spaces to access computers before home computers were available (Ames, 2019; Ensmenger, 2015). These cultural spaces, Ensmenger (2015) argues, were initially criticized as communities of "computer bums" but soon developed computer programming into a hegemonic, masculine culture that further shaped the culture of computer programming long after university computer labs were no longer a central hub of computing innovation:

> The norms, ethos, and practices established in the university computer centers of the 1970s formed the basis for the emergent computer hobbyist culture of the 1980s (and beyond) and would be perpetuated and re-created in similarly masculine spaces, from the bedrooms of pimply teenage computer hackers to the couches and erstwhile dormitories of innumerable Internet start-ups, to the studiously informal work spaces/playgrounds of corporate campuses at Apple, Microsoft, and Google, where free sodas and foosball tables are seen as being as essential to the production of software as product labs and computer workstations. (p. 54)

This early development of masculine programming environments has developed

into the early 21st century "brogrammers" represented by Silicon Valley start-up culture, as well as the massive online hate campaigns directed at women and other marginalized groups who are believed to be encroaching upon "men's space" in computers, technology, and gaming (Hicks, 2013; Salter, 2017). Ames (2019) further notes that the white male programmer's image is deeply ingrained in the imaginations underlying the "One Laptop Per Child" project. Her in-depth observations of how children in Paraguay used the OLPC laptops and software offer striking contrasts with the white male imaginaries. White, masculine imaginaries position coding and computing as primarily individual enterprises, while also employing visions of technological solutionism, and Ames (2019) found that in contrast, the children's lives and their relationships with their communities are more complex and much more meaningful than what OLPC designers imagined, or what even could be accomplished using OLPC devices.

At stake here is what does and should count as authentic forms of computing and coding. As Takeuchi et al. (2020) remind us, authenticity governs pedagogical imaginations and dictums around disciplines and technologies. Critical feminist scholars have pointed out for a long time that most disciplines rest on the notion of a "pure" discourse (Haraway, 1991; Irigaray & Bové, 1987), and pedagogy and public education has become a demand for and enforcement of docility to such discourse, particularly in STEM disciplines (Takeuchi et al., 2020). An example of enforced docility is the conformity to the gender binary even in the context of scholarship on gender in the field of Human-Computer Interaction (HCI). Keyes' (2018) summary of a series of critical reviews (Rode, 2011; Schlesinger et al., 2017) shows that scholarship on gender in HCI literature typically assumes gender is binary, immutable, and physiological. Furthermore, as of 2017, only three papers have been published in the history of the flagship conference (CHI: Conference on Human Factors in Computing Systems) proceedings that include trans users, and none include non-binary users specifically (Keyes, 2018).

The notion of technocentrism (Papert, 1987) is another form of enforced docility, i.e., the fallacy of referring all questions about technology to the technology itself. In the context of computing education, as Sengupta, Dickes & Farris (2021) have pointed out, the "essential crisis of technocentrism" (p. 12) is hiding and folding the heterogeneity of experiences within technological interfaces. Technocentricm and the imposed homogeneity, in turn, creates a device-centered view of coding in the guise of authentic practices – i.e., practices enacted by professionals in complex, real-world settings. Here again, a critical queer, trans, and intersectional phenomenological inquiry offers an important insight that hidden beneath the commonly parlayed notion of authenticity is a cultural and ideological history of masculinity and militarism.

Ensmenger (2015) notes that cultural practices of coding that value competition, mastery, and optimization arose from the hegemonic masculine culture of computing's early days in university computing labs, where "computer bums" were focused on programming "trivial puzzles" and producing code that was "beautiful, elegant, humorous, or otherwise aesthetically appealing" (p. 57). Computer bums, Ensmenger (2015) notes, would spend hours "trimming" the code, trying to make it more efficient and thus, at once, enacting and sustaining a form of masculine competition as "a means of both demonstrating mastery over the machine and establishing dominance within the community hierarchy as a form of masculine competition to impress and gain the envy of male friends in the lab" (p. 57). In this context, it is noteworthy that Chun (2004) traces the ideological history of how notions of mastery, command, and control became embedded in computing cultures to the militaristic past of the U.S.:

> Software languages are based on a series of imperatives that stem from World War II command and control structure. The automation of command and control, which Paul Edwards has identified as a perversion of military traditions of "personal leadership, decentralized battlefield command, and experience-based authority," arguably started with World War II mechanical computation. (p. 33)

This history leads us to the following question: if the epistemological roots of normative and masculinist technoscience are indeed in militarism (Gupta et al., 2019), then what are alternate epistemological spaces that may offer computing more equitable and just imaginaries? How can we challenge normative enforcements of docility to dominant epistemologies? As my critical review of the following section will reveal, one such space is the domain of queer and trans theories.

How Queer and Trans Theories Can Shape Queering Computing

Recent advances in educational computing (e.g., Paré, Shanahan & Sengupta, 2020) have drawn upon foundational constructs proposed by queer theorists such as the heterosexual matrix (Butler, 2006/1990), queer orientations (Ahmed, 2006), as well as Lane's (2009) call for trans and queer studies to engage with a fundamentally more complex, new materialist biology. Butler's (2006/1990) notion of the heterosexual matrix helps us understand how the hegemonic, discursive, epistemic practices enacted in our everyday interactions reify heterosexuality as normative experiences and expectations at the individual, institutional, and societal levels (see also: Risman, 2004). Lane (2009) critiques Butler for emphasizing "the fixity of biological materialities of sex compared with the flexibility of gender" (p. 141). Lane argues that instead of viewing the body as constraining, fixed, and given; we must view the body as a dynamic, transformative process of 'body becoming' (Lane, 2009, p. 141), where social, material, and biological aspects of experience interact with each other fluidly. Ahmed (2006) argues that straightness is not the default or "normal" identity but is also produced relationally through normative orienting gestures that connect people, spaces, and objects, all of which (re)produce cisheteronormativity.

Building on this body of work, Paré et al. (2020) demonstrated how multiagent simulations of gender and sexuality-based marginalization could help us understand gender and sexual experiences as complex, emergent, multilevel phenomena involving dynamic interactions between individuals, groups, and institutions. Paré et al. (2020) present Flocking Q.T. Stories, a multiagent-based simulation that illustrates how structural (macro-level) phenomena such as gender and sexuality-based marginalization and resilience can manifest through individual-level interactions between computational agents. Further, by engaging in conversations with people with lived or professional scholarly experience of gender and sexuality-based marginalization, they found that participants interacted with Flocking Q.T. Stories through orienting (Ahmed, 2006) their attention toward marginalized agents, as well as engaging in reasoning that connected individual behaviors with emergent outcomes.

In Paré et al.'s (2020) simulation, a classic algorithm known as Reynold's (1987) flocking algorithm was integrated with narratives of gender and sexuality-based marginalization and resilience. Their simulation consists of four types of computational agents: normative and non-normative boids or bird-droids (Reynolds, 1987) and two types of institutions: normative and non-normative. Proximity to normative boids and institutions subtracted energy from the non-normative boids, and proximity to other non-normative boids and institutions increased their energy. Each non-normative boid "carries" an audio story - a

first-person account of gender or sexuality-based marginalization and resilience. These stories were recorded by local people who volunteered to contribute a short 2-minute audio narrative of their experiences of gender and sexuality-based marginalization or resilience. All of the boids move according to Reynolds' (1987) flocking algorithm, and parameters of the Reynolds' algorithm are also affected in part by the frequencies of the audio file. The overall effect is that the movement pattern of the non-normative boids is visually distinct from the normative boids while a story is being played, causing the former to vibrate while they are also flocking. The effect also helps create a visual contrast between a flock of non-normative boids moving together with vibrations and a stagnant, non-normative boid because it is drained of energy. This contrast in movement, as Paré et al. (2020) demonstrated, alongside the experience of listening to narratives of marginalization and resilience, helped orient peoples' attention to marginalization in the simulation both at the individual level and at the emergent level.

Another fundamental epistemological perspective is Butler's (2009) account of the *opacity of the self*, referring to the delimitations to representation and recognition of the self. Butler (2009) argues that in giving an account of oneself, "there can be no account of myself that does not, to some extent, conform to norms that govern the humanly recognizable" (p. 36). Rather than conforming to the norms of human recognizability, coding that has productive use in relation to a computer must conform to what that computer infrastructure can recognize. In attempting to represent variations of gender and sexuality in 'real coding,' we should ask whether and to what degree gender and sexuality can be represented in code that is recognizable to a computer. If we code gender and sexuality with only the delimitations of the computer in mind, we risk restricting human agency. However, Butler (2009) suggests that in relation to the self and society's norms, if we can acknowledge the limits of recognizability within the confines of regulating systems, we can recognize the limits of knowing. Recognizing the opacity of the self within the system could open the possibility for a new ethics, she argues, where we no longer expect a definitive answer to the question of how to represent the self. Thus, we might open new spaces for epistemic and representational fluidity that allow the self and the other to live more fully, not reduced or determined by the confines of what can be (canonically) known. For example, Butler's (2009) notion of the *opacity of the self,* as it relates to the social regulation of identity and bodies, can be helpful in deepening our understanding of the technological regulation of identity and bodies, with a fundamental acknowledgment of the limitations of virtual representations of bodies. Butler's notion can be used to question how human bodies, agency, and identity can be represented computationally, identify its inevitable limitations, and question how we could axiologically reorient computing around these limitations and possibilities. A new ethics guided by these questions would recognize the limits of knowing imposed by the technological infrastructure and question a technological infrastructure's role in restricting epistemic and representational fluidity and human agency. An analysis of the socio-technological *opacity of the self* must recognize that the sources of opacity are socio-technically distributed enforcements and constructions that extend beyond the psychological and interpersonal. People are socio-historically situated, which shapes their designs of computer infrastructures and algorithms, an idea I will return to in my section on carceral technologies and algorithmic bias.

These epistemological perspectives fundamentally question objectivity, universalism, masculinity, and cisheteropatriarchy as problematic imaginaries around which computing is situated as a practice. Queering computing, at its core,

involves challenging these technological imaginaries. For example, building on Chun's (2004) analysis of computational performativity, Jackson (2017) looked specifically at computing as a cultural and rhetorical performance of gender that (re)produces structural masculinity in software. Jackson (2017) used examples of queer pseudocode in queer digital art practices by Zach Blas (2008) and Julie Levin Russo (2008), analyzing these through Halberstam's (2011) "queer art of failure," to demonstrate how queer pseudocode resists narratives of computer programming as "determined and correct (masterful) narratives" (Jackson, 2017, p. 16).

With certain types of necessary epistemic reorientation and representational fluidity in mind as queer goals, how would queer coding or a non-masculinist performance of coding look? Jackson (2017) suggests an interesting answer in the form of artistic examples of pseudocode that destabilize masculinist ideals of coding. However, these examples do not operate as real code because their algorithms cannot work with computers. Jackson suggests, however, that this might be the point: "Code or software as illogical seems like a contradiction, but only so when the meaning of a given piece of code is invested in the correctness of an algorithm" (p. 19). Must all coding produce correct algorithms, or could we imagine other uses of coding, be they artistic, critical, social analysis, or part of learning coding, as a vast and creative world with numerous possibilities? Queer pseudocode, I believe, can offer an exciting and playful space for exploring queer and trans imaginaries in computational worlds, and therefore, can offer an interesting area for research in computing education.

Soon and Cox (2020) offer another reorientation of computing through the lens of *aesthetic coding*, which they explain uncovers the hidden layers of coding practices in normative coding representations, such as source code, and highlights the political and aesthetic to bring attention to the social and political effects of programming. Soon and Cox (2020) frame aesthetic coding not in reference to ideas of beauty but to "what presents itself to sense-making experience and bodily perception" (p. 14), suggesting a phenomenological approach. Their approach is also grounded in critical approaches, by drawing attention to and incorporating into introductory programming lessons "power relations that are under-acknowledged, such as inequalities and injustices related to class, gender and sexuality, as well as race and the enduring legacies of colonialism" (Soon and Cox, 2020, p. 14). Soon and Cox's (2020) work offers another way to imagine queering computing in introductory programming where technical coding lessons are interwoven with cultural critiques of power structures.

The field of queer game studies offers critiques of cisheteronormativity as well as imaginaries of possible futures. For example, this body of scholarship highlights how cisheteronormative frameworks discipline gender and sexual identity into narrow, binary forms of representation (e.g., man/woman, masculinity/femininity, and heterosexual attraction) and reifies these in our gaming experiences. A further critique it offers is by illustrating how gender and sexual identities outside of these normative, binary frames can themselves be policed into narrow forms of representation – gay/straight, transgender/cisgender – and the disciplining nature of identity categories, including marginalized identities. Clark (2017) presents this theoretical positioning in Game Studies as the difference between token representation by, for instance, including a single, stereotypical, gay character contrasted with an approach which "questions the norms and conventions of how games, or specific game genres, are expected to function" (p. 4). In the following section, I present a more detailed discussion on some of the challenges and insights from queer game studies for addressing these issues, as they might also be relevant for designing computational learning

environments that orient our attention to queer and trans experiences.

Lessons for Queering Computing from Queer Game Studies

Shaw and Ruberg (2017) argue that queer theories in game studies and game design have the potential to fundamentally shift who is heard in games, how games are interpreted, and how the games industry can be (re)imagined:

> [Queer theories] offer lenses through which to reclaim the medium, giving voices to the experiences of queer player subjects and bringing to light the fact that games are queer (or at least queer able) at their core. Such frameworks have the potential to show those who make games that queerness represents far more than a niche issue or an untapped demographic. (p. xiii)

However, the existing, early 21st-century climate for games has considerable challenges to face to fully realize the potential envisioned by Ruberg and Shaw, along with other Queer Game Studies scholars, queer *gaymers*, and queer game developers. Chang (2015) raises the challenge that faces those who wish to queer gaming that relies on computers, arguing that:

> Given the binary nature of digital computers--from platform to programming--the difficulty of queering games remains a challenge. After all, what is a game but a matrix of code, power relations, and constraints? ... In other words, games always constrain players via normative narratives and mechanics. (p. 8)

Digital gaming is intricately tied in with the challenges noted in earlier sections of this paper, from the embedded masculinity in computational performativity and architecture to the deeply embedded culture of Silicon Valley "brogrammers" and online hate campaigns against marginalized people such as the 2014 #GamerGate hate campaign (Hicks, 2013; Salter, 2017). However, despite the continuing hostility towards marginalized people in mainstream video games and video game culture, the expansion of the independent "queer games scene" since 2012 is "pushing the medium toward greater inclusivity" (Ruberg, 2018, p. 417). This expansion of the queer indie game community, Ruberg (2018) argues, also provides a potential point of entry for critical engagement with "new, expanded directions for thinking about queer and otherwise marginalized perspectives" (p. 418). Through an analysis of the work of contemporary, queer, indie game designers, Ruberg (2018) demonstrates how queer indie games can take up "issues of algorithms, systems, and abstraction and repositions them within distinctly queer frameworks" (p. 418). Further, games' interactivity can be a way to challenge the idea that queer and trans representations must always show life as it is. Instead, it can "allow users to explore alternative ways of being and to purposefully complicate rather than distribute representations of marginalized people's lives" (Ruberg, 2018, p. 426).

Burrill (2017) suggests that another important way to engage with queerness is to study difference and the erasure of bodies of difference, or queer bodies, in digital games. Burrill (2017) notes the emerging interconnectedness of bodies, technology, and gaming explicitly as an essential area of study when highlighting immersive virtual reality games where the body becomes the interface and virtual representations of one's body are limited to "a corporatist, homogenous, objectified, and universal body that fits all systems" (p. 29). Thus, avatars have the potential to become yet another algorithm of oppression by conforming (virtual) bodies.

Virtual bodies, or avatars, have the potential to transform, mediate, and express

complex relationships to the body, as explored by digital media and games scholar and artist Micha Cárdenas. Cárdenas (2010) discusses her mixed-reality performance art in the virtual online world, Second Life, "that questions the one-year requirement of "Real Life Experience" that transgender people must fulfill in order to receive Gender Confirmation Surgery and asks if this could be replaced by one year of "Second Life Experience" to lead to Species Reassignment Surgery" (p. 4). Cárdenas' work shows that discussions of the complex relationships to the body, the virtual body, and gender and sexuality have the potential to be a site of deep learning about identity, representation, and our relationship to technology. Synergistic scholarship is emerging in the field of digital literacy studies; for example, the notion of *digital queer gestures* (Lizárraga & Cortez, 2019) *and humor as political possibility* in LGBTQ+ reaction videos on YouTube (Shrodes, 2020). A digital queer gesture "blends the semiotic affordances of video, audio, and text in the digital realm, [and] is animated, hybridized, and revived across time and space to inspire queer Latinxs to disrupt taken-for-granted normative practices and discourses" (Lizárraga & Cortez, 2019, p. 154). Digital queer gestures can help computational media designers recognize, interpret and incorporate such gestures as interactions between avatars in queer and trans virtual reality (VR) spaces. As Shrodes (2020) explains, "humor as political possibility [in LGBTQ+ reaction videos] expands the focus of critical media literacy beyond media analysis and production and toward the ways in which these literacies show up and matter in the everyday lives of young people" (p. 18). Engaging with the ways that LGBTQ+ young people use humour has the potential to reorient computational design and learning in virtual environments by attending to a queer form of social critique that supports, as Shrodes (2020) suggests, "nam[ing], challeng[ing], and transform[ing] dominant ideologies toward more just futures" (p. 1). Designing for queer humour in virtual environments and interactions and has the potential to combine play and social critique in ways that can support critical literacies of gender and sexuality.

The relationship between virtuality, bodies, and body becoming was further explored by Paré et al. (2019), who explored how VR and 3D sculpting can support the development of critical literacies about gender and sexuality. They presented a retrospective analysis of a design group meeting of a small group of friends in their early thirties with gender nonconforming and queer identities and life histories. The group interacted collaboratively in VR-based environments, where they created 3D sculptures of personally meaningful objects and designed their VR avatars in VR social media. Their analysis highlighted the roles of playful engagement with the *virtual body becoming* (Lane, 2009) and friendship in supporting deep and critical engagement with complex narratives and marginalized experiences of gender and sexuality.

An Important Area for Future Work: Carceral Technologies and Algorithmic Bias

Queering computing and computing education is at once an epistemological and an axiological commitment. In this vein, I propose carceral technologies, including but not limited to algorithmic bias, as an area within computing and computing education that could benefit urgently from a queer, trans, and intersectional focus. Benjamin (2019a) argues that a prominent function of technology is the surveillance of marginalized people, especially Black people in the U.S., premised on the notion that "other people's safety and freedom are predicated on our containment" (Benjamin, 2019a, p. vii). Benjamin's (2019b) *carceral technologies* draws from Browne's (2015) explanation that "surveillance is nothing new to black folks"; from slave ships and slave patrols to airport

security checkpoints and stop-and-frisk policing practices, she points to the "facticity of surveillance in black life" (as quoted in Benjamin, 2019b, p. 23). Benjamin (2019a; 2019b) shows that carceral technologies of surveillance are not accidentally racist. Instead, new technologies reproduce racist and anti-black surveillance and control that were already embedded in society. Surveillance is also not new to queer and trans people. For example, Salamon's (2010) description of trans phenomenology extends Butler's (1993) heterosexual matrix to the intersubjective embodiment of the gendered body:

> "Bodies are always shaped by the social world in which we are inescapably situated. This cultural shaping happens at the conceptual level, in that what we are able to imagine about what our bodies are or may become — even to decide what "counts" as a body and what does not — is structured by the history of how bodies have been socially understood, by what bodies have been." (p. 76-77).

The history of how bodies have been understood and the possibility for queer and transgender embodiments is one of strict surveillance and control, foremost enacted through colonialization, racism, and anti-blackness where White, European ideas about gender and sexuality were imposed on Black, Indigenous, and People of Colour (Driskill et al., 2011; Snorton, 2017), and often through the direct, governing role of colonial education (Coloma, 2006; Cruz, 2001; Ristock et al., 2019). Benjamin (2019a) builds on Mingus' poignant observation of how the "magnificence" of certain bodies—e.g., bodies of queer and trans people, and people of color, for example-- are "coded" societally "not just undesirable and ugly, but un-human," while centering only a White, heterosexist, ableist body as desirable (Mingus, 2011; as quoted in Benjamin, 2019a, p 103). Carceral technologies that specifically target Black people and marginalized people of colour include predictive policing software (Benjamin, 2019a; O'Neil, 2016), algorithmic and AI-based decision support systems for judicial cases (Alkhatib & Bernstein, 2019), pre-trial electronic monitoring systems (Benjamin, 2019a), among others. My concern is that a lack of a critical queer and trans phenomenological focus would enact and further reify technological violences on queer and trans people.

From an epistemological perspective, at stake here is perpetuating forms of knowing and technological design that contribute to or directly enact erasure and violence upon queer and trans people. In an earlier section, I reviewed Jackson's (2017) paper, which demonstrates using pseudocode examples, how we might draw attention to the limits of recognizability of gender and sexuality by computers. This discussion shifts the perspective of coding from an emphasis on producing code that can automate gender and sexuality recognition and surveillance to a much more fundamental critique of computers' limits as a cultural tool. If computers are trained to see bodies in the image of cisgender, White, heterosexual binaries, then the use of such biased datasets underlying facial recognition algorithms automatically position people of colour and non-binary, queer, and trans people to a greater risk of automated surveillance and harassment. For example, "airport security technology, databases, algorithms, risk assessment, and practices are all designed based on the assumption that there are only two genders, and that gender presentation will conform with so-called biological sex" (Costanza-Chock, 2020, p 4), which automatically positions trans and non-binary people "deviant" and "anomalous" (Costello, 2016; Currah & Mulqueen, 2011). This, in turn, increases the possibilities of queer, trans, and non-binary people being physically harassed through the targeted deployment of computational means and beyond.

This critique is not merely an addendum to the "core" technological imaginary of designing and inventing algorithms and abstractions. Instead, I call for a fundamental axiological turn toward justice from *within* the world of computing by recognizing how commonly used computational tools (e.g., search algorithms, face and body recognition software, avatars) and practices may carry forward the societal biases that oppress and harm marginalized people. We must actively improve and fix the relevant computational infrastructure and cultural expectations in ways that are specifically oriented toward queer and trans justice. My call extends and deepens existing critiques of algorithmic bias that have focused on issues at the intersection of race and gender. For example, Noble (2018) brings to light the racist and sexist underlying infrastructure of Google search algorithms, elucidating examples such as how a search for " 'black girls' surfaced 'Black Booty on the Beach' and 'Sugary Black Pussy' to the first page of Google results, out of the trillions of web-indexed pages that Google Search crawls" (p. 162). Along similar lines, Benjamin (2019a) draws attention to the ways that targeted advertising on social media sites might be lauded for its well-meaning goals, but this distracts from the many other ways that it can reproduce racism:

> But there is a slippery slope between effective marketing and efficient racism. The same sort of algorithmic filtering that ushers more ethnically tailored representations into my feed can also redirect real estate ads away from people "like me." This filtering has been used to show higher-paying job ads to men more often than to women, to charge more for standardized test prep courses to people in areas with a high density of Asian residents, and many other forms of coded inequity. (p. 17)

This kind of demographic targeting has the power to shape identities by reinforcing societal ideas of what a Black person, a woman, or a person from a poor neighbourhood should want to have and should aspire to be. It systematically filters people and shapes their lives' possible pathways, even affording more and better opportunities to those with existing privilege.

Left unchallenged, these forms of oppression, exclusion, and marginalization will continue to be the *natural* order of computing, which simply follows and replicates the arc of biases and injustice against marginalized people in society. Therefore, I see *queering* computing as a necessary mode of resistance to challenge "the order of things" (Ahmed, 2006) *within* technological realms and not merely as a critical social commentary that lives outside the inner sanctum of computing and computing education. Queering computing is particularly important because research on gender and sexuality-based algorithmic bias and computationally enacted harms is a less developed area of research. And while researchers in computing and STEM education have already identified algorithmic bias as a critical area for computational and scientific literacy (Philip et al., 2016; Vakil, Marshall, & Ibrahimovic, 2020), the field has yet to recognize gender and sexuality-based harms from critical, intersectional, queer and trans phenomenological perspectives as integral to computing education. But more imminently, such a reorientation is also essential because, as I review next, the dangerous legacy of technological surveillance and violence *specifically* targeted toward queer and trans people stemming from the 1960s (Kinsman, 1995) is still carried forward by artificial intelligence researchers (Wang & Kosinski, 2018).

Wang & Kosinski (2018) designed an algorithm using deep neural networks for analyzing profile pictures of human faces and classify sexual orientation with greater accuracy than humans. Their early pre-print and news coverage received

substantial criticism (BBC News, 2017), which they attempted to address in the final published journal article. However, their theoretical framework, methods, and interpretation of results contain numerous flaws and, as I discuss here, illustrates how cisheteronormativity, racism, and sexism become embedded in computing research, producing flawed and harmful outcomes. I can begin with the premise of the study itself: identifying one's sexuality based on their looks simply perpetuates a kind of carceral surveillance similar to what has been enforced on Black and marginalized people of colour in the U.S. (Benjamin, 2019a). Second, these researchers limited the training dataset of images to white heterosexual or gay people, thus eliminating Black, Indigenous, People of Colour, transgender people, and bisexual and other non-monosexual people. My point here is not that BIPOC queer and trans people needed to be included in the dataset but to point out that the authors' own approach simply reifies the algorithmic bias against people of colour in the context of facial recognition (Buolamwini & Gebru, 2018). Third, the authors explained that there was a risk that the dataset could be inaccurate if people on the dating site inaccurately represented their sexual orientation, but they argue that they could see no reason why people would misrepresent this information on a dating site. This assumption completely misses the numerous social risk factors that shape dating site users' representational choices to mitigate harassment. For example, bisexual people may not identify themselves as bisexual because of biphobia in heterosexual and queer communities. Similarly, women may intentionally misrepresent their sexuality to mitigate online harassment from men seeking women, allowing them to instead initiate contact with men. Fourth, the researchers also employed Amazon Mechanical Turk workers to verify that the gender of the face in the profile picture matched the user's stated gender, thus introducing cisnormative beliefs that gender can be determined by appearance. Finally, the researchers do not account for how the publicness of a dating site, as well as the type of clientele, and whom a site is primarily marketed to pre-determine who might use that site, and how they might represent themselves in terms of gendered, sexuality-based, and racialized beauty standards.

Queering computing and computing education also involves inquiring about the historical arc of violence on queer and trans people, and it helps us recognize that the reification of societal biases in software and computing cultures does not happen overnight. In 1961, the Canadian Security Panel, a special investigative panel authorized by cabinet directive, formally commissioned F.R. Wake to go to the U.S. to research and study detection tests and technologies to identify "homosexuals" in the RCMP and other "sensitive" positions of national defence (Kinsman, 1995). For the next six years, until the eventual abandonment of the project in 1967, Wake researched and developed a technology that came to be called "the fruit machine," which measured pupil dilation and gaze direction while the participant was shown a variety of images, including mildly/bordering pornographic images (Kinsman, 1995). The results from these experiments were used to "identify" individuals who were likely to be gay. Similarly, technologies of classification have also long impacted the lives of transgender people. Hicks (2019) shows how the increasingly computerized methods for tracking, identifying, and defining British citizens through the 1950s provide some of the earliest examples of transphobic algorithmic bias. Fuelled by the British government crackdown on "homosexuality, prostitution, and other 'immoral' acts that had in common their ability to upset traditional gender roles," the new Ministry computer systems were designed to "reif[y] binary gender and strength[en] the fiction of gender as an unchanged and unchanging category" (p. 24-26). The computerization of citizen records removed the small degree of flexibility that British transgender citizens previously had to change

their gender identification records and the citizen benefits afforded to them. Changing gender identification records remains a significant source of difficulty for trans and non-binary individuals at the time of this writing in the early 2020s.

These challenges for transgender people and identification technologies are not limited to citizen records but also include technologies such as automatic gender recognition software. Automatic gender recognition (AGR) uses facial recognition software to identify individuals' gender from photographs or videos algorithmically. Keyes' (2018) review of HCI papers shows that AGR research "fundamentally ignores the existence of transgender people, with dangerous results" and that "taken in conjunction with other work in HCI, this suggests that how gender is commonly operationalised in the field is one cause of HCI's erasure of trans users' needs and experiences" (p. 2). Hamidi, Scheuerman, & Branham (2018) conducted interviews with transgender people to better understand how transgender people feel about AGR technology and how it impacts their lives. The authors found that transgender people were overwhelmingly against AGR software, critiquing its ability to identify such a subjective experience as gender and the privacy concerns and potential harm that could arise from being misgendered by the AGR algorithms (Hamidi, Scheuerman, & Branham, 2018). Given the issues that have already arisen from the introduction of body scanning technology at airport security checks that regularly misgender and 'red flag' transgender people for more invasive and demeaning screening measures, it should be unsurprising that transgender people would be concerned about their privacy and personal safety regarding AGR technologies (Currah & Mulqueen, 2011). It is the lack of attention to critical perspectives, including queer and trans theories and life experiences, that further enables the reproduction of oppressive normativities in research and practice, whether it be cisheteronormative, racist, Eurocentric, colonialist, ableist, speciesist, or other forms of oppressive normativity and domination resulting from an erroneous belief in the neutrality of technology.

Discussion: Queering the Technoscience Imaginary

This chapter calls our attention to the need for challenging the hegemony of political neutrality in computing literacies, particularly from the perspective of the systemic violence and oppression it has enacted on historically marginalized people due to their queer and trans identities. The ideological and epistemological origins of technological imaginaries that have shaped computing and STEM education are far from neutral. Scholars have brought to attention how these imaginaries are entrenched in masculine and militaristic ideologies (Gupta et al., 2019; Haraway, 1991; Philip et al., 2018; Takeuchi et al., 2020) and are reified in practice in computing education in the form of device-centered ideologies of control and competition (Sengupta, Dickes, and Farris, 2021). Here, I argue for a further reorientation of the epistemological and axiological perspectives underlying these imaginaries through centering the work of queer and feminist theorists and queer and trans scholars (e.g., Ahmed, 2006; Butler, 2009; Lane, 2009). I further argue for positioning intersectionality, complexity, heterogeneity, and fluidity as fundamental epistemological commitments that challenge the White, cisheteropatriarchal normativities and hegemonies that predominantly shape databases, algorithms, and computing cultures (Costanza-Chock, 2020). This reorientation must also advance working in solidarity with queer and trans people as an urgent need both within computing and computing education (Paré et al., 2019, 2020).

As Ahmed (2006) noted, queering, or the act of making queer, involves changing

the order of things. My call for *queering* computing and computing education centers queer and trans voices in computing and computing education but also goes beyond and fundamentally transforms the *experience* and possibilities of computing. For example, grounded in queer and trans theoretical imaginaries that value ambiguity, fluidity, and body becoming, virtual reality can offer emancipatory spaces and opportunities for supporting critical literacies of gender and sexuality (Paré et al., 2019), which in turn has the potential to challenge the assumed naturalness of biological categories that underpins much of biology education in K-16 levels. Methodologically and pedagogically, Paré et al. (2019, 2020) also argue for adopting computational design approaches that are based on *active solidarity with* queer and trans people and a commitment to *listening to* experiences of gender and sexuality-based marginalization and resilience. I am also encouraged by similar arguments for methodological and axiological shifts advanced by queer scholars in education research more broadly (McWilliams & Penuel, 2017; Shrodes, 2020; Uttamchandani, 2020).

Throughout the chapter, I have highlighted the histories of erasure, exclusion, and violence on queer and trans people, enacted using technologies and as part of the computing profession. This queer history is an inextricable part of the ideological history and becoming of computing in the early 21st century, and acknowledging this history is essential for the epistemological and axiological reorientation of computing education toward justice. The appropriation of computing toward carceral means that disproportionately targets Black, Indigenous, and People of Colour and queer and trans people is also part of this ongoing history (Benjamin, 2019a; Costanza-Chock, 2020). This is particularly striking given that technologies for categorization and oppression of people marginalized based on gender and sexuality continue to be developed and studied (Keyes, 2018; Kinsman, 1995; Hicks, 2019).

We conclude with the important reminder that queering computing education and computing education research requires viewing computing in light of the historical and ongoing hegemonic, masculine control over programming; the limits to representation possible by code that a computer can recognize; the possibilities to queer code and computer architectures; the technological regulation of identity and bodies and acknowledging the harm on queer, trans and marginalized bodies through carceral technologies; and the limits and affordances of technological representation of gender and sexual identity. Our theories of learning are theories of society (Philip & Sengupta, 2020), and therefore, it is simply not enough to issue calls to study computing education without addressing fundamental biases within computational worlds that enact harm societally. Queering computing education must position and prepare learners to challenge and subvert the dominant cisheteropatriarchial cultures of the technology workforce they might join, and recognize and resist their everyday, disciplining interactions with technology that inevitably limit and shape whom they can become. Given that notions of authenticity shape much of technoscience education (Takeuchi et al., 2020), it then becomes imperative to reimage authentic computing education from queer, trans, and intersectional perspectives rather than reifying violences and oppressions through a continuance of misguided notions of technological neutrality and instrumentalist notions of workforce readiness in computing classrooms. I seek to reorient the fields of computing and computing education research toward these greater, emancipatory imaginations, with a simultaneous commitment to queering our epistemological and axiological positions.

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