Student Leadership, Systems Change: Opportunities and Tensions for Youth Impact on District-Wide Computer Science Initiatives

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Computer Science education (CSed) often aims to position youth as designers, creators, and those with a voice in their world. But do youth have opportunities to design, create, and have voice around the shape of their CSed learning experiences? In this study, we explore ways that school districts engage youth to contribute to the shaping and enactment of their CS instructional systems, efforts districts make to have these leadership roles create impact within these systems, and the tensions associated with these processes. Through in depth analysis of five district case studies, our findings highlight variance around the nature of leadership *roles*, how *access* to leadership roles is structured, student *autonomy* within and *ownership* over leadership roles, how roles *reach* into and index differential *power over instructional systems*, and how district processes of *scaffolding* and *infrastructuring* mediate the ultimate impact that students in these roles are able to have on CS instructional systems. Findings also surfaced ways that district actors dealt with a number of tensions associated with student leadership within CS instructional systems. This study provides educators, administrators, and researchers with an expansive view of the potential for students to play legitimate roles within the context of system-wide instructional efforts around CS, and aims to expand conceptions of 'equitable computer science'—up to this point largely conceived of through the lenses of access to, participation in, and experiences of CS learning—to focus on equity as also being about who has 'a seat at the table' when it comes to CS.

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1 INTRODUCTION

Computer Science education (CSed) often aims to position youth as designers, creators, and those with a voice in their world. But do youth have opportunities to design, create, and have voice around the shape of their CSed learning experiences? In this paper, we explore ways that

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school districts engage youth to contribute to the shaping and enactment of their CS instructional systems, efforts districts make to have these leaders' roles create impact within these systems, and the tensions associated with these processes.

Research on youth leadership opportunities shows how institutional support for youth involvement in change processes can result in a range of positive outcomes for youth [Mitra 2004; Ozer & Doulas 2013], as well as for the organizations and communities they are a part of [Shamrova & Cummings 2017]. Unfortunately, positioning youth into elevated roles in comprehensive education initiatives is often done poorly [Bragg 2007; Fielding 2001; Silva 2003], and can leave youth feeling tokenized and disempowered [Kohfeldt, Chhun, Grace, & Langhout 2011; Mitra 2018]. If youth have legitimate ways to contribute to equity within education efforts, this is less likely, and as such we explore empirical examples of these kinds of contributions and the ways school districts support them.

This study draws on a larger study of eight school districts of varying size, region, and demographics. At the time of writing, each has been implementing district-wide K-12 CSed initiatives for at least two years, providing a robust opportunity to examine the various roles played by students in these efforts. Study data included over 40 interviews across multiple district stakeholders, district public and internal documentation, and collaborative knowledge-building activities involving district faculty. This analysis focuses on five of these eight districts, with data related to these districts being analyzed to develop retrospective case studies that address the following questions: (1) How do school districts create opportunities for student leadership within the context of district-wide computer science instructional systems? (2) Under what conditions and in what ways can these leadership opportunities impact CS instructional systems? (3) What tensions for student leaders exist in these change processes?

Through contrasting analysis of five focal cases, we highlight how variance exists across intersecting factors in the context of student leadership opportunities within district instructional systems around CS. These factors include the nature of the leadership **role** itself, how **access** to leadership roles is structured, student **autonomy** within and **ownership** over leadership roles, how roles **reach** into and index differential **power over instructional systems,** and how district processes of **scaffolding** and **infrastructuring** relate to the ultimate **impact** that students in leadership roles are able to have on CS instructional systems.

Findings also surfaced ways that district actors dealt with a number of tensions associated with student leadership within CS instructional systems, sometimes more successfully, sometimes less so. In particular, we highlight tensions around *gatekeeping (*cases where processes supporting access break down) *set-ups* (cases where role scaffolds and attendant autonomy and ownership break down), and *tokenization* (cases where infrastructuring efforts—incorporation of student contributions into district systems—break down).

The study provides educators, administrators, and researchers with an expansive view of the potential for students to play legitimate roles within the context of system-wide instructional efforts around CS. It suggests possibilities for creating district systems that institutionalize multiple opportunities for these forms of leadership, with potential for the development of leadership pathways. For researchers, it highlights the complex dynamics involved in creating viable ways to bridge student contributions with institutional change processes, and offers an analytic framework that simultaneously speaks to student experiences and organizational dynamics. For the broader field of CS education, the study elevates our conceptions of 'equitable computer science'—up to this point largely conceived of through the lenses of access, participation, and experiences of learning—to focus on *equity* as also being about process, and who has 'a seat at the table' when it comes to CS.

2 BACKGROUND

This research sits at the intersection of three areas of literature: (1) conceptions of equitable computer science education, (2) district policy implementation and systems change in computer science education, and (3) district structuring of student leadership opportunities for impacting system-change processes.

2.1 Conceptions of Equity in Computer Science Education

In the emerging scholarship on CS education, equity has come to encompass a wide and varied set of meanings, each with different assumptions and implications [Santo et al 2019; Sullivan & Gresalfi 2020]. Views of equity that focus on access to learning opportunities are related to but distinct from actual rates of participation by students of different sub-groups within those opportunities, an important distinction given the reality that many populations of students—Black and Latinx students, female students, students from indigenous and rural communities, students with disabilities—have been both historically excluded and presently under-served by computer science efforts at all levels of the education system [Fisher & Margolis, 2003; Margolis 2010]. And these learning opportunities themselves may be conceived of as more or less equitable based on issues of inclusivity and relevance to student identities [Ryoo, Estrada, Tanksley, & Margolis 2019], linguistic [Vogel, Hoadley, Castillo, & Ascenzi-Moreno, 2010] and cultural [Kafai, Searle, Martinez, & Brayboy 2014; Lachney 2017] backgrounds, and abilities [Hansen et al 2016]. Further, the nature and depth of learning goals within those opportunities has equity implications. For instance, there may be equitable access to and participation in CS learning experiences that are inclusive and relevant to student backgrounds, but if these opportunities do not index a wide and deep range of learning goals, inequitable outcomes can still result [Fletcher & Warner 2020]. Finally, it is not only the depth but the nature of learning goals that has implications for equity—directly teaching about issues of inclusivity in computing [Parker & DeLyser 2017] along with the social impacts and potential harms associated with computing innovations and cultures [Ryoo, Tanksley, Estrada, and Margolis 2020; Vakil 2018; Vakil & Higgs 2019] represent further ways that goals of equity may be indexed within CS education.

A variety of frameworks have emerged that speak to these varied conceptions of equity at different levels of analysis. For example, Shah and colleagues [Shah et al. 2013] synthesize four strands of classroom-level research into a micro-level framework that attends to who has access to rich course content, quality instruction, identities as computer scientists, and peer relationships. At what might be conceived as the 'opposite end of the spectrum' from the classroom level of analysis and towards a more macro-level of analysis, Fletcher and Warner [2020] developed the **CAPE** measurement framework—**capacity, access, participation, and experience**—as four constructs related to equitable computer science education that can guide state-level policy actors in their development of data systems that support policy implementation, support, and accountability. In that it operates at the level of state policy, the addition of "capacity" as a construct highlights how inequities in teacher preparation along with district level processes and plans relate to downstream equity effects around student access to, participation in, and experiences with CS learning. In our prior work examining equity as it is conceived of by administrators and teachers in the context of district change initiatives, we have noted similar distinctions but with some finer distinctions appropriate to a meso or organization level of analysis. That framework, which initially motivated the research effort this study draws on, analytically distinguishes between equity in who CS is for (issues of access and participation), how CS is taught (issues of inclusive pedagogies), and what CS is taught (issues of rigor as well as inclusion of learning goals related to equity issues in CS) [Santo et al. 2019].

Notably, these existing frameworks aimed at conceptualizing equitable CS education—including our own—largely leave out questions of youth power when it comes to the determination of what CS learning opportunities look like, how they're enacted, and what goals they advance [see Ryoo et al. 2020 for a notable exception with regards to student determination of CS learning goals]. Essentially, the dimensions of equity outlined above are orthogonal to the question of who has a seat at the table in the decision-making and initiative-implementation process [Santo et al. 2020]. The current study examines how students, when supported in roles that provided them a seat at the table, were able to act in consequential and impactful ways within the context of systems change efforts around CS, expanding current conceptions of what it could mean for CS initiatives to index commitments to equity.

2.2 District Policy Implementation and Systems Change in Computer Science Education

In order to understand possible ways that districts can structure opportunities for students to contribute to district-wide initiatives around CSed, it is first important to conceptualize how districts approach change processes associated with developing such initiatives.

A leading strategy for turning educational policy into district-wide change is to develop coherent instructional systems [Bryk, Sebring, Allensworth, Luppescu, & Easton 2010; Rowan, Miller, & Camburn, 2019; Stein & Coburn 2008]. Coherent instructional systems work to align multiple aspects of a system such as curriculum development, teacher learning, and supplemental supports towards clearly defined and commonly agreed upon goals. In one example, district leaders in Union City, New Jersey prioritized a literacy goal to better serve its Latinx students who spoke English as a second language. Many elements of the system were integrated together including instruction (bilingual education), family engagement (communicating in parents' native languages), professional learning (instructional coaches), and technologies (multimedia supports), and over time the district saw improved academic outcomes for its Latinx students [Kirp 2015].

Instructional coherence is particularly important to address within the context of educational policy initiatives to implement equitable computer science education at a district-wide level for several reasons. First, as a relatively young and dynamic field, computer science is defined in divergent ways—as a set of competencies, as a community of practice, and as a series of fundamental ideas [Proctor, Bigman, & Blikstein 2019]. Research shows that this definitional ambiguity plays out in district committee meetings to determine what counts as computer science education and what is the most equitable way to implement it [Proctor, Bigman, & Blikstein 2019]. Second, as a relatively new curricular area, computer science education can be at odds with other district-wide initiatives and face institutional barriers as a result [Santo, DeLyser, & Ahn, 2020; Santo, Ahn, & DeLyser 2021]. Research shows that deliberate district-wide team-building interventions can create coherence for participating districts [DeLyser, Wright, Wortel-London, & Bora 2020].

Lastly, approaches to achieving coherence often advocate for equitable and participatory decision-making and implementation among district stakeholders [Forman, Stosich, & Bocala 2017], often indexing an orientation towards distributed leadership processes [Spillane 2012], which focus on decentering purely hierarchical decision-making structures and instead acknowledge and support varied forms of contribution from a wide range of actors and roles within the context of systems change work. This raises the question of whether and how students themselves might be part of such processes, and whether they might play some of these roles. Current conceptions of coherence center the student, but solely as the subject of the efforts of the system. And so in regards to district coherence, how might districts support students to take up roles that support the implementation of equitable CSed initiatives? In order to better engage in analysis around

these questions, we consider next the research literature that has focused on youth leadership opportunities in the context of school systems.

2.3 District Structuring of Student Leadership Opportunities for Impacting System-Change Processes

Research on how school district administrators and teachers structure and facilitate opportunities for youth to impact system-wide change processes and initiatives spans multiple bodies of scholarship including research on youth voice [Mitra 2018], youth participatory action research [Anyon, Bender, Kennedy, & Dechants 2018; Shamrova & Cummings 2017], and social design-based experiments [Gutiérrez, Jurow, & Vakil 2020]. Scholarship in these areas reveals that students can directly impact the institutional systems that they are a part of. This includes youth-led roles to contribute to leadership activities [National Research Council, 2012; Kirshner 2008; Kirshner, O'Donoghue, & McLaughlin 2002; Zeldin, Camino, & Mook 2005], curriculum development [Fielding 2001; Rudduck & Flutter 2000], professional learning [Cook-Sather 2006; Donahue, Bowyer, & Rosenberg 2003], and research and evaluation processes [Cohen et al. 2019; Fine, Torre, Burns, & Payne 2007; Ozer et al. 2020].

When youth leadership opportunities are well structured and facilitated, youth can experience a wide variety of positive outcomes [Mitra 2004; Ozer & Douglas 2013], and the processes of change that they impact can directly benefit the organizations and communities they are a part of [Shamrova & Cummings 2017]. Yet, when youth leadership opportunities are poorly structured and facilitated [Bragg 2007; Fielding 2001; Silva 2003] the impact of youth on their district's change processes may be unnecessarily limited and can leave youth feeling tokenized and disempowered [Kohfeldt, Chhun, Grace, & Langhout 2011; Mitra 2018]. Factors that limit youth's impact, even within leadership opportunities, range from personal biases that adults hold about youth's legitimacy as political agents [Su 2010] to institutional infrastructures that compartmentalize and separate youth leadership roles from school district's decision making processes [Ozer & Wright 2012]. Due to the variance of these factors across youth leadership opportunities, the nature of youth's contributions to impact district policy also varies widely [Cohen et al. 2019].

These studies suggest that the existence of youth leadership opportunities within a district is not enough for substantive change and meaningful impact to occur. As such, a closer examination of how youth leadership opportunities are structured and facilitated across school districts is important to tease out concrete examples and advice for how districts can support youth in equitable participation of system-wide change processes. Shamrova and Cummings [2017], in their systematic review of participatory action research involving youth, explicitly call for research studies to be as clear and specific as possible about the nature of the youth leadership opportunities being studied including the exact roles youth play, the distribution of power between youth and adults within these roles, the point at which youth are able to access these roles, the impact youth's actions have on the system, as well as the tensions that emerge along the way.

In the next section, we present a conceptual framework that closely examines the research literature to tease out eight specific relevant dimensions of how youth leadership opportunities are structured and facilitated.

3 CONCEPTUAL FRAMEWORK

For the purpose of this study, we present a conceptual framework that synthesizes across multiple bodies of scholarship on youth leadership opportunities (from Section 2.3) to identify and characterize the specific constructs that constitute how these opportunities are structured and facilitated. From the wide-ranging scholarship on youth leadership opportunities, emphasis was

Table 1. Qualities of Students' Involvement in District Change Processes: Analytic Framework

	Varies by	Example variations
Leadership Roles	The type of activities and responsibilities students are positioned to enact.	Informant; teacher; learning broker; researcher; administrator.
Reach	The breadth of a given leadership opportunity in terms of how it extends into one or more aspects of an instructional system.	Narrow to wide breadth into one or more areas: leadership activities, professional learning, curriculum development, learning opportunities, recruitment.
Access	The type of constraints that limit participation in a leadership opportunity, and which groups of students these constraints disproportionately impact.	Constraints via participant enrollment process, time demands, and participation logistics.
Scaffolds	The nature of support students are given to assist them in adequately enacting their roles.	Apprenticeship, joint work, facilitation [Kirshner 2008].
Autonomy	The degree of freedom students have to determine the nature of their involvement, to initiate activities, and to carry out their leadership roles.	Limited to full autonomy students express over their work.
Ownership	How the structure of a leadership role provides opportunity for personal identification with its activities and understandings of its potential impact.	Unclear to clear recognition of how the work performed matters to the students who perform it or how it ultimately impacts instructional systems.
Power over System	The nature of decision-making power students hold to directly impact a system, and on whose terms those decisions are made.	Limited to full decision-making power exercised on other's terms, negotiated terms, or their own terms.
Infra- structuring	How district staff work to reconfigure the components, relations and routines of their school to respond to, incorporate, amplify and sustain students' contributions.	Enhancing students' platforms and extending their reach; brokering relationships between students and district leaders; embedding students' contributions into district routines.

placed on empirical research that directly contrasted multiple cases along one or more analytic dimensions of how leadership opportunities for students were structured and facilitated, specifically within the context of school-wide or district-wide changes to instructional systems.

Constructs that constitute youth leadership opportunities include: *Leadership Roles* (the types of activities and responsibilities students are positioned with); *Reach* (the aspects of the instructional system students are responsible for impacting); *Access* (the types of constraints that limit students' participation); *Scaffolds* (the types of supports students are given to develop their expertise and competencies to perform their leadership role); *Autonomy* (the extent to which students have freedom in enacting or transforming their leadership role); *Ownership Over Role* (the extent to which students personally identify with the leadership roles they have and can see their work reflected in the change processes of their district); *Power Over System* (the amount of decision-making power that students have); and *Infrastructuring* (the extent to which districts reconfigure their routines, relationships, and resources to better take up and use students contributions to impact systems). Taken together, these constructs form a conceptual framework that can be analytically used to contrast cases of youth leadership opportunities, as well as to tease out the interactional dynamics and emergent tensions within each case (see Table 1 for a summary level version of this conceptual framework).

3.1 Leadership Roles

Through initiatives such as 'Students as Researchers' [Fielding 2001] and 'Students as Evaluators' [Campbell, Edgar, & Halsted 1994] scholars have shown how the roles available to students greatly shapes their voice and leadership opportunities. Fielding [2001], for example, contrasts the role of 'active respondent' whereby a district gathers perspectives from students on district-chosen topics, with the role of 'researcher' whereby a student initiates a research project on a topic of their own choosing and is supported by staff as they gather data, make meaning, and forward recommendations. Yet, this contrast between youth as providing feedback, and youth as conducting research themselves does not fully capture the richness and variety of activities that youth can engage in within district initiatives.

In Mitra's [2007, 2018] account of student leadership roles at Unity of Youth, a community-based response to racial issues at youth's local schools, youth performed a variety of work: they surveyed their peers about pressing school issues, informed their peers of the unjust nature of their state's high school exit exam, applied for funds and lobbied for school improvement, as well as answered phones, scheduled meetings, and developed campaigns. These activities evidence several roles in addition to that of researcher that will become salient in this study's comparative cases: students as teachers, as learning brokers, and administrators.

3.2 Reach

Opportunities for youth voice and leadership also differ by how deeply youth's contributions extend into instructional systems. In a study that systematically tracked every youth leadership opportunity across two high schools, Ozer and Wright [2012] found that the overwhelming majority of youth's contributions were aimed at impacting a single domain—extracurricular school spirit events—that were largely isolated from the rest of their school's instructional systems. This was true for youth leadership opportunities including student government, an advisory group, and student-led clubs.

In contrast, they present two youth participatory action research projects, at these same schools, that extended deeply into their school's instructional systems to transform professional development (faculty join a student-led 'best practices club' to have their teaching observed and improved by students), and recruitment initiatives (students strategize with counselors to diversify recruitment, and host a "welcome reception for admitted 8th graders from underrepresented groups and their parents") [Ozer & Wright 2012, p. 279]. Ozer and Wright [2012] argue that what extended the reach of the youth participatory action research project beyond the more bounded context of afterschool activities was the fact that those projects deliberately promoted youth's strategic understanding of the school's instructional systems with a view towards critiquing and improving them, a phenomenon we touch on further in Section 3.4 on scaffolds.

3.3 Access

The research literature confirms that not all leadership opportunities are readily available to all students. Although some opportunities openly enroll any students who show interest, some opportunities entail a competitive application process [Kirshner 2008]. Further still, some initiatives are only available to students who have been hand-selected by their teachers and district leaders [Silva 2003], which raises questions about whether opportunities are only available for students who are in good standing with their teachers [Voight 2015].

Additionally, the location, schedule, and time commitment of leadership opportunities has ramifications for who can participate. To prevent access to initiatives critical of them, schools have blocked students from meeting on their campuses [Shah & Mediratta 2008], making participation

difficult for students who do not have the time or means to travel off campus regularly. Likewise, initiatives that meet directly after school pose conflicts with students who participate in other after school activities or jobs [Silva 2003]. Finally, the larger the time commitment, the less likely students with competing time demands will be able to fully participate [Silva 2003].

3.4 Scaffolds

The nature of student leadership opportunities is also shaped by how much support and guidance they receive from skilled and encouraging adults. Kirshner [2008] contrasts three youth leadership cases that show three approaches to scaffolding: facilitation, apprenticeship, and joint work. In cases of apprenticeship, adults can use their expertise to coach and train students in various ways: demonstrating skills, making thinking visible, teaching about relevant socio-political contexts, providing constructive feedback to youth, and strategizing with youth on how to overcome challenges [Kirshner 2008]. In cases of joint work, adults can divide up tasks in such a way that youth take on activities that they do not need additional scaffolding for due to their pre-existing skills and knowledge [Kirshner 2008]. This joint work breaks down, however, when youth are given tasks that they do not fully understand without the corresponding scaffolding to be successful [Kirshner 2008]. In cases of facilitation, adult facilitators provide the scaffolding necessary for youth to facilitate youth-led meetings and make decisions about youth-led projects on their own with limited input or assistance from the adults.

3.5 Autonomy

In addition to showing how the nature of scaffolds varies across student leadership opportunities, Kirshner [2008] also distinguishes between the degree of independence students express within various opportunities. In some cases, students have the freedom to lead activities (as measured by how often youth rather than adults initiate and end activities), the ability to determine what kind of work needs to be done, and the latitude for how to carry out this work. In other cases, activities are mostly initiated and ended by adults, youth have less say in choosing the work to be done, and they carry out their tasks in relatively prescribed ways [Kirshner 2008].

3.6 Ownership Over Role

The nature of student leadership opportunities also varies by whether or not students (a) readily see themselves in the leadership opportunities they participate in, and (b) clearly see how their participation ultimately impacts an instructional system. Put differently, do youth work on issues that matter to them, in contexts that are meaningful to them, with outcomes that are transparent to them? In some cases, students strongly identify with their work. In an example from the literature, one youth expresses a deep sense of ownership in the way she describes her work to her friends, "I tell them I am a youth organizer…that I organize like campaigns and I work to make Marshall better for the youth and I tell them about the past campaigns we did" [Kirshner 2008, p. 83].

In other cases, youth show signs of despondency and limit their participation. This has been documented when an inexperienced adult facilitator outright dismisses youth's project ideas [Mitra, Lewis & Sanders 2013], when facilitators rush the student selection process leaving youth with "a sense of disconnection or unfamiliarity with the group members and activities" [Silva 2003, p. 17], and when adults use discourse practices that are unfamiliar with newly initiated students [Kirshner 2008]. In these cases, students find themselves in a world populated by projects, activities, and discourses that do not reflect their own interests, desires, or experiences.

Additionally, the fruits of students' contributions are not always apparent to them. In some cases youth can "point to the clearest, most concrete example in terms of creating an actual change," yet,

in other cases where change is ambiguous or slow-going youth "struggled to see effort translated into meaningful change" [Biddle & Mitra 2015, p. 13].

3.7 Power Over System

Research shows that student leadership opportunities vary in terms of whether or not youth have the ability to change an instructional system, and whether they are able to do so on their own terms, on their district's terms, or on negotiated terms. In two cases mentioned previously, the student-led 'best practices club' and the student-led initiative to diversify student recruitment, students were able to change aspects of the instructional system such as professional development and recruitment practices on their own terms.

In other cases, students follow their district's guidelines to enact change. Ginwright and Cammarota [2007] document a case where a high school student, Rosie, wanted to take AP Physics to bolster her college application, but her school had not offered AP classes in decades. She approached the guidance counselor and was told that if she could find a teacher and 20 students to take the class, then it would be offered. She did so, took AP Physics, and got into her first choice, UC Berkeley. In this case she exercised power over the system. Yet, her power was limited to the guidance counselor's terms—she did not have the power to negotiate with the counselor, nor to pursue a system level change regarding AP classes on her own terms.

Furthermore, students are not always able to change their district's instructional systems, even when following other's guidelines. Cammarota and Romero [2011] followed a group of students as they researched the educational disparities that Mexican immigrant students faced in their district. In order for their district to legally apply to provide a bilingual education program, the district had to demonstrate a clear 'need' for instruction in a language other than English. Despite the formal presentation that students gave to their district's school board that clearly demonstrated the 'need,' the school board opted not to adopt their recommendations, highlighting a case where students were not able to exercise power over the system.

3.8 Infrastructuring

Student leadership opportunities also differ in terms of whether adult facilitators and/or district decision-makers engage in what some scholars refer to as "infrastructuring"—work to "redesign components, relations, and routines of schools" to make the implementation of students' contributions more viable, amplified, and sustained [see Penuel 2019, p. 659 for terminology]. Mitra [2005] chronicled the trajectory of two student voice initiatives that began at the same school at the same time, yet operated largely independently of each other and in different relation to their school's infrastructure.

In one of the initiatives which worked to create a student-led tutoring and translation program, the adult facilitator worked "behind the scenes to gather information on school policies, to jump the program through the hoops necessary in Whitman's bureaucracy, and to organize meetings with teachers to increase support and demand for the program" [Mitra 2005, 537]. This was important work to make sure that students' tutoring and translation assistance program would be viable and well utilized within the system. Yet, the program encountered institutional regulations that limited its viability and sustainability—students were not allowed to tutor without adult supervision, and students were not allowed to provide translation assistance to parents due to the principal's concern over the confidentiality of parents' children's academic matters.

In the other initiative at the same school, students worked with an adult advisor to improve the academic success of ninth graders. The students created a number of initiatives, and their advisor also worked behind the scenes to ensure that the initiatives would be well received by the school—promoting their work at departmental meetings, scheduling a biweekly meeting with the principal

to keep him in the loop, and directly addressing any concerns from teachers or administrators. Through this work, the advisor was able to gain the support of someone influential in the school who further helped to promote the work of her students and to keep her encouraged through the process. The former group disbanded after a year, while the latter group sustained over time.

Another study [Yonezawa & Jones 2009] documents the contrasting responses of principals to students' research projects. One principal amplified students' research findings by routinely bringing their findings to faculty meetings and discussions to prompt reflective professional development activities. Furthermore, the principal helped to sustain students' work by giving them class release time and advice on creating a formalized observation instrument so that they could gather data on another part of the instructional system that mattered to them: advisory program curriculum. The principal fed data they gathered back to the school and used it to change the advisory program. In contrast, another principal responding to a similar student research project struggled to increase the impact of the students' work, partly due to institutional instability including a high turnover of administrative and teaching staff and a high rate of student mobility.

In analyzing a high school reform initiative that spanned five years and included seven urban districts, Joselowsky [2007] identified different infrastructing work that was consequential for student participation in this reform initiative. Relevant features of the infrastructure included: dedicated staff positions to align and connect student's contributions across a district's multiple high schools, policies that mandated student assistance in the development of new schools, regular meetings between representative student bodies and the superintendent, student members on the school board, and professional development for teachers and administrators around youth engagement opportunities.

More recently, Ozer and colleagues [2020], draw on concepts and lessons learned from two fields of research literature—the **use of research evidence (URE)** and **research practice partnerships (RPPs)**—that emphasize the important role that organizations' routines, relationships, and practices play within change processes. Using six illustrative cases of students' involvement as researchers in their school districts' change processes, they argue that youth's research is more likely to lead to change when that research is presented in a contextually relevant, rigorous, and action-oriented way, when the researchers have a positive communication channel with practitioners and policymakers, and when decision-makers are open to learning from and acting on the insights of other stakeholders.

The body of scholarship outlined above makes salient a wide range of features that shape youth leadership opportunities. Additional research reveals the dynamic ways these features interact, often causing tensions that must be delicately navigated by adult facilitators lest opportunities be undermined [Larson & Walker 2010]. Not surprisingly, expert and novice adult facilitators of youth opportunities respond to these tensions in distinctly different ways [Walker & Larson 2012] that directly shape the quality of youth voice and leadership opportunities.

For example, an adult facilitator infrastructured student voice research projects to be developed and sustained over the course of several semesters, yet as new student cohorts were introduced to the pre-existing project they struggled to feel ownership over it [Ozer, Newlan, Douglas and Hubbard 2013]. The facilitator, in this case, responded with several youth-centered solutions that balanced multiple considerations [Ozer et al. 2013]. In another case, however, a novice adult facilitator struggled to balance the appropriate amount of student autonomy and scaffolding as students worked on a project to implement at their school and present at a conference. He chose to give students distance so as not to interfere with their autonomy, but ultimately—without adequate scaffolding and encouragement—students felt unprepared and disengaged from the conference [Ozer et al. 2013].

In addition to tensions emerging from internal dynamics of the structure of the leadership opportunity, conflicts can arise as inequitable power relations of the systems that youth opportunities are embedded in become directly reproduced within the youth opportunities. For example, Silva [2003] found peer-to-peer micro-dynamics within a youth voice "Diversity Project" initiative that privileged certain students (White, female, middle-class) and silenced others (ESL, students of color), reproducing the very inequities of participation within their leadership group that they were attempting to address at the school level. As she puts it, "much of the diversity of the Diversity Project group was lost along the way." [Silva 2003, p. 19]. Taken together, these issues highlight how precarious leadership opportunities for youth are, and the important role that adults must play to adequately support these opportunities.

4 METHODS

Within the context of equitable computer science education initiatives, the current study addresses the following questions: (1) How do school districts create opportunities for student leadership within the context of district-wide computer science instructional systems? (2) Under what conditions and in what ways can these leadership opportunities impact CS instructional systems? (3) What tensions for student leaders exist in these change processes?

These questions were motivated by a desire to provide greater understanding of both the dynamics and approaches that district actors might employ if they are committed to establishing authentic opportunities for student leadership within the context of their district-wide CS instructional systems, and, in doing so, expand their conceptions of 'what counts' as equitable computer science education. In answering these questions, we hope to create a clearer understanding of both the efforts required on the part of district leaders to not only provide avenues of leadership for students, but also ways that this leadership can substantively impact larger systems.

This motivation led us to focus centrally in this study on the activities district actors undertook over time to create and support opportunities for student leadership and evidence of how these opportunities led to shifts and impacts within instructional systems. While in some respects this meant our analytic gaze was more centered on adult activity and actions—a move that could be construed as decentering the perspectives and motivations of youth themselves—we see this focus as meriting robust attention given the complexities of legitimately supporting and taking up youth contributions that might shape institutional activity. Essentially, our focus is on adults and institutional dynamics precisely because they are necessary to understand in order for youth leadership to be anything but marginal.

To analyze the work entailed for districts to enlist students into their processes of change—including the work to provide student opportunities and to ensure that these opportunities indeed lead to change—as well as to analyze the tensions students experience along the way, the current study draws on retrospective case studies identified within a larger study of eight school districts' CS education initiatives. These districts varied across size, region, and demographics, but all shared in common a history of implementing district-wide equitable K-12 CSed initiatives for at least two years. Districts' multi-year engagement with comprehensive change processes around their computer science instructional systems provided a robust array of institutional activities that we could explore to better understand the work performed to involve students within them.

4.1 District Selection and Focal District Descriptions

The current study stems from a larger project facilitated by the authors to both study and support district change efforts related to establishing equitable CS education. Districts were able to apply to participate in a cohort-based initiative by responding to a call for applications circulated

by CSforALL, a national organization based in the United States focused on supporting equitable CS education, both to its member network of school districts as well as to non-member districts. Applications were vetted for the following two selection criteria: (a) diverse representation of district size (small, medium, large), region (urban, suburban, rural), and demographics of students served, (b) evidence that districts were engaged in efforts to implement equitable CSed comprehensively within their district and that they could speak readily about major activities, challenges, and resources that constituted their change process. Eight districts were invited to participate in the study and associated professional learning cohort. Of these eight, we center this manuscript's analysis on five districts based on the nature of the student leadership opportunities present (see 3.3 for case selection rationale). All districts are given pseudonyms to protect confidentiality.

Yorkville School District is a small-to-midsize school district on the East Coast. They began offering AP Computer Science A in 2012 and have since built out a robust course sequence of computer science classes. Over the course of 2018-2020, the district more actively began working to broaden participation among the students who pursued computer science pathways. Yorkville began focusing on building student enrollment and teacher capacity, as well as differentiating curricular offerings in ways that provided multiple entry points for students with no or limited experience to enter the CS pathway.

Barton City Schools is a small-to-midsize district in a Midwestern suburb. Since 2016, they have invested in digital learning opportunities for their students by hiring specialists in digital learning, building makerspaces, and creating college and career pathways. As the demographics of the district shifted away from predominantly white students to include many more East African students, Barton integrated principles of cultural proficiency into its decision-making processes to better ensure that all of their students benefited from their policies.

Danforth School District is a small rural district in the Western US. In 2017, they completed a training to create a district-wide vision for implementing comprehensive CSed. Since then, they have built a makerspace that serves all of their elementary schools, offered afterschool clubs at the elementary and secondary levels, and elective CS classes and a summer coding bootcamp at the secondary level. One of their core equity foci is to bring more young women in their district into computer science courses at the secondary level.

Taylor City Unified School District is a large district in an urban center located in the Midwestern US. Taylor has been engaged in system-wide efforts to establish comprehensive computer science education since 2013, involving a wide range of both local and national partners. Its student body is majority minority, with over one third African American and almost 50% Latinx. Over 80% of its students qualify for free and reduced lunch. To date, it has successfully incorporated CS learning opportunities into almost half of the district's schools.

Due to the sensitive nature of a fifth case, limited descriptive information will be given in order to ensure confidentiality and in accordance with the preferences of the district. In all references to this case we will simply refer to the district as '**nondescript public school district' (NPSD).** We will only note that this district serves a large number of students in an urban setting and, in line with the other districts in the study, had been implementing equitable computer science education initiatives for more than two years at the time of writing.

4.2 Participants and Data

Although nearly every district in the study had examples of students involved in their CSed implementation processes, the current study will focus analysis on five cases (see 4.3 for case selection rationale). The broader study data included 44 interviews with administrators, teachers, coaches, librarians, and other faculty across participating districts. Following semi-structured protocols, these interviews aimed at constructing retrospective accounts of systems change processes

associated with district CS initiatives, including leadership practices, development of professional learning systems, curricular design, and implementation. We solicited accounts of these activities with an explicit eye on both how issues related to equitable CS education were seen and addressed by district actors. The protocol for each district's initial interviews focused on surfacing the particular role that a given participant played within their district CS work, roles that other administrators and faculty played, how the initiative evolved over time, the ways that equity was conceptualized and addressed in the initiative, the role of data collection and associated district systems, and, central to this analysis, how power, decision-making, and implementation were structured across stakeholders including teachers, families, and students. Subsequent interviews within a given district intentionally customized the interview protocol to delve further into particular dynamics, incidents, and phenomena associated with each district's CS initiatives.

Interviews were triangulated with additional data sources including 130 internal district planning and implementation documents. These data sources were solicited from district actors based on activities they shared about in the context of interviews. Additionally, video recordings were taken of six 90-minute virtual monthly meetings in which representatives from each district met as a professional learning community to share and build knowledge together [Santo et al. 2017]. Based on this range of qualitative data sources, the authors constructed district timelines that elucidated major CS implementation activities over time as they related to in-school and afterschool learning opportunities, curricular systems, student recruitment systems, professional development systems, and leadership activities.

Data pertaining to our five focal cases includes 11 interviews across 12 participants.[1] Each case presented is based on data gathering with interviews with the adult(s) who worked most closely with students in their leadership roles, as well as additional data points including either interviews with other adults familiar with students' roles, or detailed internal district documentation of the student opportunity. Member checking was conducted for each of the five cases, through e-mail or interviews, to ensure accuracy as well as to gain additional clarifications and elaborations of each case.

One issue that is important to note in terms of the participants, and resulting data sources, is that this study was unable to directly interview students that participated in the cases we document. We discuss this issue further in the limitations (Section 7), but this constraint partly drove our decision to focus our inquiry centrally on both the activities that district actors undertook to support student leadership roles and the impacts of student leadership on the instructional system itself, rather than a focus on the learning and development of the student leaders within the context of these opportunities.

4.3 Analytic Process

In the first phase of our analytic process, we identified the phenomenon of interest—student leadership opportunities in district-wide change processes—based on an equity in process orientation that stemmed from previous research [Santo et al 2020]. A first line of analysis identified the various roles that students were playing in their districts' change processes. Across 12 documented instances of student involvement in their districts' equitable computer science education change processes interviewees spoke of in beyond anecdotal ways, we identified five types of roles: informants, teachers, learning brokers, researchers, and administrators. These roles align with the kind of work students perform in youth leadership opportunities that has been documented in the research literature.

[1]One of these interviews was with two participants simultaneously, resulting in the total number of interviewees being greater than the total number of interviews.

Although these roles productively revealed to us the type of work that students performed in their districts' change processes, it did little to inform us of the work that district staff performed to support students in these roles, and, ultimately, it did little to explain the variance in impact on an instructional system. To make the work of the district salient, we began a second phase of analysis.

In the second phase of our analytic process, we used the constant comparative method [Glaser 1965] to identify contrasts between cases. Through this process we developed an analytic framework of salient categories that acted as variables that shaped students' leadership opportunities (see Table 1). Each category is well-grounded in the research literature on youth leadership opportunities in the specific context of changing school- or district-wide instructional systems (as detailed in this study's conceptual framework in Section 3). Of the 12 cases of student involvement in their district's change processes around CSed we selected five for inclusion in our analysis. These five cases reflected (a) a wide range of student opportunity platforms (from a club to a student council to a research project), (b) different types of work districts performed to support these opportunities, (c) varying levels of impact on the instructional system, and (d) a robust account that included interviews with the adult facilitators of each opportunity, and either additional interviews with district leaders or internal district documentation of the inner-workings of the opportunity.

Ultimately, we chose to provide a deep analysis of five cases, rather than an exhaustive survey-level account of all cases, because our research questions are not focused on documenting every single opportunity across all participating districts, but rather on distilling the dynamic nuances underlying specific opportunities to better explain why some were impactful on instructional systems and others were not. We re-analyzed each of the five cases in a consistent manner using the analytic framework developed, and conducted member checks to ensure accuracy of our portrayal of the student opportunity and viability of our interpretation.

In the third phase of analysis, we shifted our focus to a cross-case comparison in order to reveal differences and patterns across them. This allowed us to elevate contrasts among cases vis-a-vis two variables that supported us to 'locate' cases in relation to one another. First, we noted the degree of structure—low or high—associated with a given leadership case. Second, we noted the nature of the opportunities the leadership cases had for impact on the instructional system—emergent from the role or embedded within the role (see Figure 1). Additionally, within this final cross-case approach we identified where district supports had potential for breakdowns and resulting tensions for student leaders—in some cases this involved noting how breakdowns were avoided, while in others noting when they were not.

A final note on our methodology relates to representation of complex, and varying, institutional contexts in which our focal cases took place, variances in the 'level of activity' of these cases in terms of which elements of the instructional systems they implicated, and variances in qualities of the student leadership opportunities that were analyzed. Across the manuscript, we utilize various representational forms, from more traditional tables to provide general overviews of our cases (Table 2, above), to case narratives in Section 5 structured consistently via the analytic framework offered in Table 1, to interpretatively (as opposed to quantitatively) generated visualizations that highlight cross-case contrasts (Figure 1). In doing so, we reflexively consider where and how it is possible to attend to questions of representation and abstraction in the context of scientific knowledge production [Coopmans et al 2014] in a way the elevates salient details such that both practical and analytic takeaways can be made more accessible.

5 FINDINGS

Below, we present five cases of student leadership activities enacted within the context of, and aiming towards impact on, district computer science instructional systems, analyzed through the lens

Table 2. Summary of Focal Cases

Case Title	District Size	Urbanity	Student Leadership Roles	Instructional System Context
Coding Club Leaders	Small	Rural	Administrator Teacher Learning Broker	CS learning opportunity
Code Ambassadors	Small-to-Mid	Suburban	Teacher Learning Broker	CS recruitment system (promotional events, class-to-class recruitment)
Class Research Project	Small-to-Mid	Suburban	Researcher Informant Learning Broker Administrator	CS learning opportunity (club, mentorship, classroom redesign)
CS Student Advisory	Large	Urban	Researcher Informant Teacher Administrator	CS district leadership system CS recruitment system (CS events) CS learning opportunity (club)
Students as Curricular Informants	Large	Urban	Informant	CS curricular system

of our conceptual framework (outlined in Section 3, summarized in Table 1, above). In the first case, we explore a female-led after school coding club, one in which student leaders had broad autonomy but a more limited scope of impact. In the second, we present a secondary-level recruitment initiative that drew on student leadership to support a district's broadening participation efforts, which, while having broad impacts, entailed constrained autonomy for student leaders. In the third case, we highlight an agentic student who used a class research project as a launching point for a range of self-initiated, but district supported, leadership roles focused on addressing barriers to female participation in CS learning opportunities. The fourth case analyzes the dynamics of a CS student advisory in a large urban district, highlighting the tensions associated with incorporating student perspectives into broad-scale and complex district leadership systems. In the final case, we explore a district-level research-practice partnership that leveraged students as informants within a curricular design process aimed at creating district-wide culturally responsive middle school curriculum, highlighting how even time-bound opportunities for contribution, when combined with strong adult scaffolding and commitment to uptake of student perspectives, can result in wide-scale impacts within a district.

We present this range of cases to demonstrate how this integrative work can be accomplished without suggesting a one-size-fits-all approach. By using a single conceptual framework for analysis we show how consistent dynamics occur and play out across a variety of student leadership opportunities.

5.1 Case 1: Coding Club Leaders

In Danforth School District, a small rural district in the Western US, a female student-led afterschool club utilizing the Girls Who Code model presents a case that offers insight into how students can wield power and autonomy within a bounded sphere of influence. Haley, the district's innovation specialist and the Girls Who Code sponsor, is a passionate advocate for increasing female enrolment in CS programs in her district. At the secondary level, where CS courses are elective, she noted that "as far as gender inclusion...it is often the male secondary student who will self-select." Part of the purpose of the Girls Who Code club was to offer an accessible entry point for female secondary students to explore potential interest in Computer Science in a low-pressure environment.

5.1.1 Leadership Roles. The student co-founders of the Girls Who Code club at Danforth blended together several leadership roles, specifically those of administrator, teacher, and learning broker. In some respects, the administrator role was 'upstream' from their roles as teachers and learning brokers—it reflected their broad latitude to structure the entire club approach, which we will explore later in the case.

As administrators, they deliberated and made decisions regarding how to use club funds to further their goals, what kinds of club activities and learning opportunities members would have, and how to engage in recruitment strategies that would grow their ranks and enact their values around broadening participation. Funding priorities for Girls Who Code student leaders included student field trips, technology hardware and software, and competition funds. Advertised club activities included service-learning opportunities, guest speakers, and "creating things that matter." Recruitment strategies included targeted outreach to dynamic students, and marketing the club to be appealing to girls who don't readily identify with computer science.

In addition to the strategic decision-making involved in their administrator roles, club leaders also played the role of teacher. Taking inspiration from *Brave, Not Perfect*, a book written by Reshma Saujani, the founder of Girls Who Code, they identified four skills that they valued: bravery, resilience, creativity, and purpose. When they pursued a months-long activity to 'create something that mattered to them,' club leaders worked to design a video game that addressed issues of self-esteem and confidence. As described in the written pitch of the club, "This game takes a player through various stages of a girl's life and helps girls make decisions at each stage. For example, in the lunchroom, a girl is faced with the awkward moment of choosing a place to sit. She can choose to sit at a table alone or introduce herself to someone new. The BRAVE choice helps her progress in the game." As club leaders collaborated to help each other design this game, as well as onboard new students into the design process, they acted as teachers.

As they pursued recruitment activities, club leaders also played the role of learning broker. Haley and the three student co-founders identified 30 female students across grades 8-11 that stood out to them as leaders and wrote each one a recruitment letter that broadcasted the four skills (bravery, resilience, creativity, and purpose), messaged the underrepresentation of females in STEM skills, and invited them personally to join the club. Club leaders also acted as learning brokers by changing the name of the club to emphasize the value of bravery, in the hopes that students interested in issues of self-esteem and confidence, not just computer science, would join the club.

5.1.2 Reach. Danforth offered multiple learning opportunities for students to get involved in Computer Science at both the elementary level (e.g., CS class rotations, after school club, and district-wide STEM makerspace) and secondary level (CS electives and afterschool clubs such as robotics and game design). However, the student leaders of the Girls Who Code club, which acted as an additional entry point exclusively for female students, was fairly bounded. It served the typical number of students in afterschool clubs, with participation ranging from a handful to a few dozen.

5.1.3 Access. The Girls who Code club itself was open to all secondary female students, meeting once a week directly after school on-site at the district's only high school, situated next to the district's only junior high school. The club appeared to be a low-pressure and low-stakes way to explore an interest in Computer Science while also appealing to students' interests in issues around self-esteem and confidence.

In terms of the particular leadership roles in the club outlined previously, in contrast to some other cases we will share, access to these roles did not entail a lengthy application process or unreasonable time commitments, but there was some amount of structure to denote formal leadership,

with specific positions of president, president-elect, and a cabinet of two to three members. These positions were filled using a well-worn approach to extra-curricular club leadership—student voting. This meant that while there were limited numbers of 'formal' leadership positions, the question of who would fill them was left up to club members.

5.1.4 Scaffolds. Haley officially served as the sponsor and advisor of the Girls Who Code club, and while attending meetings she played a facilitator role. As a facilitator, she supported club leaders to be administrators by providing structured opportunities for club leaders to engage in deliberative decision-making. For example, towards the beginning of the club Haley asked club leaders to discuss important questions such as, "How are we advertising this? How are we packaging it this year? What do we want our club meetings to look like?" She allowed club leaders to reach their own conclusion and make their own decisions, providing the student leaders with decision-making autonomy and refraining from inserting herself into their discussions.

5.1.5 Autonomy and Ownership Over Role. Foundationally, the club being co-founded and then formally led by a group of three students suggests a high degree of autonomy and ownership on the part of the club leaders. They were able to put into action their vision for developing a new opportunity, and strongly identified with those roles as leaders of a new club, creating formal leadership positions that marked their sense of responsibility. Once it was established, they collectively worked to shape priorities, activities, and marketing strategies. They used this freedom to build out elements of the club that reflected their interests, passions, and values—a positive indicator of ownership. As noted, the student leaders took inspiration from Saujani's *Brave, Not Perfect* book to emphasize skills that they were interested in such as bravery, resilience, and creativity, and directly built these themes into the scenarios of the video game they were designing with the broader group of club members. Furthermore, they used the video game as a vehicle to address issues they identified with from within their school experiences, such as the awkward moment of choosing where to sit in the school lunchroom.

Club leaders' autonomy and ownership were also on display in their deliberations around how to frame the new club for other students, with considerations being given to whether the club's name adequately characterized the identity they brought to the club as, for example, a student who finds programming fun and is aspiring for a career in computer programming (we explore this example more deeply below). In contrast to the other cases presented, club leaders had the freedom to advocate for and enact their vision for how to best play their various roles as administrator, teacher, and broker.

5.1.6 Power Over Instructional System. This autonomy and ownership over their leadership roles was in this case paired with clear power to decide how the club would run, with the club leaders making consequential decisions that directly transformed the nature of the club. Haley supported club leaders in this—she actively positioned them as having full decision-making power, and did not make decisions for the club leaders or step in to have the final say if she disagreed with a decision. While their power was bound to the club context, the student leaders fully expressed it, and shaped the club actively to address things they felt were important.

One of the most central examples of their power to decide how the club would look was the aforementioned decision to change the name of the club, a salient transformation, especially given that there was a powerful external frame—"Girls Who Code"—coming from a nationally prominent external actor that they actively decided to shift. During their discussion about the name, one club leader who coded for fun and planned to pursue CS academically favored the title "Girls Who Code", because she felt it offered a sense of empowerment through the club members' identities as girls interested in CS. Another club leader pushed back—in her view, the title Girls Who Code

acted as a barrier to appealing to girls who did not yet see themselves as coders. As Haley describes this discussion,

> *"We talk a lot about girls. Again, we've got... I'm not just self-identified as a coder. So Girls Who Code is a deterrent sometimes 'cause I'm gonna say, "That's a label. I'm not a girl who codes. I don't classify myself as that so I don't belong there." And so we changed the name of our club." (Haley, Innovation Specialist, 3/31/2020)*

Other decisions included, as previously mentioned, determining funding priorities, club activities, and recruitment strategies. This level of power is, in part, what separated this club from the districts' elementary level CS afterschool club, in which students actively worked on CS projects but did not have structured discussions and the final say in the club's priorities, activities, and outreach.

5.1.7 Infrastructuring. Haley performed work to amplify and sustain the Girls Who Code club. To amplify the club, Haley helped the club leaders set up a club recruitment booth during events such as rush week in the Fall, freshman orientation night, and parent-teacher conference nights. Haley also, along with other staff and parents, served as chaperone for club field trips which included an event to hear Reshma Saujani speak and ask her questions, as well as a field trip day that included elementary students from the district. Furthermore, Haley helped to sustain the club by applying for grants and for awards where club members were able to compete and show off their work, and then use their awarded money to fund future club activities.

5.1.8 Impact on Instructional System. Although club leaders had decision-making power to transform the Girls Who Code club, this power did not extend to other parts of the district's CSed work. The impact of their leadership was most central within this single element of the broader CS instructional system. Within the scope of the club, however, there was evidence of impact—student leaders grew their enrollment from five students in the first year to over 30 students in the second year, although the enrollment numbers did decline in the third year. This growth corresponded with their decision to change the name of the club and to their letter writing recruitment campaign, highlighting impact at the least in terms of increasing access to the particular learning opportunity they led.

In Haley's opinion, the student voice and leadership in this club is what directly impacted enrollment numbers:

> *"Some years, the president is very dynamic and pulls in people and everyone's open to it. And sometimes there are crickets and that's been such an indicator to me of the importance of the student voice and the student leadership aspect, because students will gravitate towards the dynamic student leader, regardless of what the club is, regardless of what the thing is. You can make anything engaging if you like the people enough." (Haley, Innovation Specialist, 3/31/2020)*

This perspective from Haley, and the broader autonomy and ownership shown by a small group of student leaders, raises questions around how to sustain leadership in contexts such as the one described here, especially if impact is contingent on dynamic leaders. Additionally, while the bounded impacts of these student leaders are worth recognizing as valuable and important on their own terms, the case raises questions of what it might look like for a district to extend the club leaders' impact to other aspects of the instructional system and what might be required to do so.

5.2 Case 2: Code Ambassadors

In Yorkville School District, a small-to-midsize school district on the East Coast, a recruitment effort to increase participation in computer science pathways demonstrates a case in which students were given roles that had limited autonomy, but enjoyed a school-wide platform and were able to significantly impact the CS instructional system through supporting efforts to broaden participation in CS courses. Nicole, a mathematics department supervisor who was an early advocate for Computer Science in her district, detailed how she used her position in the math department to hand pick and support students to be 'Code Ambassadors'.

5.2.1 Leadership Roles. Code Ambassadors played multiple roles. During CSed week, which critically coincided with student course registration, Code Ambassadors acted as teachers by facilitating 'hour of code' activities in the school library and school cafeteria during each lunch period. Any student who wanted to stop by and participate in the Hour of Code could do so with the ready assistance of the Code Ambassadors. The Code Ambassadors used their social network to draw crowds to the Hour of Code events. As Nicole describes it,

> *"The Code Ambassadors definitely put pressure on the adults to participate. They targeted their own teachers, administrators they knew even office and kitchen staff. It was a real whole school event. Then it cycled, the adults drew more students first as spectators then as participants." (Nicole, Math Department Supervisor, 6/4/2020)*

Additionally, Code Ambassadors acted as learning brokers. Along with CS teachers, Code Ambassadors gave computer science promotional presentations in every math classroom at the high school level. These presentations included video testimonials of students sharing their stories of how they developed interest in computer science as well as CS course advice that was tailored to each math classroom. For example, Exploring Computer Science, game/web design, and computer technology were promoted to Algebra and Geometry students, whereas AP Computer Science Principles was promoted to Algebra 2 students, and AP Computer Science A was promoted to students in pre-calculus and above.

5.2.2 Reach. In Yorkshire District, nearly all high school students take one or more math classes during their high school years. By going into every math classroom with a CS teacher each year for the past couple of years, Code Ambassadors had a platform that reached nearly every student. In cases where a Code Ambassador had a scheduling conflict, the CS teacher covered for them, ensuring every math classroom was reached. Likewise, if a math student was absent on the day of the presentation, their math teachers took note, and Nicole shared the video stream with them. As Nicole described this approach,

> *"We have very few kids who are not in math classes for four years. And so we use that as sort of like our captive audience, so we know that every student is getting the message. And then we have kind of make-up sessions. So teachers identify kids who might have been absent and we funnel out the video streams to them." (Nicole, Math Department Supervisor, 6/4/2020)*

The platform itself reached directly into the district's infrastructure around recruitment and promotion practices for increasing CS course enrollment. Code Ambassadors were not simply promoting one course or one aspect of CS, but were covering the full range of Yorkshire's high school CS pathways from topical courses to AP courses, with potential to impact recruitment along the entire pathway.

5.2.3 Access. Yorkshire district has a diverse student population that mirrors the racial demographics of their state. Nicole intentionally selected willing students who, collectively, were representative of the larger student body to be Code Ambassadors. By controlling the channel by which students were recruited to be Code Ambassadors, Nicole was able to ensure a diverse representation of students to fill this role, which fit her district's larger equity goal of broadening participation in CS by having the full representation of students involved in recruitment efforts. To further broaden the diversity of voices heard during Code Ambassadors' promotional presentations, Nicole included video clips of students who were not initially interested in computer science, but then pursued it after taking a CS course.

5.2.4 Scaffolding. Since Nicole invited participation from amongst willing students to be Code Ambassadors, she presumably selected students who were knowledgeable and skilled enough in Computer Science that they can help other students participate in Hour of Code activities. She did not reference, for example, any additional training or support structures for the Code Ambassadors ahead of the Hour of Code events. When it came to their role of supporting recruitment, Code Ambassadors and CS teachers performed joint work when they shared the responsibility of visiting classrooms and giving CS presentations.

5.2.5 Autonomy and Ownership Over Role. By nature of being willing to participate in the invited opportunity by Nicole, Code Ambassadors presumably had some amount of ownership over their role. They also may have had some autonomy in being able to choose which Hour of Code activities to recommend to which students, and what parts of their own personal experiences with CS to share with their peers. Code Ambassadors certainly showed autonomy and ownership by reaching out to their social networks to draw a larger audience to their facilitated Hour of Code activities. At the same time, Code Ambassadors played highly prescribed roles within their district's CSed Week activities and math class visits. They followed relatively straightforward routines with little deviation, both in their teacher role to assist their peers in Hour of Code activities and in their learning broker role to promote CS courses to math students. Essentially, how these roles would function and what activities they would entail was largely determined by district actors, rather than students themselves.

5.2.6 Power Over Instructional System. Just as Code Ambassadors had little autonomy to deviate from their prescribed routines, they also had relatively little power to make decisions that would transform the Code Ambassador platform or their districts' broader CSed initiatives. It is important to note that Code Ambassadors did not need a high degree of power to effectively perform their roles and follow the routines and responsibilities laid out for them, and ultimately to have a positive impact on the CS instructional system.

5.2.7 Infrastructuring. Nicole amplified the work of Code Ambassadors during the Hour of Code activities by embedding the event in their district's annual routine. She also leveraged her network of administrators, teachers, and even local journalists to attend the event which, in turn, generated buzz and drew even more students into the event for the Code Ambassadors to connect with. As Nicole explained this strategy,

> *"We ask all of the administrators and as many of the teachers as we can to model for kids their own willingness to participate. [...] One of our assistant principals, he types with two fingers and so it was really cool to see him... The kids were like huddled around him, laughing hysterically, and then they'll post that up to our social media feeds." (Nicole, Math Department Supervisor, 6/4/2020)*

Additionally, district administrators and CS teachers supported Code Ambassadors as learning brokers by creating a presentation video in cooperation with the technology and engineering department, partnering Code Ambassadors with a CS teacher to co-present, scheduling math class visits, and setting up a tracking system to ensure that even absent students were able to view the presentation video. All of this work entailed "a massive amount of coordination" as the CS teacher, Rosalyn, puts it,

> *"Because the students have to have a free period, they've probably gotta know me for it to be meaningful, and I've gotta have help from other teachers, so I've gotta work to buy them in. And there's 14 math teachers so you're talking about 80 presentations over three weeks. So, if I'm teaching, I have to walk away from my class for 10-15 minutes, go make the presentation, come back to the class, the teacher will switch with me so that can happen. Or I'm going during my free period." (Rosalyn, CS Teacher, 5/21/2020)*

Through this infrastructuring work, district administrators and teachers supported the platform of the Code Ambassadors to have a wide reach. More broadly, district actors made several key decisions that acted to support the likelihood that Code Ambassador students, and the teachers they co-presented with, would reach their goals around broadening participation. First, Nicole intentionally utilized the timing of CSed Week, which corresponded with student course enrollment in the district. Many students were trying out CS activities and learning about CS course offerings right as they were considering which courses to enroll in. Second, after hearing a CS pitch session by Code Ambassadors and a CS teacher in their math class, students filled out a survey that asked, "based on the presentations you've heard, what courses are you interested in taking?" These surveys then informed teachers recommendations during individual student conferences about course registration. In a broader sense, while these were not "direct" supports for students in the Code Ambassador role, they were elements of a larger infrastructure aimed at ensuring that role's success.

5.2.8 Impact on Instructional System. Nicole and her district's assistant superintendent attribute a large increase in student enrollment in CS classes to the work of Code Ambassadors along with expansion of the district's CS pathway to include new courses, noting that they saw these two shifts in their implementation directly contributing to an increase of over 100 student enrollments in CS course in a single year. Working in line with a broader district infrastructure, Code Ambassadors played an impactful role in supporting their district's larger routines and goals around broadening participation through targeted recruitment efforts for computer science classes.

5.3 Case 3: Class Research Project

In Barton City Schools, a small-to-midsize district in a Midwestern suburb, a female junior student, Tamara, undertook a critical research project into her district's barriers to equity for female participation in CS opportunities. Her work offers a case in which emergent opportunities for leadership were well aligned and well-received by district administrators and CS teachers. Tamara's story was shared with us primarily by her CS teacher, Marlene, who described Tamara as a go-getter, and by the district's instructional technology coordinator, Selena.

5.3.1 Leadership Roles. As part of an advanced social studies class project, Tamara had the opportunity to propose a research project, and she chose to investigate a question that reflected her own experience in her district's computer science courses. As Selena, the district's instructional technology coordinator, put it, she wanted to know "why aren't there more girls in our computer science courses?" To answer this question, Tamara took up the role of researcher and interviewed

her peers to learn more about their motivation around course selection. Selena recalls that one such question Tamara asked in her peer interview was, "At any point in your freshman or sophomore years, did a counselor or a teacher recommend computer science to you?" Selena shared that the number of female students who responded yes to this question was "really sadly low."

As Tamara shared the results of her peer interviews and her recommendations based on these results with Selena, Tamara took on another role: informant. The results of Tamara's peer interviews, as Selena described them, were that female students' course enrollment decisions were, "driven by two main things. One is friends, what are their friends taking? And then two is, what are teachers encouraging them to take?" As Selena described, the recommendations Tamara gave based on these results were that "she felt we really needed to do more on the social aspect of getting girls, encouraging other girls, younger girls, to engage in the [CS] classes. So having a mentorship kind of program or something for junior and senior girls to connect with freshman and sophomore girls..." and that "we needed to do a better job in our sophomore teachers and our counselors working with our sophomores to promote Computer Science for girls."

Tamara also acted as an informant to Marlene, her CS teacher. Marlene recounted a set of recommendations from Tamara centered on redesigning the look and feel of the CS classroom itself:

> *"She has this plan and this action of, well, maybe we need to repaint our classroom instead of the color that it is. Maybe we have to go order some new pictures that are in there and make it more inviting for the female students. . . . and maybe changing the way the desks are arranged and all these different ideas that she's coming out with and doing research on." (Marlene, CS Teacher, 5/14/2020)*

Tamara also had the chance to sit down with her district's high school principal to share her research findings.

In addition to being a researcher and an informant, Tamara assumed the role of learning broker on several fronts as she aimed to independently enact recommendations based on her research for increasing female enrollment in her district's computer science opportunities. Tamara applied for and won two separate CS-centered national awards that provided her with mentorship. In turn, Tamara mentored her peers to apply for these national awards, offering to have meetings to go over what it takes to sign up and be involved in the process. In terms of transforming the design of Marlene's classroom to be more appealing for female students, Tamara applied for a grant to get paint to paint the classroom. And in a combination of both a learning broker role as well as that of an administrator, Tamara started a Technovation club, which she invited female students to and set up zoom calls with multiple CS mentors who held computer science positions and jobs at local companies to speak to club participants.

5.3.2 Reach. Of the numerous roles she took on, Tamara's research project—with its attendant researcher and informant roles—in particular had wide reach. It informed multiple parts of her district's CS instructional system including how CS was promoted (i.e., counselor recommendations and peer outreach), how CS classroom spaces were designed, and what CS opportunities were available for students (i.e., mentorship and new clubs). Tamara's ambitions also took her reach for this project beyond her district's high school. As Marlene recounted,

> *"She wanted to work on this project so that the school board and the city is aware of how important computer science is, no matter what area of computer science, to have more females get involved. So she is part of this research study. She's interviewed the superintendent, she's interviewed Selena, she's interviewed some other people within our area, and outside of our area, too, contacts, as to how do we get more women or girls, or females, however they wanna identify." (Marlene, CS Teacher, 5/14/2020)*

Driven by a clear passion for broadening participation for young women in CS, Tamara extended the reach of her platform well beyond the confines of her class research project, an activity that traditionally might only have its results seen by a single teacher.

5.3.3 Access. Tamara pursued her research in the context of an advanced social studies class, one where other students in the same class had similar opportunities to pursue equivalent research projects. Yet, there was no prescribed topic around the underrepresentation of females in computer science in their school district—that was a topic that emerged from Tamara's conversations with Marlene when Tamara was trying to come up with an idea for the research project. This specific opportunity, then, was not a pre-established routine that students typically access in this district. Rather, Tamara opportunistically forged it from the platform of a class assignment that itself was not directly about accessing a predefined leadership opportunity that district actors had envisioned.

5.3.4 Scaffolds. In her role as researcher, Tamara was presumably supported by her classroom teacher on how to conduct research and interpret findings as part of her class assignment. Additionally, Tamara received support and encouragement from Marlene who helped her to brainstorm CS related topics, and further supported Tamara by connecting her to district administrators to be interviewed as part of her project.

In her role as informant, Selena and Marlene supported Tamara by connecting her to various district administrators that she could share her findings with. As Marlene recalled,

> *"[Tamara] came and she had asked what are some resources, who are some connections? So I connected her to the superintendent, connected her to [Selena]… and I'm sure [Selena] then connected her to many other people, too, and then to the principal." (Marlene, CS Teacher, 5/14/2020)*

In her role as learning broker, Tamara further benefited from Marlene's social network. As vice president of her local CSTA chapter, Marlene had connections through industry and educator groups. Marlene was well positioned to help connect her students to award opportunities. As Chloe, the District's Director of Partnerships describes the scene of Marlene and Tamara strategizing together after school,

> *I would meet with Marlene after school and Tamara and several other students would be there, and Marlene is there with them. It's just kind of part of what she does... She's very involved in professional organizations, and she knows how to get all of these kids linked up with these organizations where they can win awards and do competitions and present their research. (Chloe, Director of Partnerships, 7/20/2020)*

As Tamara pursued these connections, she began to win awards and find mentors, which opened up additional opportunities for connections that she could then leverage as part of her own network.

5.3.5 Autonomy and Ownership over Role. Across all four of her roles Tamara expressed high levels of autonomy and ownership. As a researcher, she formulated and pursued an original research topic that mattered to her. As an informant, she did not simply share her research project back to her class, but also sought out and put her findings and recommendations in front of multiple district administrators and her CS teacher. As a learning broker and administrator, she not only devised recommendations, but took upon herself the responsibility of enacting them—applying for grants, starting clubs, and mentoring her peers. That she took the opportunity of what might have been a more straightforward class assignment to essentially create an informal leadership position

around CS in her district that spanned and evolved into multiple roles—first as researcher, then informant, and finally learning broker and administrator—is itself a clear expression of autonomy and ownership, sensibilities that took Tamara beyond the confines of her initial project course project into the inner-workings of her districts' instructional system.

5.3.6 Power Over Instructional System. As mentioned above, Tamara exercised power by sometimes directly changing aspects of her district's instructional system, and at other times essentially voicing directions for change to those in positions of power. Based on the findings of her research, she worked, in concert with administrators, to change the parts of the system that were holding females back from fully participating in CS learning opportunities. Her creation of the Technovation club reflected some amount of power to institute a new element of the district instructional system—an afterschool opportunity—which she then shaped as a learning broker both recruiting female students to join the club as well as mentors from outside the district to support it. Additionally, Tamara collaborated closely with Marlene to make her district's high school CS classrooms more inclusive and appealing for female students, including applying for funding to repaint the walls. In these ways Tamara held or shared power to impact her district's CS learning opportunities.

As would be expected, Tamara did not hold power over the decision-making process of her districts' administrators—this is a reality implicit to the role she took on for herself as an informant. Ultimately, it was up to Selena to decide to act on Tamara's recommendations to improve recruitment strategies by, for example, talking to guidance counselors about why they were disproportionately recommending CS courses to male students but not female students. Yet, that Tamara identified the recruitment issue, designed a solution to it, and connected it to a district CSed equity issue that Selena cared about, shows that Tamara did position her roles as a researcher and informant in a way that created the conditions for impact, even if Selena had the ultimate say when it came to implementation.

5.3.7 Infrastructuring. Selena and Marlene listened to Tamara's findings, prioritized her recommendations, and began to act on them. Selena, for example, talked about how Tamara's findings raised awareness around the need to talk with the adults in the high school—such as guidance counselors and math teachers—to make sure that they "are not hindering students," but instead "actively encouraging them to try things within computer science." Marlene began to transform her CS classroom space in response to Tamara's recommendations. She changed some 'simple things', as she puts it, such as switching out black picture frames for wooden picture frames, adding Kleenexes, hand lotion, and extra pencils to a section of her classroom, displaying photos of the walls of students with their CS mentors, and creating a wall of fame for students that have received certifications in the classrooms. Tamara's insights led Marlene to be more thoughtful and responsive to her individual female students' preferences and mindsets, so that she could address issues such as perfectionism head on. By taking up and acting on Tamara's findings, Marlene and Selena effectively amplified Tamara's work. Notably, Tamara played a role in sustaining the work she began by training additional students to pursue CS awards and by seeking grant funding for some of her recommendations such as repainting the walls of the CS classroom.

5.3.8 Impact Over the Instructional System. As mentioned previously, both Marlene and Selena shared their plans to act on many of Tamara's recommendations. At the time of writing, Selena planned to talk to guidance counselors and math teachers to make sure they actively encourage female students to try Computer Science courses, while Marlene planned to continue to transform her classroom space and pedagogical practice to be more responsive to her female students. These system level impacts can at least in part be attributed both to Tamara's extensive work as a

researcher and informer, but also, critically, by Marlene and Selena's willingness to listen to and honor Tamara's recommendations.

Additionally, and as previously mentioned, Tamara transformed the CS opportunities that female students had access to in her district's high school. As Marlene noted, Tamara was connecting "girls that probably never thought of or even have taken one of my computer science classes" with computer science mentorship opportunities. By focusing on the social and mentoring aspects of computer science, Tamara actively contributed towards the goals of making computer science more accessible to female students in the district.

5.4 Case 4: CS Student Advisory

In **Nondescript Public School District (NPSD),** a CS student advisory group for high school students offers a complex case of how an institutionalized student leadership opportunity with potential for students to have broad impacts can run into challenges of equitable access and limits of student power with attendant issues of tokenization, even while students display autonomy in their leadership roles. The case of the advisory was shared primarily by Natalie, an elementary CS coordinator on the district's CSed team, who discussed her time facilitating the advisory for two years, following its founding three years prior by another CS team staffer. Tom, another administrator on the CS team, provided additional context on the relationship between the broader team and the advisory.

5.4.1 Leadership Roles. Students on the advisory engaged in four, sometimes overlapping, leadership roles. In running CS events in schools across the district, they acted as teachers. In one of their larger, district-wide projects, they conducted a student survey around CS learning experiences that gathered over 2,500 responses, with advisory members acting as researchers. In the context of efforts to establish CS honors societies in their individual schools, they acted as administrators, attempting to create a new element within their schools' CS instructional systems. And, in that the group was set up and framed explicitly as an 'advisory', members were meant to act as informants, with a goal of bringing student voice to the district's CSed initiative.

5.4.2 Reach. Of all the cases we examined, the NPSD student advisory was one that was perhaps most centrally positioned to have wide reach. It was run out of the district's CS education office, a large team responsible for bringing CS learning experiences to all students in the district. With its stated mandate to bring student voice to that team and the instructional efforts led by it, the student advisory was situated close to 'the top' of the district's CS instructional system and decision-making structure. Theoretically, students on the advisory were positioned to have a broad impact, but as we'll explore, a number of issues hampered their ability to reach it.

5.4.3 Access. While it was meant to be a group representing student voices across a large and diverse district, Natalie noted a number of equity issues when it came to access and resulting representation within the group. When it was initially set up prior to her involvement, Natalie shared that the advisory had what she saw as a "very rigorous application process", involving both a lengthy application as well as a formal interview. In her view, the process was "super selective". This resulted in the advisory members coming mainly from the district's selective enrollment schools, ones that had the most developed CSed departments. Natalie did note that there were eventually some students on the advisory that came from less resourced schools both generally and when it came to CSed, but implied that the advisory did not fully represent the range of students and schools in the district.

5.4.4 Scaffolds. Beyond coordinating recruitment efforts and scheduling regular meetings for the advisory to come together, Natalie acted as a facilitator to support advisory members to carry

out their roles in a number of ways, specifically focused on their group deliberation skills and their research skills. First, Natalie focused on supporting the group's processes of ideation and collaboration, creating structures in their quarterly meetings where she "model[ed] what it looks like to do group decision-making, what it looks like when you're trying to come to consensus…". Her participation in these discussions were minimal to ensure students had autonomy and ownership over their decision-making process. Second, she actively supported the development and implementation of their idea to run a district-wide student survey around CS. She helped them practice data skills related to interpreting, representing, and coming up with recommendations based on their results.

5.4.5 Autonomy and Ownership Over Role. The activities of the advisory suggest that they had fairly wide leeway in determining what their roles and participation looked like and that they had ownership over these roles. As noted, the council, with facilitation by Natalie, brainstormed a number of both collaborative and individually implemented projects, including the district-wide survey, school events, and the attempt to set up CS honors societies. In each of these cases, Natalie shared that ideas for the projects came from the advisory members themselves, evidencing that there was latitude in the nature and enactment of their leadership roles.

There were also other indicators that students on the advisory exerted autonomy and ownership, though not always within their formal roles on the advisory or with the support of district actors. Natalie shared an account of a number of advisory members independently organizing their own CSed events available to youth in the city; securing guest speakers, making their own 'swag', conducting outreach, and facilitating the events.

5.4.6 Power Over Instructional System. In considering each of the roles they played, as teachers, researchers, administrators, and informants, advisory members had varying degrees of power over instructional systems around CS within NPSD. As teachers, they were able to decide what learning experiences they would design and facilitate for their fellow students in the form of 'one-off' school-based events. As researchers, data suggest that they had discretion in what questions would be asked in the district-wide survey they conducted, how it would be implemented, and what analyses and recommendations would come out of the research.

However, it is in their role as informants and administrators where questions of what power they had over the instructional system become more nuanced. As noted, while in their role as administrators they were able to decide to pursue the development of CS honors societies in their individual schools, the lack of dedicated district funds for the advisory to draw on limited their ability to enact this project, one that did not come to fruition (this was noted as at least partly due to lack of funding, but also due to the onset of the COVID-19 pandemic).

When it came to their role as informants, one explicit in the advisory's mandate to bring student perspectives into the district-wide CS initiative, it's important to note the nature of the role itself is not characterized by decision-making power over the district CS instructional system, except over the scope of the research itself. As informants, they were meant to provide feedback to those that designed and implemented the system. However, within this, data suggest that they had a limited opportunity to meaningfully enact the role.

Natalie shared that while others on the broader CS team were theoretically supportive of the advisory, there were many indicators that the group was not something that was taken seriously. For instance, when the advisory met at the district central office where the whole CS team worked, Natalie would let others know, and said that "People would pop in, like 'Hey, nice to see you guys'; and then just leave." She also saw her own role, as the person on the CS team coordinating the advisory, as an indicator of its lack of power when it came to informing the elements of the district's CS effort she saw it as being most relevant to. She shared her perspective on the matter:

> *"I feel like [the advisory] wasn't really on anybody's radar. And the fact that no one on the high school [CS] team was willing to take it on when it was more connected to [high school CS]... They said no, they said 'we don't have enough time'. [...] Maybe it was more the fact that it wasn't really a priority other than a stated priority. It was on our radar that it was a priority, but it wasn't ever talked about in a meaningful way. So, yeah, we can keep meeting, but if you want somebody to really be connected to this, it needs to be connected to the high school team. And I did say that. Like someone who's actually working with high school teachers." (Natalie, Elementary CS Coordinator, 8/13/2020)*

In interpreting what she shared, it's possible to see a fairly plausible dynamic—a desire to have student voice be present on the part of district leadership, but a lack of resources on the part of overworked administrators ("'we don't have time'") or investment ("it wasn't really a priority other than a stated priority") necessary to make this form of student leadership meaningful, authentic, and, ultimately, impactful. When asked directly about whether students were aware of their lack of power, Natalie enthusiastically replied in the affirmative. "They totally knew. They knew my position, and what power I had", and shared that she saw the advisory as in some ways a "token effort".

5.4.7 Infrastructuring. Natalie leveraged her institutional networks to amplify advisory members' contributions, by supporting the planning and implementation of CS learning events that advisory members ran in their own schools, and, in a couple of instances, in other schools in the district. Additionally, she was able to utilize the broader infrastructure of the district to support the circulation of the advisory's survey, which was distributed through the email lists maintained by the CS team. Yet, she noted that ultimately, she was not able to create an effective institutional bridge that could help support the advisory's research efforts to influence the broader district CSed team and its work. She attributed this to the limits of her own positionality as an elementary CS coordinator within the team, which she saw as misaligned to the reality that the advisory was made up of and focused on high school students. As a result, the configuration of an elementary CS coordinator in a high school advisory council, she was not well connected to amplify the students' contributions in their role as informants.

Similarly, she was not well positioned to sustain the advisory members' efforts either. She noted that there was no budget for the advisory, and that she was limited in terms of certain kinds of support for initiatives that the advisory wanted to pursue. This was evident in the example of the advisory attempting to initiate CS honors societies in their individual schools, but having to come up with plans to find external funds to support it, as opposed to being able to greenlight these efforts out of the gate with direct support from the district central office.

Confirming the interpretation noted in the prior subsection, Tom, another administrator on the CS team, shared context on the disconnect between the advisory and the district's broader CS infrastructure. He highlighted that during the period of study, there was substantial staff turnover among team members who would likely have been best positioned to integrate and incorporate the work of the advisory Most importantly, he noted that at the end of the day, incorporating perspectives that came from the advisory wasn't a central element of the district's strategic plan around CS, a plan that the team held itself to actively: "We knew we wanted to worked with students, but it wasn't tied to an accountability metric of process at the time. It didn't tie in at a high level."

5.4.8 Impact on Instructional System. The dynamics described thus far suggest that students on NPSD's CS advisory had some direct impacts on localized elements of the district's CS instruc-

tional system—such as in their own schools—but that these impacts were not fully proportional to the potential reach of the advisory outlined above. The CS events that advisory members led at their own schools and in others in the district directly provided other students in the district with learning experiences, and, potentially, ones where those students were more able to see themselves in CS as a result of being taught by peers instead of teachers. But other efforts were limited in their impact.

In the case of setting up CS honors societies in their individual schools, advisory members were hampered in making an impact by a lack of funds. And most centrally, in the form of impact that might have had the greatest reach—informing the broader CS team that ran the district's entire CS initiative—Natalie shared that she saw no results that came from their efforts. The findings of their survey were briefly presented—only by Natalie, not the students themselves—to the broader CS team in the context of a staff meeting, and while there were specific recommendations that came along with them in terms of potential shifts to CS instruction, both she and Tom acknowledged that there was not substantive engagement with these recommendations, and viewed these recommendations as ones that were unlikely to be taken up. One frame shared by Natalie seemed to sum up this dynamic when it came to the impacts of these student leaders: "They were more powerful on their own than they were with me."

5.5 Case 5: Students as Curricular Informants

In Taylor City Unified, a large metropolitan district in the Midwest, district staff partnered with university-based researchers to design an intermediate CS curriculum rooted in student interests and cultural backgrounds. As one district administrator described the curriculum, "[It would be] culturally relevant and would help students from a very diverse set of backgrounds see themselves in computer science and in this curriculum." To ensure that the content and material of the curriculum reflected students' experiences, the project team hosted a series of participatory design workshops [DiSalvo, Yip, Bonsignore, & DiSalvo 2017] specifically for the students, parents, teachers, and families served by the district.

5.5.1 Leadership Roles. The central role of students in this case was as informants, sharing about their personal experiences, interests, and perspectives in ways that the district's university partners later drew on in their curricular design work. During the first half of workshop sessions, students were prompted "to share a community they were part of," and asked to think about "what you want to see up on the screen when you're in a classroom." According to two of the facilitators of these sessions, students discussed a range of interests from favorite neighborhood outings, (e.g., visiting the library, sleepover at the museum), to recreational activities (e.g., playing sports and videogames), to values and commitments (e.g., empowerment, representation). During the second half of the workshops, students worked together in small groups to design modules that they would like to see in a computer science curriculum. As one of the project members put it, the sessions were "definitely more like collecting ideas, getting feedback and stuff, and so that we could then integrate in what they were saying."

5.5.2 Reach. As the curriculum design effort these students participated in was slated to create a central curricular resource for middle school CS classrooms in the district, the role they were in had broad and substantial reach. However, what was not clear from data collected that participants, and students in particular, fully understood the degree of potential reach their role entailed, given that it was both uncommon for students to participate in curricular design processes, but also because of the time-limited and short-term nature of their engagement.

5.5.3 Access. To make these participatory design workshops convenient for students and families to attend, the project team located them at community centers nearby to district schools and in multiple neighborhoods across the district, offered multiple session times and varied the timeframe to include both weeknight and weekend options. There were no prerequisites to participate in the sessions, including prior knowledge of or experience with CS, and the curricular design team worked with teachers in the district to actively recruit students to participate, though did note that the somewhat vague nature of the opportunity made this process challenging. As one team member noted, "it was difficult to recruit because people didn't know what this was", which was perhaps related to the broader realities that this form of activity and role are not 'standard' for students and families.

5.5.4 Scaffolds. Within the context of the workshops, the project team designed scaffolds for the experience with three important constraints in mind. First, the varied expertise of the students when it came to computer science. Second, the short timeframe of the single, four-hour workshops as the central form of engagement. And third, the differential power positions of the participants which again, included not only students, but parents, teachers, and administrators. In order to productively support students to succeed in their informant role in light of these factors, the project team created highly structured activities that rested on careful facilitation.

With regard to varied expertise in CS on the part of the participants, one of the facilitators noted that "all of our activities were designed without any computer science involved". They created accessible activities involving pen and paper, and focused on drawing on student perspectives and experience more generally, rather than on CS understanding —"it was more their knowledge and their ideas being able to come out". Within the context of some activities that focused on giving feedback to a pilot lesson and on drafting their own, the facilitators shared the following:

> *"We focused very hard on thinking about, okay, we're gonna give them our existing module but we're gonna give it in layman's terms. So we tried to really break down the computer science concepts into everyday language. Here's what our current module looks like, so when you do your module you understand kind of where we're coming from and can use that information but also don't have to understand exactly what two-way synchronization is besides one spread does something and the other reacts and that one does something back, that's all you need to know. So you need to know back and forth, you don't need to know message passing and the intricacies of that." (Sheena, Research Partner, 7/15/2020)*

This kind of attention to prior knowledge, and how prior knowledge might intersect with students viably engaging in the design activity, is consequential—a lack of orientation to such questions could have resulted in the activity being somewhat of a 'set-up', with students asked to do something they were unable to do. While study data did not provide direct evidence that students did not encounter challenges in engaging in the lesson design activity, the perspectives from three facilitators indicated that they all saw the resulting activity as one that was viable for students to engage in, and productive in generating ideas that informed the curriculum design process.

The final consequential element of the workshop scaffolding related to issues of power differentials that facilitators aimed to account for in their approach. First, there was attention made in their choice of workshop setting. While they could have used university or district facilities, the team chose to hold the workshops at local community centers, noting that they were "trying to create a level playing field, and level a little bit between the adults and the kids too", with the implication being that locating on school grounds would favor the positionality of the teachers and administrators or, on university campuses, the research team.

Within the workshop activities themselves, they gave attention to the groupings and positionalities of adults and students and how these might impact productive engagement. One facilitator shared that they intentionally made some activities with groups that mixed adults and students, and others where students were designing in 'student only' groups. Beyond this, in the context of mixed groupings, they attempted to counter existing power differentials. One facilitator shared about this approach in this way:

> *"There's an obvious power dynamic any time there's adults and kids together. And so we wanted to make sure that we could break down that power dynamic and work outside of the power dynamic. And so what we did is, the first activity we did, we had them create personas of who they believed was a likely learner of this computer science curriculum we were developing. And to break down some of those barriers, we started by making the kids experts and having the adults interview the kids about the learner they were designing. And so they were designing together, but the kids were in charge, and then they flipped and the kids got to take the interviewer power over the adults and be interviewing the adults while they designed a learner." (Sheena, Research Partner, 7/15/2020)*

Again, we do not have direct evidence that designing the participation structure to intentionally reduce power differentials between students and adults was successful, though the facilitator accounts did not indicate otherwise. Regardless of our ability to evaluate the efficacy of these decisions, the active attention to such a concern, one that the facilitators noted as well-established in existing research on adult/youth collaborative design, highlights what they saw as the importance of carefully creating scaffolds that support youth to be successful in their roles as informants on an element of the instructional system that they rarely have input on.

5.5.5 Autonomy and Ownership Over Role. While there was substantial scaffolding, and, as we'll explore, this resulted in students being able to substantively influence an important element of the district's CS instructional system, the nature of the structure that mediated their role as informants suggested that students had limited autonomy with regards to how they could carry it out. While the scaffolds actively aimed to support youth to share their perspectives, even aiming to reduce power differentials between adults and youth that might limit their willingness to share, we did not see evidence that students had autonomy around *how to enact the role itself*. The workshop opportunity was highly structured by the design team, so there was little opportunity or latitude for students to participate in ways other than those laid out within that structure. This stands in contrast to the case of the student advisory, where student leaders were given wide latitude in terms of the directions and focus of the activities they would undertake in their role.

For example, students here were not given opportunities to make decisions over what workshop activities they would or would not participate in, or to create some other avenue to provide feedback on the direction of the curriculum. Noting this is in no way a critique of the design and participation process; given the short-term engagement, it would have been quite complex to give students autonomy vis-a-vis how their role as informants was structured or enacted, something that would likely have required more long-term engagement, different forms of scaffolding and participation structures that looked different from a single workshop.

Similarly, due to the nature of the participation structure that made their feedback possible, data suggested that it was challenging for students to establish deep ownership over and identification with the role of being an informant on the district curriculum. The project team shared that one limitation on this front was the way they had structured their human subjects guidelines, which in this case prevented them from gathering contact information of the students and families that

participated. This meant that even if they had wanted to create additional opportunities for engagement that might have resulted in greater ownership over the role, they would not have been able to do so. Additionally, the team shared that even if their human subject guidelines had allowed for further interactions, due to resource constraints, it would have been unlikely that the team would have been able to implement them. One facilitator shared that "in our position we didn't have the luxury of iterating in quite the way that would have been ideal". But the restrictions also meant that other small moves that might have resulted in greater ownership over the role, such as virtually sending out preliminary results for member checking, or even informing participants of the overall shape of the curricular design effort as it evolved, were not possible. One member of the team noted that he would have liked to share the results more directly, "as a way to show [them] your ideas and opinions are really valuable, showing what the end product looks like. As opposed to a year and a half later, they do this computer science curriculum that happens to have Cardi B and some other musicians in a studio producing beats and then connecting the dots…".

5.5.6 Power Over Instructional System. In that their role was as informants on potential pedagogical approaches, the students were never intended to have direct decision-making power over parts of the district's CS instructional system. However, the role was framed to them as about having voice and influence. As one project team member put it:

> *"The way we framed it in our recruitment was very explicit: "We're creating this new curriculum and we want your voices to be a part of the creation of this thing", so it was very much framed as empowerment, which I think is very important for the students and parents because those are two parties who generally aren't given those opportunities, whereas teachers and administrators are much more in control of those decisions. So from the student and parent perspective, it was much more like bringing their voice to the table and were positioned as "You are the experts in the set of prior knowledge and experiences and cultural resources that you have, like that is an expertise that you and only you have, and that is something that we wanna be sure is a part of the material that we're developing." (Mark, Research Partner, 8/14/2020)*

There was clear commitment on the part of the design team to "bring student voice to the table", but in that students were not actually on the curricular design team, that team itself had to serve as the mechanism by which student voices would, or would not, influence district instruction. Receptive system leadership—in the form of the curriculum design team—was required in order for their perspectives to influence instruction in the district. As suggested earlier, the nature of the analysis and design process on the part of the team was the form that this receptivity took. Honoring and translating the perspectives of the students, as one member of the team noted, was a nuanced process:

> *"The last activity, where we had kids designing their own modules—there's no expectation that the thing that a kid produced after three and a half hours of thinking in the space is ready to be taught to, you know, a thousand kids across the district. But at the same time, figuring out, so what form does that contribution take, and how do we respect and honor those ideas and draw from them without tokenizing them or just ignoring them." (Mark, Research Partner, 8/14/2020)*

While it is beyond the scope of this analysis to explore fully the complexities of translating 'raw' ideas provided by students and adult stakeholders during a participatory design process into a viable curriculum, the project team shared clear steps they took to allocate resources and intentionality within this process. They engaged in activities of transcribing, parsing ideas from the

data, and creating rules that aimed "to not have certain ideas take over and look more important" when presenting results of the analysis to the broader team. All of these moves evidence a kind of resourcing associated with translating student voice into actual influence on instruction that are noteworthy in their depth and intentionality, pointing to what might more plainly be understood as 'taking student perspectives seriously.'

5.5.7 Infrastructuring. In order to amplify students' contributions, the design team worked to take the results of the participatory design workshops and incorporate them into the curricular designs. One member of the project team described their process of sorting through the ideas in this way:

> *"The big rule was 'take it rather than leave it.' So, what we did is we transcribed everything, and then we took those transcripts and a team of three of us went through and we pulled anything that we considered as an idea. And we wrote rules - An idea doesn't have to be a noun, an idea can be a verb.' We erred on the side of 'Pull it rather than leave it.' [...] We have a list of like 5000 things that we've called 'ideas', and then we're trying to whittle these down but without giving preference." (Sheena, Research Partner, 7/15/2020)*

The process as described above evidenced a robust process that gave deep attention to what was shared by students and adult informants, one involving careful analysis and synthesis of the perspectives provided. It would be easy to imagine a scenario where resources were not dedicated to conducting what can be seen here as a careful form of listening, but rather simply 'checking the box' of gathering stakeholder voices but then going on to simply design curricula in a way that didn't deeply incorporate those voices. As we will explore next, this element of the process was a key mechanism through which student power over the instructional system was realized.

5.5.8 Impacts on Instructional System. In taking their ideas seriously through synthesis of perspectives and translation into curricular designs, the project team made it possible for students that had participated in what might be seen as a small engagement—a four hour workshop—to have a substantial impact on the broader CS instructional system in the district. As one member of the team put it, "we've used so many of these themes, every one of our modules can be tied back to a theme", referring to the synthesized categories that emerged from the perspectives shared during the participatory design sessions. While the students were not 'in control' of these impacts, as with most forms of systems change, impacts often emerge at the intersection of legitimate shared leadership, with a variety of contributions required to drive changes to instruction. Practically speaking, the curriculum went on to multiple years of piloting, with wide usage across the district. Project leaders reported its use within more than 80 classrooms serving over 1,100 students at the time of writing, indicating that student contributions to the effort were tied to direct impact on student CS education opportunities within the district.

6 DISCUSSION

As we look across these cases, a number of themes emerge for consideration that can guide further work on both the part of district leaders as well as researchers. The first two themes relate to leadership structure and nature of the associated opportunities for impact. A third theme focused on tensions observed in these cases, as well as implied by them. The final outlines the potential for elevating, coordinating, and systematizing student leadership in CS instructional systems through the development of intentional district infrastructure.

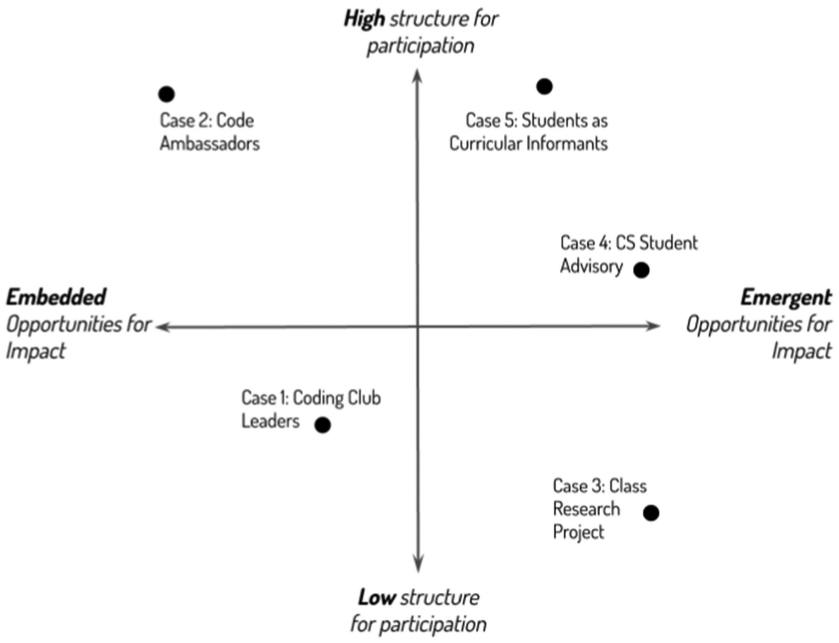

Fig. 1. Interpretive case mapping in terms of the nature of leadership participation structure and nature of opportunities for impact on district instructional systems.

6.1 Student Leadership Structures and Opportunities for Impact

In considering these cases, we begin to see distinctions along two axes - the degree of structure associated with the roles (high or low), and the nature of the opportunities for impact (embedded or emergent).

In Figure 1, we offer an interpretive mapping of the cases described in the findings along these two axes. The Coding Club Leaders case offers an example of what might be seen as a 'sandbox'; it offered wide latitude to the student leaders, who had autonomy and ownership within their roles and power over their bounded context of their leadership. Being a bounded context, but with some limited facilitation from district leadership (lower structure), the student leaders were fairly free to make what they would of the club—they were offered a sandbox to figure out how to be leaders, but one that was somewhat disconnected from the broader instructional system around CS. The opportunities for impact were most *embedded* in the leadership opportunity itself, one fairly prescribed to the context and genre of "the afterschool club", though what those particular impacts would be was contingent on the agency and discretion of the club leaders.

The case of the class research project shares some similarities to the Coding Club Leaders, but also important differences. Tamara similarly had a somewhat *low* structure context—a class assignment—to work within, and one that was not explicitly either about leadership or computer science. She chose to use this structure to speak to the broader CS instructional system, creating a more *emergent* opportunity for impact on that system. Neither her choice to take on a leadership role of researcher and informant nor the opportunities for impact associated with doing so were not predetermined.

Both the Code Ambassadors case and the Youth As Curricular Co-Designers case share a similar feature of a *higher structure* around the leadership opportunity—in the first case an established and well specified district recruitment routine, in the second an intentionally facilitated participatory design workshop—that they worked within. Neither of these contexts offered participating

students large degrees of autonomy about what the role they were taking on would entail, decisions about the role were clearly bounded by district actors. However, in the Code Ambassadors case the nature of the impacts was more *embedded* in the role; students enacted their roles of recruiting their peers into secondary CS courses during their district's annual CSed week. This contrasts with the curricular co-design case, where while there was high structure to the opportunity, the nature of the impacts on the system were not predetermined. While the impacts were focused on a particular curricular initiative, the design team did not know what perspectives the participating students would express and how these perspectives would potentially shape the direction of the curricular design.

The case of the CS student advisory is one characterized by a medium level of structure—a clear application process, formal meeting routines, guided facilitation by an educator—but one that gave wide latitude to student leaders once on the advisory to determine what kinds of activities they would pursue, which meant opportunities for more emergent, rather than predetermined, impacts.

The nature of infrastructuring entailed to amplify and sustain students' contributions differed significantly across embedded and emergent opportunities for impact. Code Ambassadors, whose opportunities for impact were embedded in the role itself, benefitted from district leaders who strategically timed the recruitment activities of the Code Ambassadors to lead directly up to student course enrollment for the following semester. Likewise, the impact of Code Ambassadors' presentations were amplified by having students fill out a CS course interest survey, the results of which informed what courses teachers recommended to them. The infrastructuring work performed in this case entailed tightly coupling and strategically timing various components within the recruitment aspect of their CS instructional systems. In the case of emergent opportunities for impact, such as when students were curricular informants for a new CS course or acted as a researcher to uncover barriers to equitable participation in CS, infrastructuring entailed active listening to new ideas, synthesizing and prioritizing across ideas, and creating plans and putting in the effort to enact students' ideas.

6.2 Tensions: Gatekeeping, Set-ups, and Tokenization

Across the cases, we observed some direct tensions associated with student leadership in district CS initiatives, as well as tensions avoided through careful considerations on the part of district actors. We consider three tensions; gatekeeping, set-ups, and tokenization.

6.2.1 Gatekeeping. As in society more broadly, questions of who has access to leadership opportunities are critical to consider. The case of students as curricular informants highlights a strong attention to access in the design team's choices to, for example, consider how the timing and location of participatory design workshops could impact who participated. However, the case of the CS student advisory included evidence that the structures in place around access, specifically the intensive application process, resulted in a group largely constituted by students with greater privilege within the district. In one example not included in the manuscript but from this same study we saw secondary students set up their own club, perceived by a district leader as largely about "padding their resumés", and did little to make shared leadership available to other students, creating a gatekeeping effect.

6.2.2 Set-ups. Once in leadership positions, students must be effectively supported to enact them, with relevant capacity building and resources to make informed decisions or take actions implicit in these roles. When they are not, it can result in a "set-up", where students are asked or nominally empowered to act as leaders in some way, but not prepared to succeed in them. We saw intentionality to avoid this in the case of the students as curricular informants example, where the design team developed ideation activities explicitly in ways that did not rely on prior

CS knowledge when they knew they were not going to be recruiting students that had experience in CS. In an additional case we encountered in the study more broadly but not presented above, students were thrust into roles of orientating other students, and expressed that they were both not given a choice to take on the role, but also not prepared to help their fellow students—they were not given guidelines or support around how to fulfill the role.

6.2.3 Tokenization. Finally, if students are given equitable access to these roles, and even supported to engage in them, it is possible for student leaders to feel like their participation is not valued, and for further marginalization of student voices to occur even within a context where they are meant to be uplifted and respected. The case of the CS student advisory offers a cautionary tale on this front—students on the advisory where put into a context meant to institutionalize student perspectives so that they might inform the larger district initiative, but in their most substantial effort to do so, conducting and sharing results of a district-wide survey, there was no evidence that suggested either valuation of their perspective by relevant district stakeholders or evidence that their recommendations were taken seriously. This tension aligns with previous research by Joselowsky [2007] who noted that district leaders did not always prioritize or authentically engage with the suggestions for school reform coming out of their youth-engagement efforts, and who connected this to a lack of infrastructure for institutionalizing student roles and for training administrators and principals for how to incorporate students' suggestions.

In offering lessons for district leaders and directions for further research, each of these tensions highlight different points in the student leadership process and elements of district infrastructure supporting it that we recommend they approach with intentionality. Gatekeeping can occur when processes supporting *access* break down, set-ups can occur when *role scaffolds* and attendant *autonomy* and *ownership* break down, and tokenization can occur when *infrastructuring* breaks down.

6.3 Future Directions: District Infrastructure for CS Student Leadership Pathways

The diverse cases presented highlight multiple legitimate ways to support student leadership within the context of district work on equitable CS education. Collectively, they do not portray an exhaustive account of all possible approaches to student leadership, but they do suggest the value of providing heterogeneous opportunities for youth to engage in change processes around CS instructional systems. Not all students share the same motivations, CS background, or school experiences. Therefore it is important to provide multiple pathways for students to participate as leaders.

In each case, we have shown particularities in terms of the nature of the leadership opportunity, how it's accessed and supported, and what kinds of impacts it might have. Some required little preparation or background knowledge, such as the Students as Curricular Informants and, to some extent, the Code Ambassadors cases. Others both asked more of students and also gave them more latitude, like the Code Club Leaders. Another case—the CS student advisory—involved filling a broader position of potential impact and influence, and thus responsibility and prior experience.

Looking across these cases from the perspective of district leadership, it's possible to imagine development of a broader infrastructure for student leadership in computer science initiatives within a given district. Such an infrastructure might include various forms or structures around student leadership outlined here and systematize them so that they are sustainable, but also coordinate them such that students might enter leadership pathways around CS that are more low-stakes and require less experience and then be supported to move into ones that involve both increasing knowledge and experience, but also reach, responsibility, and potential for impact.

6.4 Future Directions: Student Leaders Contesting District Assumptions

While the roles we identified—teacher, learning broker, administrator, researcher, and consultant—all represent legitimate and important ways for students to contribute to the advancement of

equitable computer science education within schools and districts, one role is notably absent: that of advocate. In none of the cases did we see students contesting, for example, the purpose of the CSed learning opportunities within their district's instructional system, or broader assumptions around who computer science is for and what it might look like. The case that came closest to this was the CS student advisory, where data gathered from their district-wide survey formed the basis for critical feedback on the quality of the pedagogy offered within introductory secondary CS courses. For the most part though, the cases evidenced students functionally participating within the bounds of the core assumptions of their district's CS instructional systems, rather than contesting, advocating, or aiming to transform their goals.

In considering future work in this area and in line with existing work on student voice that takes a more explicitly adversarial stance [see Ryoo et al. 2020], we see the possibility of both better understanding and actively supporting students to advocate around the nature of CS and it's broader goals within education as fruitful and important. Paying heed to how young people want to position themselves in society, how they want to be seen, and what social futures they want to pursue might reflect a broader authentic commitment to youth voice and power. In doing so, it may be possible to move beyond the prefigured assumptions of compulsory schooling with regards to youth futures to support them to author new ways in the world, a potentially liberatory perspective on what it means to educate.

7 LIMITATIONS

While we see value in the cases and analyses presented here, it is important to acknowledge the limitations of our study, both to contextualize its claims as well as to raise possibilities for future work in this area. The nature of our methods—cross-case analysis based on retrospective interviews with district faculty, augmented by district documentation—was well suited to the claims made about the high-level nature of district infrastructure supporting student leadership in CS, the kinds of roles student leaders engaged in, and their impacts on the system. However, these methods limited our ability to shed light more directly on the student-level outcomes associated with their leadership roles as well as the micro-dynamics associated with their engagement in these roles that have been explored by other scholars focused on students working to make equitable transformations around CS in their district [see Ryoo et al. 2020]. The area in which we made observations and claims about students' potential subjective experiences—specifically related to ownership over their roles—is one we see as specifically important to qualify given this limitation. Micro-dynamics associated with student leadership in district CS work is an area that our data made clear and is rich in terms of potential both in terms of better understanding effective practice and potential tensions, and one where our study aimed to make limited claims. Given our data, the core inquiry focused more on the relationship between CS instructional systems in a broad sense and the specific ways students participated and were positioned as leaders within them.

8 CONCLUSIONS

The findings of this study demonstrate that it is possible and, under the right conditions desirable, for districts to advance their equity agendas around CSed through directly involving students as leaders in these endeavors. We explored how various leadership contexts positioned youth as informants, learning brokers, teachers, researchers, and administrators, and how the broader structures that these roles are situated in can support equitable access and create the conditions of autonomy and ownership within leadership roles on one hand, and power and attendant impacts on the other.

More broadly, all of the examples shared here point to a dimension of equity that is not centrally about equitable education *outcomes*, but rather about equitable education *processes*. Having students take on active roles in shaping education systems challenges typical power dynamics

inherent in most institutions they inhabit, ones that too often position young people solely as subjects of the policies, intentions, and designs of adults. Challenging the assumptions of this dynamic and beginning to think about how the power to decide and enact education can be shared between young people and supportive adults is itself an important goal to explore and advance when it comes to establishing equity within computer science education.

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