Reaching for "All": Understanding the Challenges and Needs of Schools Lagging in CS for All Efforts

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ABSTRACT

Over the last decade, substantial strides have been made in the CS for All movement, with the widespread the enactment of policies that promote the implementation of CS education in K–12 schools. Despite this progress, at the current rate of growth, it is estimated that it will take four decades to actually reach CS for all students [13]. This sobering finding highlights the urgent need to understand why so many schools are lagging in implementation, and to identify solutions that could address this gap.

Using school-level survey data and administrative school records, we investigate the barriers to scaling up CS education in New York City. Common to many school reform initiatives, some schools were early adopters and eagerly embraced the call to provide CS to all students. Others, despite years of effort and support, have yet to offer CS or serve a small percentage of their enrollment. Our findings suggest that while "normative" perceptions of CS (e.g., beliefs about its' value) are similar among lower- and higher-implementing schools, some "technical" challenges—such as lacking an implementation plan and shared school-wide vision for CS—and "political" challenges—such as the lack of support from administrators, are greater for schools struggling to offer CS. Though these findings focus on one district, they are relevant to the many others engaged in CS for all efforts. This study builds on previous research by shedding light on the distinct challenges and needs of "lagging" schools, and provides insight into effective strategies for bringing CS education to *all*.

CCS CONCEPTS

• **Social and professional topics → K-12 education**; **Professional topics**; **Computing education**;

KEYWORDS

CS for All, K–12 education, Broadening participation, Scaling up

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1 INTRODUCTION

The Computer Science for All movement in the US has motivated promising shifts in policy and practice to support K–12 CS education. For example, over the last five years, funding for CS education and professional development has steadily increased, substantially more schools offer CS courses, and all 50 states now allow computer science to count toward graduation [2]. Despite this progress, the field has a long way to go before CS for *all* students is realized. For example, in 2021, only 5 percent of U.S. high school students were enrolled in a foundational CS course. Further, there are large, persistent race/ethnicity and gender disparities in who takes CS courses, and consistent underrepresentation of English language learners, students with disabilities, and low-income students [2, 12] throughout the computing pipeline. At the current rate of growth, Guzdial estimates it will take four decades to actually reach CS for all [13]. Given the unacceptability of that projected timeline, it is imperative to understand the barriers to implementation as well as strategies to accelerate the adoption and scaling up of CS.

2 STUDY CONTEXT

New York City, like many other cities in the U.S., has devoted substantial resources to K–12 CS education through a CS for All initiative. The goal of the 10-year initiative is to provide meaningful, high-quality, and equitable CS education to all students at each grade band (i.e., K–2, 3–5, 6–8, 9–12). Toward this end, the district provides professional development (PD) to teachers on a wide range of curriculum and pedagogy, lasting from 25 hours for foundational courses, to more than 100 hours for advanced courses. The district also provides leadership PD to school administrators and CS teacher leaders, with guidance on CS planning, instruction, and culture building. On spite of these efforts, a concerning number of schools are not close to serving "all" of their students: in nearly half of the district's schools, fewer than 10 percent of students enrolled had a CS experience by the end of their grade band [5]. Moreover, when there is CS participation, it tends to be inequitable—with Black, Latinx, and female students less likely to take CS courses than their White, Asian, and male peers.

3 BACKGROUND LITERATURE

Our analyses are guided by the literature on school reform and scaling up of initiatives, particularly Coburn's conceptualization of dimensions of scale [1], and Oakes' conceptualization of the technical, normative, and political considerations for school reform

[16]. Coburn notes that to achieve "deep and lasting change," reform efforts must focus on more than just increasing the number of schools involved. Rather, scaling up is a complex and multidimensional effort that involves "deep and consequential change in classroom practice" (pg. 4) that is supported and sustained through policy and infrastructure. She further notes that scaling up requires a shift in ownership, moving from an externally motivated initiative (e.g., a district or state mandate) to one that is owned by those at the center of the work (e.g., teachers and school-level administrators).

Building on Oakes' school reform framework, prior research outlines CS barriers that are technical, normative, and political in nature [8, 11]. Technical barriers are factors that limit a school's capacity to offer CS, including lack of teacher knowledge about CS, the school's CS vision, or how CS aligns with other initiatives; and lack of participation in PD and curriculum development. Normative barriers include commonly held attitudes that shape how much CS is valued or prioritized by school staff, or that lead to biased beliefs regarding which students belong in CS classrooms. Finally, political barriers refer to how district policies (e.g., graduation requirements), allocation of resources, relationships and power dynamics, or a lack of support from school and district leaders might hinder CS implementation. These three elements are often interrelated and overlapping: for example, technical barriers that prevent students from participating in CS may be driven by beliefs about the value of CS, as well as politically motivated decisions around resource allocation and graduation requirements.

Previous research has pointed broadly to the challenges teachers face in implementing CS in their classroom, despite having access to and participating in sustained PD [6, 17]. These include technical and political challenges such as lack of time to prepare lessons, lack of instructional time, competing priorities, and the need to prepare students for high-stakes tests, as well as normative challenges such as biases about who should take CS. Schoolwide implementation challenges have also been documented. These include technical barriers such as a lack of knowledge about how to integrate CS into the wider curricula of the school [4], a shortage of instructors who can teach CS, and limited opportunities for PD [9]; political barriers such as a lack of administrative support and infrastructure to integrate CS [4]; and normative barriers such as stereotypes and assumptions about who belongs in CS [12].

Although these challenges have been identified, it is still unclear why some schools in a districtwide initiative—with access to substantial support and PD resources—have achieved full implementation, while others struggle to serve even a small number of students. Understanding the distinct barriers that stand in the way of reaching all in schools that were not early adopters is key to answering the call to scale up CS education.

4 METHODS

Our study used a mixed-methods approach to investigate the relationship between schools' progress towards reaching all students with CS education and the technical, normative, and political barriers to scaling up. The study was conducted in NYC, a large urban district that serves predominantly low-income, Black, and Latinx students.

4.1 Research Questions

This paper explores the following research questions:

RQ1 How do schools at different levels of progress towards achieving CS for all differ in terms of key technical, normative, and political elements?

RQ2 Do schools at different levels of progress make different types of recommendations for support?

4.2 Data Sources

Our analysis draws on multiple data sources. We administered an online survey in Spring 2021 to all schools with at least one teacher who had participated in any type of district-sponsored CS curriculum PD between 2016 and 2021 (N = 676). We asked the school's "CS Lead"—a teacher who participated in the district's CS leadership PD—to complete the survey on behalf of the school. If a school had multiple CS Leads, we asked them to either work together or to designate one lead to complete the survey. If no one in the school had participated, we asked the school principal or a staff member who had the most knowledge about their CS instruction and programming to complete the survey. Of the 676 schools, 363 responded, yielding a response rate of 53.7%.

We also used data from school administrative records (e.g., student demographic data), CS PD attendance reports, and student course-taking records between the 2016–2017 and 2020–2021 school years. We aggregated the course-taking and PD attendance data to the school level in order to analyze the survey responses by level of CS implementation at the school.

4.3 Sample

Our analytic sample includes 358 schools that responded to the survey *and* were assigned an implementation level[1]. To determine the level of CS implementation at a school, we looked at students who had CS instruction at any point over the three- or four-year grade band, aligning with the goal of the initiative to reach all students with at least one CS experience per grade band. A total of 48.6% (174) of the schools in our sample served elementary students, 15.9% (57) served middle school students, and 22.4% (80) served high school students. Thirteen percent (47) served students at multiple levels (e.g., grades K to 12 or 6 to 12).

4.4 Measures

4.4.1 Implementation Measures. In order to assess a school's level of CS implementation, we created a measure that captures two key components of the CS for All initiative: saturation and equity. Saturation is the percentage of students in the school who had at least one CS experience by the end of their respective grade band in 2020–2021. The equity score uses three metrics to measure the extent to which student participation in CS is equitable for girls, Black students, and Latinx students—the subgroups that the district initiative is most focused on. These three metrics, influenced by Fergus' work exploring disproportionality in education [7], are *participation rate* (proportion of the subgroup that took CS), *composition index* (participation rate compared with the subgroups' representation in the overall population), and *relative participation ratio* (odds of

[1]Five schools were lacking implementation levels due to missing administrative data.

the subgroups' participation relative to all other groups). For each subgroup s, we define the equity measures as follows:

Equity Measure	Formula	Condition for Equity
$E_1(s)$: Participation Rate	$E_1(s) = \frac{n_{s[cs]}}{n_s} - \frac{n_{[cs]} - n_{s[cs]}}{N - n_s}$	$\lvert E_1(s)\rvert \leq 0.1$
$E_2(s)$: Composition Index	$E_2(s) = \frac{n_{s[cs]}}{n_{[cs]}} - \frac{n_s}{N}$	$\lvert E_2(s)\rvert \leq 0.1$
$E_3(s)$: Relative Participation Ratio	$E_3(s) = \left(\frac{n_{s[cs]}}{n_s}\right) / \left(\frac{n_{[cs]} - n_{s[cs]}}{N - n_s}\right)$	$0.9 \leq E_3(s) \leq 1.1$

NOTE: Let N be the total number of students at a school, n_s be the number of students in subgroup s, $n_{[cs]}$ be the number of students that took CS, and $n_{s[cs]}$ be the number of students in subgroup s that took CS.

We used these measures to determine equity and saturation scores ranging from zero to four, as defined by Table 1. For each school, we summed its equity and saturation scores. Schools with a sum of scores between zero and three were categorized as "lower-implementing" and schools with a sum of scores ranging from four to eight were categorized as "higher-implementing." Using this criteria, 40.8% (146) were lower-implementing and 59.2% (212) were higher-implementing in the 2020-2021 school year. Table 2 describes the respondents by school and implementation level.

Table 1: Criteria for Implementation Scores

Score	Saturation	Equity
0	0%	No subgroups met the equity condition for any metric
1	1-29%	At least 1 subgroup did not meet the condition for all 3 metrics
2	30-59%	All 3 subgroups met the condition for 1 metric
3	60-89%	All 3 subgroups met the condition for 2 metrics
4	90-100%	All 3 subgroups met the condition for all 3 metrics

Table 2: Percent of Respondents by School and Imp. Level

Row %	Elementary	Middle	High	Other
Lower-imp.	36.3	17.8	30.8	15.1
Higher-imp.	57.1	14.6	16.5	11.8
Overall	48.6	15.9	22.4	13.1

Although respondents assumed a variety of roles at their school, we found that their roles were similarly distributed in both implementation levels, as demonstrated in Table 3.

Table 3: Percent of Respondents by Role and Imp. Level

Row %	Principal	Assistant Principal	CS Lead	Other
Lower-imp.	63.1	82.3	59.2	93.1
Higher-imp.	79.4	82.6	41.3	91.3

NOTE: Respondents were able to select multiple items to indicate all of the roles that they filled at their school. A single survey could have been completed by multiple respondents.

4.4.2 Survey and Participation Measures. To understand the CS context at the school, we used a number of survey items related to CS teams and implementation plans. Specifically, we asked if the school had a CS team, and if so, who was on the team (e.g., principal, guidance counselor, CS lead teachers). We also asked if the school had a CS implementation plan, and if so, which elements were included in the plan (e.g., goals statement, vision statement, plan to engage families, etc.). From our participation data, we determined whether the respondent's school had participated in PD, what types of PD they participated in, and how many teachers were trained at the school.

To capture respondents' perceptions of several technical, normative, and political aspects of implementation we produced three composite variables created through principal component analysis (PCA) with ten survey items, each of which were measured on a five-point Likert scale ranging from strongly disagree to strongly agree. In our PCA, we used varimax rotation and, using the Kaiser criterion, retained three components with eigenvalues over 1 that explained 77.9% of the variance.

The first composite variable evaluates the strength of respondents' internal vision of CS at their school. The survey items contributing to this variable are: (1) I am able to articulate my school's vision for CS; (2) I understand my school's definition of CS and can explain it to others; and (3) I am aware of how my school's CS vision aligns with other school-wide initiatives and takes into account competing priorities. These items align with Oakes' conceptualization of *technical* elements of school reform.

The second composite variable captures respondents' impressions of the value of CS at their school, using the following items: (1) CS education is currently a priority for my school; (2) The majority of teachers and counselors in my school think it is important to offer CS; and (3) School and classroom activities are shifting perceptions and mindsets around "who CS is for?". These items align with Oakes' conceptualization of *normative* elements of school reform.

The third composite variable measures respondents' perceptions of the external CS support at their school, and includes the following items: (1) There is collaborative planning time for working on school CS implementation; (2) Teachers in my school are able to articulate the school's CS vision; (3) Teachers in my school understand the school's definition of CS and can explain it to others; and (4) Teachers in my school have access to professional development and resources for CS implementation. Although some statements are similar to those in the first composite variable, we view these items as aligning with Oakes' conceptualization of the *political* elements of school reform, as they speak to the access to resources and strength of *external* support structures that are often mediated through political factors.

Our PCA generated a continuous version of each composite variable, with a higher composite score indicating stronger agreement with the prompt. Each item was weighted by its factor score and standardized (M=0, SD=1), had factor loadings ranging from 0.72 to 0.90 in the PCA, and had strong reliabilities when loaded into their respective variables ($\alpha_1 = 0.92, \alpha_2 = 0.82, \alpha_3 = 0.90$).

4.5 Analytic Approach

We used SAS to generate descriptive quantitative results. We ran chi-squared tests on indicator variables and Mann-Whitney U-Tests on continuous variables to test the statistical significance of group differences, accounting for the non-normality of our data.

We also analyzed an open-ended item that asked, "What recommendations would you give the district to improve school support for CS implementation, planning, or CS culture building?" A total of 77 lower-implementing and 135 higher-implementing schools responded to the prompt. We content-analyzed the responses and developed a set of fourteen codes to group together responses with similar themes. In a second round of analysis, we gave each response a subcode to indicate if the recommendation was normative, technical or political in nature. Team members discussed the coding scheme and its application and updated codes as needed. Insights gained from the open-ended item analysis were used to provide qualitative context and understanding to our analysis of the close-ended items.

5 RESULTS

In this section, we address our two research questions. In Sections 5.1— 5.3, we explore RQ1: *How do schools at different levels of progress towards achieving CS for all differ in terms of key technical, normative, and political elements?* In Section 5.4, we use our analysis of an open-ended survey question to answer RQ2: *Do schools at different levels of progress make different types of recommendations for support?*

5.1 Technical Dimension of Implementation

5.1.1 Professional Development. Participation in PD is a key technical element of school reform, because it is often the vehicle through which districts build teacher knowledge and capacity to implement change. Our analysis supports this observation: as shown in Table 4, lower-implementing schools were less likely to attend CS leadership PD than higher-implementing schools (p<.0001). They also tended to have fewer teachers who participated in CS curriculum PD (p<.0001).

5.1.2 Implementation Plan. Another technical element we asked about was the presence of a CS implementation plan. During PD, teachers and administrators were given materials to develop a plan for implementing CS at their school that included developing a shared vision for CS; engaging in self-reflection around priorities, vision, and equity; and establishing strategies for acquiring, utilizing, and managing technology. Lower-implementing schools were significantly less likely to have a CS implementation plan than schools with higher implementation levels: 44.5% of lower-implementing schools reported not having a plan, compared to only 25% of higher-implementing schools (p<.0001). Lower-implementing schools were less likely to report having key components, such as a goals statement, a vision statement, and plans for organizing CS events, evaluating CS goal completion, or engaging families in CS.

5.1.3 Internal CS Vision. Through a composite variable, we measured the respondents' familiarity with their school's CS vision and definition of CS, which corresponds to the technical dimension of knowledge surrounding CS implementation. We found that CS leads and school administrators in lower-implementing schools were significantly less likely to agree that they can articulate their school's CS vision, understand its definition of CS, and know how their school's vision aligns with other initiatives and priorities, compared with their peers in higher-implementing schools (p<.05).

Table 4: Technical Elements by Implementation Level

		Lower-imp.	Higher-imp	Diff.
Professional Development	% Attended leadership PD	43.8	69.8	-26.0^{****}
	Mean # teachers trained	2.4	3.2	-0.8^{****}
CS Implementation Plan	% Has goals statement	38.4	52.4	-14.0^{**}
	% Has vision statement	32.2	49.5	-17.3^{**}
	% Has plan for organizing a CS event	29.5	46.2	-16.7^{**}
	% Has plan for increasing access to underrepresented students	27.4	33.5	−6.1
	% Has plan for evaluating if CS implementation goals are met	15.1	25.0	-9.9^{*}
	% Has plan for engaging families in CS education	21.9	41.0	-19.1^{***}
	% Has other implementation plan	9.6	7.6	2.0
Internal CS Vision (% Agree or Strongly Agree)				comp.*
	(1) I can articulate my school's CS vision.	72.1	82.1	−10.0
	(2) I understand my school's definition of CS.	73.0	83.6	−10.6
	(3) I know how my school's vision aligns with other initiatives and competing priorities.	67.2	76.4	−9.2

*p<.05, **p<.01, ***p<.001, ****p<.0001

5.2 Normative Dimension of Implementation

Our second composite variable assessed the value that respondents and their schools placed on CS education, representing the normative beliefs, attitudes, and assumptions that they have toward CS. Interestingly, we found no statistically significant differences in CS value—respondents from lower-implementing schools were just as likely as those from higher-implementing schools to agree that CS is important and a priority for the school, and that activities at the school are shifting perceptions around who CS is for.

Table 5: Normative Elements by Implementation Level

	Lower-imp.	Higher-imp.	Diff.
CS Value (% Agree or Strongly Agree)			
(1) CS is a school priority.	68.8	75.7	−6.9
(2) The majority of staff think CS is important.	69.9	68.2	1.7
(3) School and classroom activities are shifting perceptions of "who CS is for."	68.3	70.6	−2.3

5.3 Political Dimension of Implementation

5.3.1 External Support for CS. Our last composite variable evaluated the level of external support at the respondents' schools and teacher access to resources such as PD and collaborative planning time, which are products of political factors, such as decision making around resource allocation and the distribution of support and responsibilities within schools. As with CS value, there were no statistically significant differences in perceptions of external support for CS between respondents at lower- and higher- implementing schools. However, it is interesting to note that for both groups, the percent who agreed or strongly agreed with external support CS items—ranging from 33.6 to 62.6—was consistently lower than the percent who agreed or strongly agreed with internal CS vision and CS value items—which ranged from 67.2 to 83.6.

5.3.2 CS School Team. Another political element of CS implementation is the "CS school team." As part of the CS for All initiative, schools in the district were encouraged to designate a team composed of teachers who participated in the curriculum PD and other school staff who were charged with planning and overseeing the CS programming in the school. We consider CS school teams to be a political element that supports reform by codifying relationships, support structures, and the distribution of power for planning and decision making around CS implementation. Most of the schools responding to our survey did have a team (80.1% of lower-implementing and 86.3% of higher-implementing), with no statistically significant difference between lower- and higher-implementing schools. Furthermore, multiple aspects of a school's CS team composition—the presence of a principal, assistant principal, or one or more CS teachers, and the number of personnel on the team—did not differ by implementation level. However, we found that lower-implementing schools were less likely to have a CS Lead teacher (p<.05) and more likely to have a guidance counselor (predominately at the high school level) on their school team (p<.05). Lower-implementing schools also had fewer CS Leads at their school (p<.01). The importance of a CS Lead teacher may reflect Coburn's notion of a shift in ownership to those at the center of the work [1].

Table 6: Political Elements by Implementation Level

		Lower-imp.	Higher-imp.	Diff.
External CS Support (% Agree or Strongly Agree)				
	(1) There is collaborative planning time for CS.	49.2	51.0	−1.8
	(2) Teachers can articulate the school's CS vision.	33.6	34.4	−0.8
	(3) Teachers understand the school's definition of CS.	33.9	38.9	−5.0
	(4) Teachers have access to PD and other resources.	62.6	62.6	0
CS School Team	% Has a CS Lead on school team	44.5	56.1	−11.6 *
	% Has guidance counselors on school team	12.3	5.7	6.6 *
	Mean # CS Leads at the school	0.3	0.6	−0.4 **

*p<.05, **p<.01

5.4 Recommendations for Support

When asked in an open-ended survey question for recommendations to improve school support for CS implementation, planning, or CS culture building, respondents' answers included technical, normative, and political elements. Most of the recommendations (68.9%) mentioned technical elements, especially PD. These suggestions focused mainly on having more opportunities for PD, differentiating sessions based on skill level or position on the CS team, and holding the PD sessions at different times (e.g., during the school day rather than on Saturdays, etc.).

This year specifically there is a lack of PD time and collaborative planning for teachers which makes it challenging to turn-key the CS work to more of the school community. It might be helpful if the CS team offered PD to all staff (perhaps per-session might help to get staff to engage outside of school hours).
— Higher-implementing school

The second most common type of recommendation was related to political elements (24.5%). This included recommendations such as making CS a graduation requirement, increasing allocation of resources like time and funding, and emphasizing the importance of administrators being invested in the CS program at their school.

My principal keeps telling me that because CS4All hasn't "given me one dollar", she cannot add additional sections of CS. It's simply not a priority for her.
— Lower-implementing school

In contrast to the findings above (about similar perceptions of external support), more lower-implementing schools mentioned the need for administrator buy-in and support in their recommendations, compared with higher-implementing schools (16% versus 10%).

Principals and assistant principals need to be well trained and vested into building CS culture in their buildings. The work of CS leads and CS teachers is almost impossible without the support and motivation from administration.
— Lower-implementing school

Finally, about 15.1% of the recommendations were normative in nature, such as urging staff to value CS, encouraging teachers to accept a new mode of teaching, and strengthening the CS culture in the building.

Recognition by admin and all staff that education without CS integration is irrelevant for future endeavours in society and diseducation of our urban, in particular, our inner city students. Without CS for All, traditionally underserved students, families, and communities will continue to be minimalized and marginalized in society, remaining the under-class.
— Lower-implementing school

Currently our CS Lead teachers are having a challenge getting tired, tenured staff to accept something new (and viewed as extra) AND untenured teachers are quite worried about their student's focus and result on major subject area assessments.
— Lower-implementing school

Overall, higher- and lower-implementing schools made a similar proportion of recommendations related to normative and political elements, while higher-implementing schools were more likely to make recommendations related to technical elements. Table 7 displays the distribution of recommendation type by level.

Table 7: Percent of Recc. Type by Implementation Level

Row %	Technical	Normative	Political
Lower-imp.	58.4	13.0	26.0
Higher-imp.	74.8	16.3	23.7
Overall	68.9	15.1	24.5

NOTE: Codes were not mutually exclusive (e.g., a recommendation could be both normative and political).

6 SUMMARY AND DISCUSSION

Our findings identified key similarities and differences in the technical, normative, and political aspects of CS implementation for lower- and higher-implementing schools. We found the greatest discrepancies in the technical dimension of implementation: although the *types of requests* for technical support were similar between implementation levels, the difference lies in the extent to which technical resources were being *utilized.*

Lower-implementing schools sent fewer teachers to CS leadership or curriculum PD, and were less likely to have developed a CS implementation plan or key plan components such as a goals statement, a vision statement, and plans for organizing events, evaluating goals, or engaging families in CS. Surprisingly, higher-implementing schools also requested more technical support than lower-implementing schools—one might assume schools are higher-implementing precisely because they have fewer technical support needs. Instead, it may be that higher-implementing schools make more requests for supports than lower-implementing schools because they have a more concrete understanding of their technical barriers and are more familiar with requesting and deploying those technical supports. Schools that utilize technical resources may have a further advantage if it bolsters normative supports (e.g., having a clear schoolwide vision for CS increases teachers' personal beliefs in the value and importance of the work), and lower-implementing schools may be at a double disadvantage by not having these technical supports in place.

Thus, identifying the underlying factors that contribute to the lack of technical resource use is imperative to understanding the unique barriers that lower-implementing schools face. To this end, we explored several normative and political elements of a school's CS programming. We found that, surprisingly, normative values of CS—its priority and importance and the perception of "who CS is for"—were similar between the two groups. It therefore may be the case that the individual motivation to implement CS is not a primary factor in implementation differences and technical resource usage; rather, more systematic barriers may be at play.

The political elements of a school's CS programming may hint at these systematic challenges. We found that lower-implementing schools made more requests for political support, such as administrator engagement and allocation of technology, time, and funding. While there was no difference between the groups in perceptions of external CS support (e.g., access to PD) or the presence of an administrator on the CS school team, lower-implementing schools were less likely to have a CS lead on their CS team and made more—and qualitatively stronger—requests for administrator support. This finding suggests that schools may need fundamental political support—in terms of buy-in from school leaders or support from a CS lead—to get their CS program off the ground. Taken together with the finding that respondents from higher-implementing schools also had a stronger internal vision of CS, these results indicate the importance of having not only administrator support, but also a key staff member who can champion a strong CS vision and program for the school.

7 LIMITATIONS

The conclusions drawn here are limited by the fact that we do not know if the schools responding to the survey were representative of all schools in our sample. For example, respondents may be more supportive of CS education than non-respondents. In addition, we collected one survey per school: The opinions of the respondent may not be representative of all administrators and teachers in the school. Finally, our analyses are descriptive and correlational in nature. We are not able to claim causal relationships. Instead, we aim to provide an exploratory and theoretical foundation for future research on how to bring CS for All to scale.

8 CONCLUSION

To date, much of the focus on K–12 CS education has been on the critical need to develop teacher capacity to implement CS curricula and the challenges teachers face in providing high-quality CS instruction [3, 4, 6, 18]. Less attention has been paid to scaling up CS education. Yet, we know from education school reform and scale-up literature that for initiatives to be successful, they must attend to multiple factors beyond teachers' individual capacity to implement curricula [1, 10]. This study examined the specific challenges and needs of schools that, despite resources and support, have struggled to make progress where other schools have succeeded.

Applying Oakes' framework of the technical, normative, and political dimensions of school reform, our findings suggest that while normative perceptions of the value and prioritization of CS are similar between lower- and higher-implementing schools, technical challenges to implementation—specifically the lack of resource use—and political challenges, such as a lack of support from administrators and CS leads, are greater for schools struggling to offer CS. Additionally, these factors may all contribute to and be exacerbated by a weaker vision of CS as expressed by the CS spokesperson at the school.

Ultimately, it is likely that what differentiates higher- and lower-implementing schools lies at the intersection of these technical, normative, and political dimensions. It may be their cumulative effect that allows schools to successfully scale up, rather than any single factor or set of factors that makes the difference.

9 FUTURE DIRECTIONS

While our study provides insight into the challenges and needs that are specific to schools lagging in CS implementation, it also points to areas for future research. First, Coburn's conceptualization of scale highlights the importance of looking at more than the number of teachers, schools, or districts reached. The CS for All movement cannot be deemed successful without "attention to the nature of change in classroom instruction; issues of sustainability; spread of norms, principles, and beliefs; and a shift in ownership such that a reform can become self-generative." (p. 4). Future research assessing CS for All must also include measures of depth, spread, sustainability, and shift in ownership. Second, CS for All movements across the country are increasingly attending to the fact that expanding access and participation is not sufficient to address deep-seated inequities and structural racism that produce gaps in CS opportunities and outcomes [11, 13, 14]. Thus, we must move beyond numerical assessments of parity [7] to include a broader vision of equity in CS education.

Related to Coburn's notion of deep and meaningful change, gauging the success of CS for All should include assessments of students' experiences and access to instruction that affirms cultural identities, elevates historically marginalized voices, empowers students as agents of social change, and supports their engagement, learning, growth, and achievement in CS [15]. Guzdial's prediction that it will take 40 years to achieve "All" at the current rate looms large for the CS for All movement. This study demonstrates that attending to teacher capacity building is not enough to achieve scale. To change this trajectory, it will be imperative to consider the multidimensional aspects of scaling up and to address the technical, normative, and political barriers to getting to all.

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