CS-CAVE: DISTRICTS' ROLES IN BROADENING CS ACCESS

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This research investigates the spread and sustainability of university efforts to increase the number and types of computer science (CS) courses available in K-12. Two university/K-12 collaborative projects in the San Diego region provide insights into pathways for sustainability. Nearly 75 teachers were trained to teach CS Principles through professional development by university CS faculty and staff. Despite myriad challenges, one-third of the teachers implemented the course. Subsequent research explores three school districts as active players rather than passive recipients (or worse, resistors) of NSF-funded university-led efforts, revealing political and cultural challenges to implementation and sustainability of CS education reform.

Computing pervades contemporary life. The US economy demands workers with computational competence. Yet, few K-12 students, particularly those from low-income and minority backgrounds, have access to formal learning opportunities in computer science (CS) [2]. To meet economic demands and give students access to opportunities, the US education system must expand CS offerings in K-12 education. Equally critical, this expansion must be equitable and accessible to diverse student populations, not limited just to the affluent and tech-endowed schools.

Educational leaders call for expanding access to K-12 computing education, with deliberate attention to broadening participation by students traditionally underrepresented in computer science, including female, African American, Latino, Native American, and students with disabilities/learning differences. Researchers have documented disparities in students' K-12 access to computer science learning opportunities, but higher education's investment to actively assist K-12 is more recent [1]. Higher education partnerships with K-12 have increased the number and types of CS courses available for students. Our research expands the scope to investigate sustainability and spread of CS reforms.

Two sequential CS education projects involving collaboration between California higher education (UC San Diego and San

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Diego State University) and K-12 education in the San Diego region highlight this recent progression from implementation to sustainability research in K-12 CS education, providing insight into pathways for sustainability.

Two efforts to broaden participation in CS: From *ComPASS* to *CS-CaVE*

In 2011, the National Science Foundation (NSF) funded teams at University of California San Diego (UCSD) and San Diego State University (SDSU) to conduct research on adapting a college-level course, CS Principles (CSP), for high schools in San Diego County, California. This CE21 project, "Computing Principles for All Students' Success" (ComPASS), aimed to create a broader pool of CSP teachers, expand CSP class offerings, increase the number of schools offering CSP, and broaden teacher and student participation. ComPASS project objectives were to:

- develop and evaluate content and pedagogy training and support resources for teachers (with or without computing backgrounds) to teach CSP;
- build a regional computing education community to provide sustainable peer support for new CSP teachers.

ComPASS has trained approximately 75 teachers to teach CSP, through intensive CS workshops and professional development led by UCSD and SDSU Computer Science faculty and instructors from the San Diego Supercomputer Center (SDSC). However,

despite more than a year of preparatory educational outreach to county and district leadership and prerequisite endorsement from each teacher's principal, a major challenge to the *ComPASS* project emerged. Individually recruited *ComPASS*-trained teachers returned to their schools eager to teach CSP, only to discover that decision-makers, budgets, technology limitations, institutional policies, etc. barred their way. Time after time, teachers discovered that the CSP courses they were trained to teach and had planned to teach were dropped from the master schedule. Explanatory factors included low-enrollment or administrative decisions that the teachers' talents and credentials were needed to teach another "more core" course, such as mathematics or science. The course's initial status as an elective without college-prep standing yielded classrooms of marginally engaged students with no other options—a challenge for any teacher but particularly for teachers implementing new material. Despite these challenges, nearly a third of the *ComPASS* teachers implemented the course, providing useful feedback to the *ComPASS* team.

Growing awareness of the complexity of these challenges prompted the UC San Diego leadership at the Supercomputer Center to partner with the Center for Research on Educational Equity, Assessment, and Teaching Excellence (CREATE) also at UC San Diego for a subsequent STEM+C project. NSF's STEM+C project, "Computer Science: Creating a Village for Educators" (*CS-CaVE*), combines the know-how and networks of SDSC, UCSD Computer Science faculty, and CREATE[1] to address a different aim from *ComPASS*. Specifically, *CS-CaVE* examines how school districts might become active players instead of passive recipients (or worse, active resisters) of university and NSF efforts to broaden participation in computer science (CS). Working with district partners, *ComPASS* and *CS-CaVE* reveal that the technical aspects of CS curriculum and teacher training present only one set of challenges. The political and cultural aspects of ensuring that such courses are offered and thrive in districts compound the complexity, presenting another set of very different challenges.

Social and political—rather than technical—dimensions may often stymie equity in education

Critical challenges to reforms for educational equity are often cultural and political [3]. Changing attitudes and behavioral patterns have historically proven far more difficult than solving technical problems. Those who tackled long-standing inequities in educational opportunities based on race and class distinctions—from desegregation in the 1950s and 60s to de-tracking in the 80s and

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[1] CREATE is a unique, design-based research center with a long history of working collaboratively with K–12 districts and schools in the San Diego area, leveraging resources from the university to serve local high-need schools and districts.

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90s—struggled more from lack of political will and challenges reshaping cultural norms than from technical challenges of busing, or pedagogy for teaching diverse student groups.

At each implementation level—state, district, school, and classroom—politics (who makes decisions), budgets (where finite dollars go), and organizational norms (it's always been done this way) often become the primary drivers (and saboteurs) of equity-minded reforms.

CS-CaVE brings together design-researchers from CREATE, computer scientists from UC San Diego and SDSC, and educators from three large regional districts that serve large numbers of low-income students, English learners, and students with special needs. *CS-CaVE* studies the complex social and political ecosystem surrounding CS education and challenges to ensuring sustainable CS for diverse student populations. Together these three school districts serve over 40% of the region's secondary school students.

CS-CaVE's team engages a number of "master teachers" recruited and nurtured through the *ComPASS* project, supporting them to drive change within their districts to increase students' access to CS learning opportunities. The university and SDSC provide assistance to the districts in the form of new CS content, facilities, equipment access, modest funding for teacher professional development stipends, evaluation services, and overall consultation. However, the districts are "in charge" of the growth of their CS course offerings, both during and after the grant ends. CREATE researchers examine how the three districts use resources, strategies, communications, and influence to promote and sustain CS.

Early results from *CS-CaVE*: Districts' narratives shape answers to, "Why CS?"

The three districts show fascinating early success stories, achieving as much as nearly a 600% increase in students taking CS courses. From 2013/14 to 2014/15, they have rapidly expanded their CS opportunities for low-income, minority students; nurtured passionate internal/external champions; and espoused specific narratives that allow for broadening CS participation within their boundaries. Preliminary research results from in-depth interviews in spring

Districts	# Schools	# Teachers	# 7-12 Students	# (%) English Learners	# (%) Students with Disabilities	# (%) Free and Reduced Price Lunch Eligible
District A	176	5614	108,783	27,686 (25.5%)	12,174 (11.2%)	65,037 (59.8%)
District B	31	1753	41,340	8,167 (19.8%)	4,835 (11.7%)	22,725 (55%)
District C	29	1220	22,274	4,043 (18.2%)	3,019 (13.6%)	13,703 (61.5%)

2015 with 33 district administrators, principals, master teachers, and classroom teachers reveal that a primary strategic difference among districts is the choice of what kind of compelling *narrative* officials have used to frame their districts' CS work. Because CS growth must fit within pre-existing narratives of ongoing reform movements in each district, each district has woven a different story to answer the question of *Why CS?* These narratives then drive who gets involved, who benefits, and inherently who might protect and/ or nurture the reform's future fate.

District A:
CS strengthens career pathways and real-world connections
In District A, CS lives in the College Career Technical Education (CCTE) division and is championed on the ground by a resource teacher overseeing Instructional Technology, a group within CCTE that is overseen by the Office of High School Improvement. District A's narrative as to *Why CS?* is less about broadening participation in CS or competitiveness for their college-bound students (contrasting narratives that might emerge in other contexts). Rather, district officials supportive of the reform see CS courses, in part, as strengthening career pathway strands in high demand by students and the marketplace, as well as helping serve the technical and political District need to bring CCTE pathways into federal compliance for continued funding.

Indeed, District A's recent internal audit of its CCTE pathways alerted officials of federally funded pathways that did not adequately provide high-quality content and sequencing. Although the Information and Communication Technology (ICT) pathway fared better than some, it needed some course realignment. So district officials now present Computer Science Principles as a great entry-level course to reinforce their ICT pathway. Simultaneously, shepherds of the ICT pathway are clarifying and refining the meaning of computing education, emphasizing high-level skills of computational thinking used in programming, and updating old models that focused on computing tools and applications.

The choice to position CS within CCTE reform inherently shapes the reform itself. It dictates which teachers get involved in CS training and coursework (those teaching within or to students headed to an ICT pathway), which school principals learn about the reform (those with an ICT pathway or one in development), and which kinds of supplemental funding (from CCTE) can augment *CS-CaVE* support.

Positioning CS within CCTE also makes CS itself somewhat secondary to District A's larger aims to retain students by linking student learning to "real-world content." Like culinary arts, robotics, or health sciences, CS and ICT pathways are options to increase student engagement in school. What this also means is that although many more students may, over time, have access to ICT pathways (and CS), District A does not see CS as essential for *every student*—in contrast to core curriculum.

District B:
CS develops students' mathematics abilities and should count as math
In District B, CS classes live in math departments, are primarily championed by math teacher leaders, and are supported by

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top-level school/district leadership. At first glance, District B's narrative echoes some of District A's desire to use CS for real world content—but in support of a core subject area: mathematics. District B's public narrative answers *Why CS?* by positing that CS supports the district's Common Core agenda by developing students' computational thinking and strengthening the district's integrated math instruction.

But digging deeper into the District B way of thinking, we learned through a series of interviews up and down the system that District B is in part using the narrative of CS for math as a way *both* to address students' mathematical struggles, *and* to deliberately move CS from the periphery to the "core" to ensure longer-term sustainability of CS coursework in their district. In particular, District B officials have worked hard over the year to integrate CS with mathematics in several ways—including by getting some CS courses to satisfy the coveted "C" math requirement by the University of California/California State University a-g college entrance system. They believe that making CS "count" for a math course will inherently stabilize CS offerings for years to come. Or, as one district official stated, "it's easy to continue to push electives to the fringe, but if you have a class that's replacing a primary core then you can't get rid of it." District B's efforts then reflect a deliberate attempt to move CS politically and strategically into the heart of K-12 education: mathematics.

District B's effort to lean heavily on mathematics teachers also fits well with the political climate in the state of California, where legislative moves have recently restricted which teachers can teach CS coursework. Mathematics teachers (in contrast to science teachers, for example) are allowed to teach CS, as are instructional technology teachers from CCTE divisions within districts.

District C:
STEM awareness and opportunities—from fairs and festivals to robust course offerings
District C has recently launched efforts to broaden participation in CS via partnership with UCSD. District C's efforts are led by a science resource teacher in the curriculum office. Admittedly not a CS teacher leader, this science teacher leader received approval from district officials in 2013 to launch a community campaign to encourage greater STEM awareness among the district's majority Latino, low-income families. District C's narrative: CS courses are STEM electives that elevate students' and families' awareness about innovation and careers in STEM. In doing so, they help make their formerly lagging district "Future Ready."

> Thus, for District C the narrative of 'STEM for all' (combined with concern that the district was "behind the times") framed support for CS courses in middle and high schools as evidence of their focus on preparing students for jobs of the future.

Since 2013, District C has increased STEM awareness through a family-focused STEM Fest, inviting various community agencies to set up booths, run demonstrations, and showcase students' STEM projects. UCSD has presented 2-4 booths each year. One district official explained, "I think we're just now . . . shifting to understand the importance of supporting our STEM programs. Four or five years ago you really didn't talk about it a whole lot, but now that we have an increased awareness … I've had lots of STEM conversations."

Computer science courses comprise one next step in transitioning from fairs and festivals to more robust student offerings. District officials noted that authentic support for STEM pathways in CTE, robotics teams, etc., meant more than offering their existing CAD courses, which would be insufficient to meet the rising demands from students and the community. Another district official explained further,

> *The concept is starting to gain traction… We've offered computer courses…through CTE. But programming's always been a gap mainly because at the high school level you often form robotics teams...to do the robotics projects for FIRST and for the Alliance they need a coding aspect. They've often just filled it with whomever they can in their class that knows code, and that's kind of been how the teams have formed. Now those teams are getting really competitive [describes CCTE push as well] … So it's the right time. We're kind of meeting things right at the right time, I think, with this grant.*

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How districts choose to position CS provides new lessons to achieve sustainability in CS education

The narratives that each of the three Districts A, B, and C have adopted vary in their framing. These variations affect how and which teachers become involved, funding availability to support CS growth and sustainability, and who champions the CS cause inside the district. They reflect three different strategies that are driven in part by district-specific contexts: their developmental trajectory in CS, and worries, concerns, priorities, and opportunities perceived within their communities. These are rarely technical conversations or considerations. More often they are deliberate political and cultural strategies enacted by district officials to build support for CS and to position CS growth for at least the short and mid-term. The *CS-CaVE* research team continues to watch and learn with and from these three intrepid districts, discovering much about how CS courses might be best positioned in different district contexts to make both scale and sustainability more likely. *CS-CaVE* aims to provide a close examination of educator colleagues' strategies to alter their social-cultural, political, and technical systems to make CS part of public education for all (or at least far more) students. **Ir**

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