CS-LISTEN: Students as Active Changemakers in RPPs

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Abstract

The CS-LISTEN National Science Foundation (NSF) Research Practice Partnership (RPP) is housed within the Center for Research in Education Equity Assessment & Teaching Excellence (CREATE) at UC San Diego. For 23 years, CREATE has housed trusted, long-standing partnerships with districts, schools, and local educators. CS-LISTEN's RPP meets with an advisory board of non-profit, university, and K12 teachers (bi-annually), four districts' and school-level administrative leaders (quarterly), ten high school teachers (weekly), and 112 participating students in small teams (weekly) at schools. Youth Participatory Action Research (YPAR) methods allow CS-LISTEN Student Co-Researchers (SCRs) to work alongside teachers and CREATE researchers to gather data and research their schools/peers as to why many underrepresented students do not participate in computer science (CS) classes. Nine SCR teams designed unique research questions and surveys, collected data, and conducted analyses. SCRs reported findings and recommendations to school and district leaders, and designed, coordinated, and led Action Cycles to increase CS participation at schools. In Action Cycles, students, CS-lead teachers, and administrators worked to enact SCR teams' recommendations. They did this through the creation of new a) virtual re-branding via promotional projects and presentations, b) coding bootcamps and hackathons, and c) incorporation of novel systems-level changes at their schools and districts. Preliminary findings from RPP member (student, teacher, and administrator) interviews reveal that CS-LISTEN student RPP members have helped expose CS broadening participation in computing (BPC) issues in novel ways. The nine SCR teams and the RPP efforts overall show how students can act as changemakers within RPP structures to catalyze BPC equity projects in schools and districts. This paper shares best practices and strategies for designing and implementing YPAR, and specifically student-co-research, as a foundational pillar of RPPs to improve BPC projects and increase more equitable student engagement in computer science.

Keywords

Computer Science Education, Youth Participatory Action Research, Research-Practice Partnerships

Why Computer Science Needs YPAR + RPP

In the United States, broadening participation in computer science has become a paramount call to action. According to the U.S. Labor Statistics, the demand for students learning computer science (CS) has risen in the past two decades [13]. With the global pandemic, improving participation in CS is even more important [6]. But participation among low-income students, students of color, and female students has stagnated [3]. To tackle this dire issue, many governmental, non-profit organizations, and school districts have partnered to address CS rates through research-practice-partnerships (RPPs). Nonetheless, within RPPs, K12 students as changemakers remain rare. In this article, we demonstrate how CS-LISTEN places students in the driver's seat, alongside teachers, district and school leaders, and university researchers, through the use of Youth Participatory Action Research (YPAR) structures and practices.

CS-LISTEN: Computer Science Learning and Inquiring with Students through Equity Networks

CS-LISTEN is a National Science Foundation funded RPP that includes four districts' and school-level administrative leaders (meeting quarterly), ten high school teachers (meeting weekly), and 112 participating students (in small teams) (meeting weekly) across nine high schools.

The work of the CS-LISTEN RPP is to investigate: *How can the inclusion of student voice in the design process increase engagement in K12 CS pathways?* By employing YPAR practices and structures, CS-LISTEN researchers worked with Student Co-Researchers (SCRs) and teachers from January 2020 to June 2021 to gather, analyze, and present data on CS at their schools. Overall the groups studied why their schools/peers do or do not enroll larger numbers of underrepresented students in CS classes. (See figure below for an example of the SCR Cycle within CS-LISTEN.)
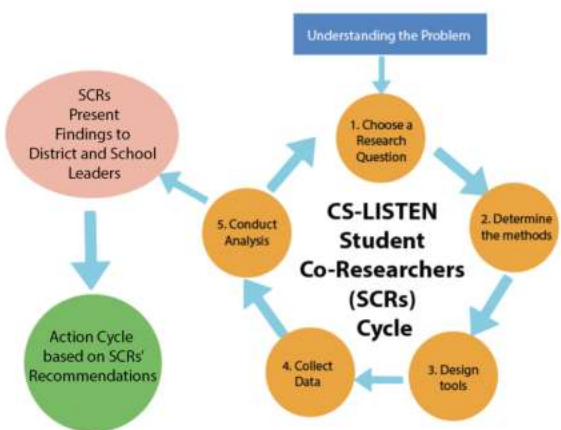
During the first five phases of work (see the orange cycle above), the nine CS-LISTEN SCR teams and their teachers designed unique research questions and surveys, collected data, and conducted analyses. The SCR teams then reported findings and recommendations to their respective school and district leaders, at a large (virtual) conference -- CS LISTEN UP -- attended by 250+ students, parents, educators and administrators including district superintendents in November 2020. (See pink circle above.)

Lastly, RPP teams of university leaders, students and teachers -- periodically joined by administrators at the school and/or district levels -- designed, coordinated, and led Action Cycles to increase CS participation at schools. (See green circle above.)

In Action Cycles, students, with CS-lead teachers, enacted recommendations through the a) creation of new virtual re-branding and promotional projects and presentations, b) coding bootcamps & hackathons, and c) incorporation of new systems-level changes at their schools and districts. By describing this process, we share our initial findings and recommendations for doing YPAR in the scope of RPPs.

What is Youth Participatory Action Research (YPAR)?

Starting in the mid-2000s, social scientists began exploring how to engage youth in research and practice. Epistemologically, YPAR extends from participatory action research (PAR), which uses both quantitative and qualitative methods "to interrogate the conditions of oppression and surface leverage points for resistance and change" [4]. Theoretically, YPAR comes from critical psychology and positions youth as agents and experts of their own lived experiences [7]. Essentially, YPAR work is 1) grounded (in students' experiences) 2) participatory (with students as partners) and 3) transformative (make communities/lives better). Anyon and her colleagues' meta-analysis of 67 YPAR studies conducted from (1995 to 2015) suggests that engaging in YPAR positively impacts participating youth who experience an increased sense of agency/leadership, interest levels in career development, and critical consciousness [1]. Yet, while the third dimension of student voice/YPAR work demands "transformation", there is far less published work on the qualitative or quantitative impact of student voice work on institutional change. Few studies have tracked how student-driven research impacts institutions and systems [8].

School and District Contextual Factors for CS-LISTEN Sites

CS-LISTEN engaged YPAR student teams that we call Student Co-Researchers (SCRs) within our collective RPP. Our goal: to investigate and begin to address uneven school and district patterns on CS enrollment at the nine participating high schools and within their four respective districts. Altogether the districts serve a majority of San Diego County high school students. The four districts were San Diego Unified School District (SDUSD), Sweetwater Union High School District (Sweetwater), Escondido Union High School District (EUHSD) and Vista Unified School District (Vista). All nine participating CS-LISTEN comprehensive high schools serve highly diverse populations. Their districts are equally diverse overall, as noted in the table below: "EL" (English learners); "SWD"

(students with disabilities); "FRPL" (free/reduced price lunch); and "F/H" (Foster/Homeless).[1]

Districts	#Schools	# Teachers	# Students	# ELs	# SWD	# FRPL	#F/H
Escondido	7	466	9,480	1,204	663	5,859	47
San Diego	176	5,614	108,783	27,686	12,174	65,037	600
Sweetwater	31	1,753	41,340	8,167	4,835	22,725	206
Vista	29	1,220	22,274	4,043	3,019	13,703	153
Total	243	9,053	181,877	41,100	20,691	107,324	1,006

During the 2020-21 CS-LISTEN project, the nine participating high schools enrolled students from grades 9th-12th, averaging 1,955 students per school. Approximately 72 percent of the students at the schools were eligible for free or reduced-price meals and the majority of the schools' students are Latinx. The nine CS-LISTEN high schools enroll a total of 12,440 Latinx, 2,487 White, 677 Black, 639 Asian, and 102 Pacific Islander students.

CS-offerings: The participating schools all offered Advanced Placement CS Principles (AP-CSP) during the 2019-21 school years. In addition, the majority of schools also offered the more advanced AP-CSA course and/or a more advanced comparable CS course (e.g. Computer Gaming). A few schools offered an even earlier sequenced course (pre AP-CSP) using curriculum such as Exploring CS, and CS Discoveries. A couple of schools also had additional supplemental/related courses such as Data Sciences that were positioned within the mathematics departments rather than college and career readiness or technical education units of their districts.

YPAR Student Recruitment

The 112 participating CS-LISTEN SCR students were recruited through a combination of teacher solicitation through classroom presentations, school announcements, and personal invitations by teachers/administrators to potentially interested students. Students who joined their schools' SCR teams also helped to recruit peers to join the teams. Special efforts were made to recruit among both CS experienced and non-CS students as well as to recruit a diverse team of students at each school regarding their academic backgrounds, grade levels, and race/ethnicity/gender. Participating students received a thank you gift card of $100 at the end of their participation, along with a certificate.

What Did the Student Co-Researcher RPP Teams Accomplish?

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[1] While this table helps lay out demographic patterns, we recognize students live in an intersectional world of underrepresentedness, occupying more than one subgroup simultaneously.

All nine CS-LISTEN SCR teams worked with their teachers and university leads to identify and then investigate a joint CS research question. The SCRs used primarily survey data to answer their respective research questions. (See the following figure for the nine SCR teams' questions categorized by type.) The CS-LISTEN university researchers lead a series of meetings and brainstorming sessions to assist SCR teams and their teachers. In these meetings, teams crafted meaningful research questions. Researchers helped ensure that the questions were operationally definable and pursuable within the four-month time frame. In all cases, preservation of the students' collective voice and perspective remained paramount during research question creation.
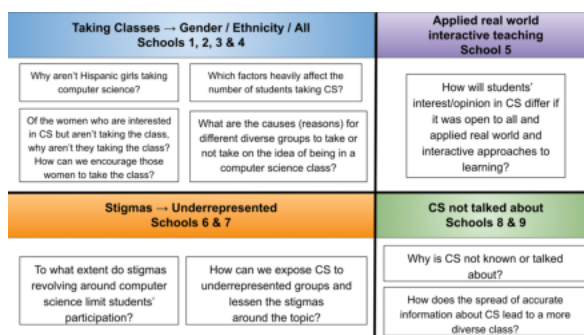
After research questions were identified, researchers continued to work with the SCRs and the teachers on methods. The nine teams ended up using survey methods. University leads were impressed by the amount of data gathered and analyzed by the SCR teams with their teacher leads, particularly during the pandemic. Across the nine SCR teams, survey responses ranged depending on the topic being addressed, with some teams surveying over 700 students at their schools and others a more targeted 80+ students.

Next, we describe the scope of work SCR teams accomplished while conducting their research projects. Then, we describe how some members of the SCR teams (and other students who joined later) worked with teachers, administrators, and university leads to move the SCR teams' recommendations into Action Cycles.

SCR Data Collection and Data Analyses

After identifying their research question and study populations, each SCR team worked carefully with their teacher leads and UC San Diego CS-LISTEN researchers to develop methods that would help answer their questions. In the end, the SCR teams used Google Forms to gather their data because of the familiarity of Google Forms among their student populations. Although all nine SCR teams ended up using surveys, surveys are not necessarily the only method YPAR projects can deploy. SCR teams were encouraged to

think about adding interviews to their data collection and some had planned to before the Covid-19 disruption in March 2020. As for the data collected, the surveys varied by schools in terms of length, format, questions asked, and respondents surveyed. As a support, UC San Diego team leaders created informative slide decks for the teachers and SCR teams as they crafted their surveys. These decks introduced survey methods, question construction, skip logic instructions, scales, and access to public databases, among other topics.

All nine SCR teams and their teachers used these slide decks within the weekly meetings with UC San Diego researchers to craft nine distinct surveys that focused on their research questions. Then the SCR teams deployed their surveys.

Once the SCR teams completed data collection (most were finished just prior to the shutdown in March 2020), data analyses were paused until fall 2020. Data analyses were also supported by the UC San Diego team and teachers through the creation of slide decks and mini-lessons on data analyses. Teachers also helped SCRs make sense of the data they had collected.

The SCR teams and their teacher leaders uncovered many findings from their survey analyses. For instance, at Morse High School the SCR team and teachers asked, "To what extent do stigmas revolving around computer science limit students' participation?" They came to the conclusion that the majority of surveyed students were both open to CS information and woefully uninformed at the same time. While a majority of students surveyed (67%) appreciated the importance of CS to society, a majority (57%) also had no idea what it was exactly. Students knew it was important, but they didn't know what it was. Indeed only 7% of surveyed students at MHS rejected the idea of having CS introduced to them at all. At the end of their analyses, the MHS SCR team and their teachers concluded:

> We should strive to provide more opportunities to learn more about coding specifically, we believe that with more effort thrown into communities like ours, we can raise the number of minorities pursuing Computer Science in their post-education career.
>
> *Morse High School SCR team*

At Orange Glen High, the SCR team was interested in finding out, "What factors heavily affect the number of students taking CS?" In their survey of 303 students, the OGHS SCRs found that the majority of students did not know what CS is, and female students were less likely to want to take CS. The OGHS SCRs analyzed that one of the

factors may be due to the fact that female students reported using their class schedules more often to plan out their future courses. This sometimes led female students to conclude that CS classes did not fit into their schedules. Because of this, OGHS SCRs posited that there may be a systemic scheduling issue (real or perceived by females), preventing some young women in particular from pursuing CS classes.

Finally, at Hoover High School, the SCRs and their teacher asked, "How will students' interest/opinion in CS differ if it was open to all and applied real world and interactive approaches to learning?" They concluded that Advanced Placement CS Principles (AP-CSP) should be open to all students regardless of their tracks and academies. Since Hoover High students apply to Academies at the start of their freshmen year, SCRs pinpointed that the opportunity to take CS classes was only available to students in the Academy of Information Technology, (AOIT). AOIT students represented only a subset of students within the larger high school. Students outside of AOIT were unable to enroll in the AP-CSP course. As a result of their research, the Hoover SCRs and their teacher then recommended that a brand-new section of AP-CSP should be opened at Hoover, but this time for all Hoover HS students.

These are just three examples of how SCR teams moved from their research questions to data instrumentation, collection, and analyses. All nine schools' SCR teams followed a similar trajectory.

SCR Teams' Findings and Next Steps

By fall 2020, the SCR teams had produced a mountain of data and analyzed their findings alongside UC San Diego researchers and their teacher leaders. These findings were later compiled and shared with a large audience of 250+ at the CS-LISTEN UP conference in November 2020. They also produced a list of recommendations for each school to broaden participation in computer science.

For many YPAR projects, this is often where the story ends. YPAR students do studies, and then present findings. Usually it is up to the adults with power to then enact (or not) the changes recommended. Fortunately, the RPP structure of the CS-LISTEN UP grant and the NSF support allowed for the second phase of our collective work to begin: The Action Cycles.

Action Cycles: YPAR to Practice

What are Action Cycles? CS-LISTEN Action Cycles involve small teams of students, educators, administrators, and UC San Diego researchers taking SCRs' recommendations and designing, testing, and re-testing the SCR recommendations

as interventions. In an Action Cycle, newly designed interventions might take the form of early prototype efforts field-tested at one school or with a small group of students (in a single class period for example) or even larger campus initiatives (e.g. a new school-wide recruitment strategy for women). In this way, CS-LISTEN, as a RPP, leans on the structures and practices of SCRs (as YPAR) and Action Cycles to gather new insights (through student research) which lead to potentially new school or district practices and policies over time (through Action Cycles).

Whatever the interventions, **the CS-LISTEN Action Cycle is where the research transforms to practice** — in the form of prototyping, testing, and retesting.
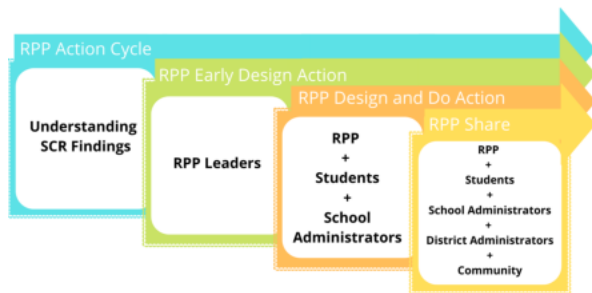
Early Assumptions and Shifts in Practice

Early on, and in our original grant proposal, we assumed that adult RPP members (teachers, administrators, and district folks) would largely run the Action Cycles. After meeting twice with our project's advisory board, however, we heard the strong suggestion that students might continue to play important roles in the Action Cycles. District officials also stated that they saw tremendous value in encouraging the SCRs to continue as active members.

Once the transition started from SCR work to the Action Cycles, we quickly learned that a high number of SCRs were indeed interested in actively working on their school's Action Cycle teams. They were interested in seeing where their recommendations would go. They were intrigued with the idea of having a voice in allocating the Action Cycle budgets afforded to their sites by the grant. Many SCRs seemed to have developed a collective sense of social justice around the need to broaden participation in CS.

> I like the fact that we are working towards diversifying the computer science field because as a school, we have a lot of minorities here, and I just want them to be represented more in that field.

Latinx female student from Hoover High School

What I find exciting about CS-LISTEN is working with people that I really don't see everyday and working towards a problem that we may actually make a difference within our school.

Black male student from Morse High School

As a result, at all nine schools, SCR team members stayed involved as leaders of the Action Cycles. Schools varied with some schools retaining a single SCR team member and others actually growing their student involvement to 30+ students. All but two of the lead teachers also stayed with the Action Cycles and continued to provide a space (usually virtual) where the involved students could work in teams and with other educators on Action Cycle tasks when needed.

Examples of Student Co-Research to Action Cycle Work in CS-LISTEN RPP Teams

At Morse High School, for example, the SCR team's research had identified a **key issue — outreach to younger grades.** Students, they found, through their survey work, were unaware of CS opportunities and courses at their high school. When the school shifted to the Action Cycle period, the first step was for the students and teachers to discuss these recommendations with the Morse High principal in a follow-up meeting. In addition, a district resource teacher who was placed at Morse High also became keen on working on this recommendation. The MHS RPP team had transitioned to include UC San Diego CS-LISTEN researchers, SCRs, new students, the lead teacher, and the principal and district resource teacher. (While the principal was unable to attend weekly meetings, she attended some and willingly responded to emails, requests for in-person meetings, and took on tasks to review letters and advocate for the RPP's work.)

Through the efforts of the school administration, district resource teacher, students and the MHS CS-LISTEN teacher lead, the MHS RPP tested the idea of creating an on-campus club called Morse Codes that would then spearhead various types of student-led outreach. The Morse Codes group (which ended up being over 20 active students who created their own Discord group to work collectively online) then worked with the district resource teacher to create online coding camps for younger students in the school's feeder pattern. The high school principal committed to using her substantial social capital to convey to her feeder pattern principals at local K-8 schools to advertise and actively promote the camp to their younger students.

The SCRs at Orange Glen High School in the Escondido Union High School District (EUHSD) uncovered a **key issue — an under awareness at their own school about CS**

courses. Within this school, a key connection was a very active district-level Director of College and Technical Education, who also oversaw all the district's CS pathways and courses. This director became very involved in the SCR team's work at OGHS (and at the other two participating high schools too). She attended many of their meetings and helped shape the types of work that might happen in the schools' Action Cycles. This included launching a "Choose You" campaign in English and Spanish on the district's website, which highlighted CS courses that could be taken in the career and college pathways. In the end, at OGHS and across the other two participating district high schools (Escondido and San Pasqual), the Action Cycles focused on a mix of targeted CS outreach (e.g. guest speakers targeting female students) and a focus on greater cooperation with counselors to insert a CS course description in the catalog/schedule that could dispel misconceptions about CS courses. The district director helped the students by advising them, placing some of their newly created artifacts on the district website to champion the CS courses at their schools, and sharing the Action Cycle work with the superintendent, district leaders, and notably the school board.

At the school site level at OGHS, Action Cycle work also included students talking to school counselors to promote more active advising of students as to how they might fit CS in what students saw as an already impacted four-year schedule. The district leadership helped the Action Cycle students even present to the districts' counselors as a whole about the affordances of taking CS.

As mentioned in the section before, the Hoover HS SCR team's research also unveiled a **key issue — that computer science was restricted to only one academy within their larger high school.** As the team and school moved to an Action Cycle phase, the teacher and continuing students were excited to have the support of their principal who had attended the CS-LISTEN UP conference and who had heard their presentation. He and another site coordinator at the school met with the Action Cycle student and teacher team to brainstorm their next step efforts. Over the course of the next few months several important changes occurred. Most notably, the school decided to change its enrollment offerings by placing another CS course on the schedule, and for the 2021-22 school year, the course (for the first time) will now be accessible to all students at the high school, not just those in the Information Technology academy.

Although we have highlighted three of the nine schools above, it is important to note that the RPP work in the Action Cycles varied tremendously by schools. If we look across the nine schools, work in the Action Cycles can be grouped into three broad categories: Promotion/marketing, virtual CS introductions, and systematic change.

Promotion/Marketing: Given restrictions of online schooling during Covid-19, the Action Cycles at each school focused efforts on revamping their schools' social media efforts around CS. RPP Social media campaigns were led by the students, teachers, and when appropriate administrators, who launched new student-drafted content on Instagram and TikTok as well as created new web-based content, digital flyers (in Spanish and English), infographics, and videos for webinars. Online materials such as these were used by Action Cycle teams to raise CS awareness. Escondido High School's (EHS) Action Cycle team, for example, created and then distributed to students new CS promotional materials. These materials were meant to assist students, particularly female students and Spanish-speaking students, as they planned their next classes for fall 2021. For instance, the EHS RPP drafted and printed out the infographics (below) to hand out to parents/guardians and students. The infographic, in English and Spanish, highlighted available opportunities and the affordances to learn CS, including taking AP-CSP, joining CS clubs, and future job opportunities relating to CS.
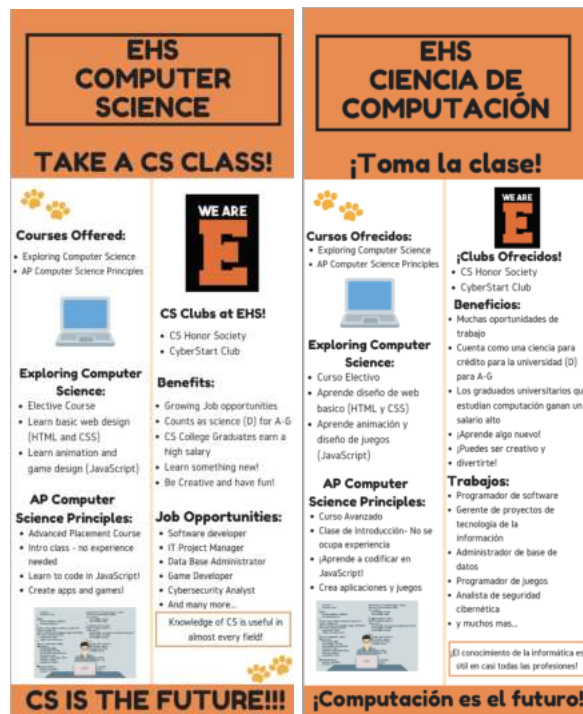
Virtual Events to Introduce CS: Other work launched in the Action Cycles centered on teams hosting virtual events to introduce coding using Code.org's Hour of Code. These events aimed at promoting CS often among younger students (pre-high school). For example, in the Sweetwater High School Action Cycle RPP, the teacher and students collaborated with local middle school administrators and teachers to recruit younger students to extracurricular

opportunities so that they could know what CS is and, hopefully, enjoy it. Over winter break, the Sweetwater High RPP held two coding camps, one for middle school and one for students from their high school. Later, Sweetwater held a second promotional coding camp with Castle Park High Action Cycle leaders during their joint spring break. Similarly, Mission Vista High School's Action Cycle team also hosted a virtual introductory hackathon during their spring break. All camps were well attended, often co-facilitated by educators, and always co-promoted and informed by district/school administrators and teachers, including from the feeder schools. All addressed the research findings of under awareness of CS in these schools.

Systematic Change: Action Cycle teams also dove into systematic change. We already described how, at Hoover High, the principal, school administrators, and counselors listened to the Hoover SCRs' recommendation to expand the school's CS course offerings starting fall 2021. In addition, in the Vista Unified School District, Mission Vista High and Rancho Buena Vista High Action Cycle efforts worked with their schools' administrations to improve the diversity of their CS pathways and expand interest among all students. Mission Vista High worked on reformulating the ways in which their school's CS courses were (or were not) treated and advertised in official course descriptions as a pathway. They also worked on making CS classes count towards a-g requirements for the University of California and California State University admissions requirements. Both RBVHS's and MVHS's Action Cycles focused on re-branding their CS courses by providing more age-appropriate marketing materials. Mission Vista even went a step further and in summer 2021 offered a class for CS1, so students had more room in their schedules to take CS2 in the fall. They also recently lobbied the California Scholastic Federation (CSF) to grant higher CSF status to these same courses. In the Vista Unified School District, RPP students and teachers from both high schools were invited into the districtwide STEAM team discussions which brought together leaders from across the district to reformulate STEAM offerings K12.

Lastly, in the Escondido Union High School District each school (Escondido, Orange Glen, and San Pasqual High) conducted their own respective Action Cycles. But the work also was raised to a systemic level when the three Escondido high schools began working more closely with district leaders and school counselors to add to the district website's "Choose You" campaign. In their case, the schools' Action Cycle work was elevated through the addition of the District's Career College and Technical Education Director more directly into the RPP team.

Across the nine schools, the move to Action Cycles rendered adjustments in the RPP team members, their commitment to the work, and their generation of new materials, tools, artifacts and organizations. District and school administration and teacher participation increased at most sites. Still what was unexpected was the sustained interest and energy from SCR students, and, in some cases, new students (recruited by SCRs) to RPP efforts during the Action Cycle period.

CS-LISTEN Learning from Communities of Practice

According to Penuel and Gallagher's *Creating Research Practice Partnership in Education* [9], effective RPPs share some important characteristics: They 1) focus on problems of practice 2) engage in long-commitment with school districts and key stakeholders 3) establish a mutualistic relationship and 4) generate original analyses.

CS-LISTEN is an innovative RPP because it focuses on broadening participation in CS by incorporating student voice. But the act of including students in RPP work of this nature requires that adults be particularly mindful of how RPP work needs to be adapted to consider the needs of student participants, specifically.

In our case, we borrowed thinking on what it means to become a successful RPP (as one that merges SCRs/students, university researchers, and district and school leaders/teachers) from literature on communities of practice (CoP). From its onset, CS-LISTEN used a CoP framework to evoke learning collectively and individually. More specifically, our team attended to the research that effective CoPs have the following features [5, 10, 11, 12].

1. **Joint Enterprise:** Deciding on a shared pursuit or aim – note this can and should be negotiated and re-negotiated over time by members of the CoP.

2. **Mutual Engagement:** Regular and desired interaction and the building of relationships toward the joint enterprise.

3. **Shared Repertoire:** Description of the tools, language and knowledge, and artifacts that characterize group participation.

Enacting Joint Enterprise in a Student-inclusive RPP

Using the CoP literature as a guide, we began the CS-LISTEN SCR teams' development with teachers and students by launching the work at a **joint enterprise** event — CS-LISTEN Launch — in January 2020. At this in-person (pre-pandemic), multi-hour event, speakers made

presentations so that the SCRs, teacher leaders and university researchers could develop a collective understanding of the problem of CS underrepresentation, and the goals of broadening participation. The launch occurred at the start of the CS-LISTEN **joint enterprise** as a collective move. We did this as CS-LISTEN required joint work, but new SCR (and adult) participants likely needed individual professional learning on CS underrepresentation.

Following the January 2020 CS-LISTEN Launch, we engaged with the 100+ SCRS and 14 teacher leaders in weekly sessions from January-March 2020. These weekly sessions enabled the teacher-student-university teams to develop a sense of deep commitment towards our **joint enterprise** of broadening participation in CS. In March-April 2020, the pandemic abruptly shutdown in-person work causing us to pause the CS-LISTEN project while our K12 partners got their bearings and dealt with the chaos of the spring shutdown. But we knew we had achieved a sense of joint enterprise when in fall 2020, we re-started the project with the SCR teams (few were seniors the year prior) and a majority of students in all nine SCR teams, and every educator, rejoined the work.

Work on **joint enterprise occurred a second time** during the overall project as we shifted from the SCR teams' research to the RPP Action Cycle phase of our collective work. This time, however, the SCRs work drove the discussions. At the CS-LISTEN UP conference in November 2020, SCR teams and their teachers showcased their newfound knowledge about the CS inequities at their schools. With a substantial audience of administrators, teachers, and counselors (from across the county), the SCR teams and their teachers shared understanding within a larger CS broadening participation community of actors.

Like the students quoted earlier, students across SCR teams reported in June 2021 that they better understood the need to broaden participation in CS, at their schools and throughout the U.S.. Focus groups with small groups of students at all nine schools confirmed this as students expressed how much they had learned about the need to broaden participation in CS. One student stated in spring 2021:

> This project has made me realize the extent to which, computer science is isolated to only one specific gender or one specific race, and others are kind of intimidated by that, or they don't want to pursue computer science because it's dominated by a certain group of people.
>
> *Latinx female student from San Pasqual High School*

Moreover, students and teachers alike expressed how they not only saw the need to grow CS pipelines in K12 systems, but they also saw how doing so was connected to larger issues of workforce development, college and career access and even the ambitious goal of disrupting cycles of generational poverty. As one student explained why s/he/they thought the project was important:

> I feel like you can help them get it, step out of the generational poverty, because there's millions of jobs open for CS, because it's currently one of the most increasing job markets there is right now. Generally, very decent salary that could help many students...leave that cycle of, like, just graduating and going to work. So I feel like it's something that could definitely help many minorities break a cycle in their family, and go more towards higher education, because like by helping build this path that we did right now, it'll help them be more [likely] to do this in college.
>
> *Latinx female student from Orange Glen High School*

Mutual Engagement as a Way to Build RPP/BPC Connections

Mutual engagement (another key facet of an effective CoP and our RPP) was fostered, we believe, through the regular weekly meetings of the SCR teams in the first half of the project and the usually weekly or bi-weekly meetings of Action Cycle RPP teams in the second half.

Through 2020-21, Action Cycles at each of the nine schools had student leadership and participation, enjoyed weekly teacher leadership, and engaged their school/district administrators as partners in broadening participation in CS. Later they added more teachers, administrators, and other students in the Action Cycles further enhancing this sense of **mutual engagement**. Students and teachers and even administrators who attended the meetings became committed to one another and the work. As one SCR team member from Orange Glen and the Sweetwater High Principal who attended many meetings also said,

> I'm very grateful to be exposed to leaders such as [Kirk Rogers, from UC San Diego] and Ms. Coching [teacher], who have really been supporting us throughout this whole thing, guiding us, but also letting us [do] our own thing.
>
> *Latinx female student from Orange Glen High School*

I felt it was very interactive and engaging and all students participated. I don't remember a single student idly sitting by or in the meeting, but not participating. Because if that would happen, we would have maybe asked, 'So do you have any ideas or anything you would like to contribute?' We never felt the need to do that. Everyone participated.

Principal Sweetwater High School

Mutual engagement was accomplished through the weekly SCR meetings, weekly larger RPP Action Cycles team meetings, as well as through bi-annual meetings with advisory board members and periodic meetings (usually quarterly) with district officials. Feedback from the advisory and district officials were incorporated into CS-LISTEN throughout the year. Both the advisories and the district meetings also restarted in the fall of 2020 and had high participation throughout 2020-21, despite remaining virtual and despite the continued Covid-19 shutdown of all the high schools through February 2021 and hybrid reopenings.

Focus on Shared Repertoire: Artifacts, Tools, Knowledge as RPP/BPC work

What do we attribute to this sustained sense of joint enterprise and mutual engagement? Research on the deliberate construction of communities of practice suggests that providing CoPs with flexibility in their focus (to match their specific contexts) and creating a **shared repertoire** of artifacts, tools, language, and knowledge can be helpful in sustaining CoP work. We found this also to be the case.

Shared repertoire in the context of CS-LISTEN occurred in the form of jointly constructed artifacts. During the initial SCR phase of the project, UC San Diego CS-LISTEN researchers worked to create and then use with teachers and SCR teams a series of slide decks that researchers produced weekly to guide SCR team meetings (before and after the Covid-19 shutdown). This series supported the teams' understanding and research over time. They were created to be flexible scaffolds for the teams, which were encouraged to adapt them to their weekly meeting needs.

Another example of a CS-LISTEN shared artifact was the video presentation that each team of students and teachers made of their SCR team findings. These video presentations were all created by SCR teams and shared at the CS-LISTEN-UP Conference in November 2020.

Finally, a joint professional video was created of all the SCRs' and teachers' work and was used to showcase and celebrate the collective group's work from spring 2020 to fall 2021 and beyond. The individual presentations by school SCR teams and the professionally produced video can all be found on our CS-LISTEN website: https://cslisten.ucsd.edu/resources/

Later, during the Action Cycles, the definition and development of **shared repertoire** were also fostered as teams generated new tools and artifacts of their own. The Action Cycle period was particularly successful at supporting shared repertoire because it often explicitly called on RPP members to create numerous tools and artifacts.

The Power of Community in YPAR RPPs

Key to CS-LISTEN's success of launching an effective student-inclusive RPP has been meeting regularly enough such that 1) we launched successfully and then regularly met (weekly) in order to develop local meanings, jointly constructed and re-negotiated over time, on what the students, teachers, administrators and university members worked on (**joint enterprise**), 2) we negotiated with all members how often, when and where and how we worked (**mutual engagement**), and 3) we developed specific knowledge, practices, and tools for our work (**shared repertoire**) that were able to be deployed flexibly by members. CS-LISTEN used these three frames from the CoP literature to guide our meaning making and practices. While we attended to the joint work and practices of the RPP as a whole, we also attended to the individual engagement and development of CS-LISTEN members, students, and adults.

Youth Can Make Meaningful Contributions to RPP Work

Bringing student voice into broadening CS participation is a fresh contribution to the RPP paradigm. More specifically, we used Youth Participatory Action Research (YPAR) strategies through student co-research into CS-LISTEN RPPs. This proved to be a novel and fruitful way to tackle CS underrepresentation. CS-LISTEN, allowed small teams of students at nine high schools an active role in both the *research and practice* as foundational pillars of RPP work. In this way, the students became true partners and leaders of CS-LISTEN's RPP research and action cycles.

But embedding CS-LISTEN's YPAR work into full-fledged RPPs required significant attention to youth professional and scholarly development. We realized this early on and designed our project with youth in mind so that they could legitimately become full partners in the RPP. Students who were in CS-LISTEN SCR and Action Cycles have had many opportunities for professional growth because we realized that the students needed explicit instruction on how to bring

their recommendations into action. Examples of explicit instructions we engaged in included making sure students had an understanding and focus on critical content, breaking down complex skills and strategies into smaller instructional units, and providing frequent and corrective feedback [2].

In addition, we learned that all parties (educators, admin and students) required assistance in social science research skills and knowledge. Even CS knowledgeable educators wanted CS-LISTEN UC San Diego researchers to scaffold them into social science research paradigms. Students, teachers and administrators early on confessed they felt ill-equipped to conduct social science research. But with support and scaffolding, they found their footing and became more confident in their ability to do this work in the RPP.

> Research in general I thought that was like a foreign concept to me like I thought it was very scary like only smart, smart people do it. But after this, I feel like it's something that's more. It's more. How do I say, like, you can do it, like, 'Hey I like it's not as inaccessible as I thought it was.'

Latinx female student Orange Glen High School

At the same time, CS-LISTEN researchers learned a great deal from this RPP work. We recognize that the CS-LISTEN project thus far work is imperfect. Our reliance on joint enterprise, mutual engagement and shared repertoire as features of a robust Community of Practice, while helpful, were helpful but sometimes fell short when it came to addressing underlying issues of educational inequity we too faced as a project. For instance, while we opened the SCR/YPAR experience to all students, we had to work extra hard to recruit and retain students from outside high-track/Advanced Placement (AP) courses. While we were reasonably satisfied with our initial recruitment in January 2020-March 2020, we found that after the pandemic and the restart in October 2020, more academically successful students sustained their participation in the SCR and Action Cycles than their peers who were struggling a bit more academically. And, we are painfully aware that some original CS-LISTEN students, whose life circumstances had left them more vulnerable, disappeared from the RPP entirely. Our teammates (teachers, students, and ourselves) made extra efforts to reach out and retain these missing students, yet, regardless of our intentions to retain/recruit more students from less advanced/honors track academic backgrounds, doing so was challenging. Honestly, our RPPs were not always successful at doing so. Undoubtedly, this project was greatly affected by the fact that it had to persist during a global pandemic, where students from the most vulnerable and housing insecure populations had to pivot to

being breadwinners for their families. Check-ins with some of our missing students confirmed that some of them who had started on CS-LISTEN prior to the pandemic had pressing family monetary or health concerns. Despite their desire to continue with CS-LISTEN, they were forced to prioritize other facets of their lives. But we are determined not to hide behind the pandemic as an excuse. We aim to do better to address these inclusivity issues within our RPP work.

We also learned a great deal about the critical role of fully engaging district and school administrators. More than anyone else, they and the lead teachers have been essential at taking RPP work to scale during the Action Cycle period.. Without these individuals and the organizational capital they possess in their sanctioned roles, all three Escondido Union High School District SCRs and Action Cycle teams would not have been able to advertise their work districtwide on the website. Hoover High teams would not have been able to add a second CS course for all students. Sweetwater, Mission Vista, Morse, and Castle Park High teams would not have run as successful coding camps for their younger peers. Even though they were not always able to meet weekly with Action Cycle teams, principals, counselors, district-level directors and superintendents were essential in the RPPs.

Although CS-LISTEN has established a solid ground game in student-inclusive RPP work in broadening participation in CS, the project has two more years of support to continue improving our collective practice. Over the next two academic years, 2021-2023, we anticipate working with 18 more teams of students, educators, and administrators to refine our work on YPAR/SCRs and RPPs. We also acknowledge that it is (as of August 2021) too early to tell as to whether or not our collective work has impacted actual CS enrollment in course pathways. Early reports from schools during spring 2021 enrollment periods suggested the numbers are up — we will have to see when fall 2021 numbers are solidified: Have we broadened participation in CS at these nine schools? We do not yet know for sure.

What we do know is that students are on board for working alongside us, and their educator colleagues, to find out.

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