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Evaluation of the Silicon Valley Research Practice Partnership for Computational Thinking and Positive Identity

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Introduction

This is an evaluation of the Silicon Valley Research Practice Partnership for Computational Thinking and Positive Identity for Computer Science (SVRPP), funded by a Computer Science for All grant from the National Science Foundation (NSF).

The SVRPP is composed of representatives from the Santa Clara County Office of Education, the Krause Center for Innovation within the Foothill–DeAnza Community College District, the San José State University Center for STEM Education, WestEd, Berryessa Union School District, Milpitas Unified School District, and Orchard School District. The SVRPP started working together in summer 2018 and received a Computer Science for All grant from the NSF for April 2021 through March 2024. This 3-year grant provided the opportunity for the SVRPP to form a research and practitioner partnership in order to increase computational thinking and positive identity for students who identify as Latina in grades 4 and 5.

This report covers the impact of the SVRPP during the 2022–23 school year and the first semester of the 2023–24 school year.

Background

Based on the literature, the SVRPP felt that cultural stereotypes were prohibitive in encouraging underrepresented female students to pursue a career in computer science (CS) or engineering (Cheryan et al., 2015). For instance, in the 2017–18 school year, 762 students in Oregon participated in one of two Advanced Placement CS exams. Of those students, only 10 percent were students of color and only 23 percent identified as female (Goode et al., 2020).

In 2016, former President Barack Obama endorsed expanded funding for CS education in the nation's secondary schools. State agencies, industry leaders, and educators embraced the challenge eagerly, knowing the future health of the U.S. economy would rely on a workforce that is equipped with skills in CS and computational thinking (CT).[1] Despite the need, inequities exist between who is receiving high-quality CS instruction and who is not. For example, Salac et al. (2019) pointed out that major metropolitan school districts around the country are implementing CS in elementary school classrooms as part of the NSF's Computer Science for All initiative without focusing on equity. When they analyzed the performance of students in grade 4 in the Chicago area who completed modules of a CT curriculum, they found that all classrooms benefitted from the CT curriculum but that there were differences in performance between high- and low-performing schools. Their work emphasizes the dearth of effective strategies and curricula for teaching CT practices equitably.

Theory of Improvement

The SVRPP was guided by a theory of improvement (Figure 1).

Aim: Improve math achievement and abstraction for Latina students in grades 4 and 5

Primary driver 1: Increased positive identity among Latina students in grades 4 and 5

Primary driver 2: Increased skills in abstraction among Latina students in grades 4 and 5

Secondary drivers:

Primary driver 1

a. teachers' increased capacity for culturally responsive teaching
b. a system to assess the impact of curricula on Latina students' cultural and gender identity in grades 4 and 5

Primary driver 2

a. teachers' increased pedagogical knowledge in abstraction
b. a system to assess the impact of curricula on Latina students' math achievement in grades 4 and 5

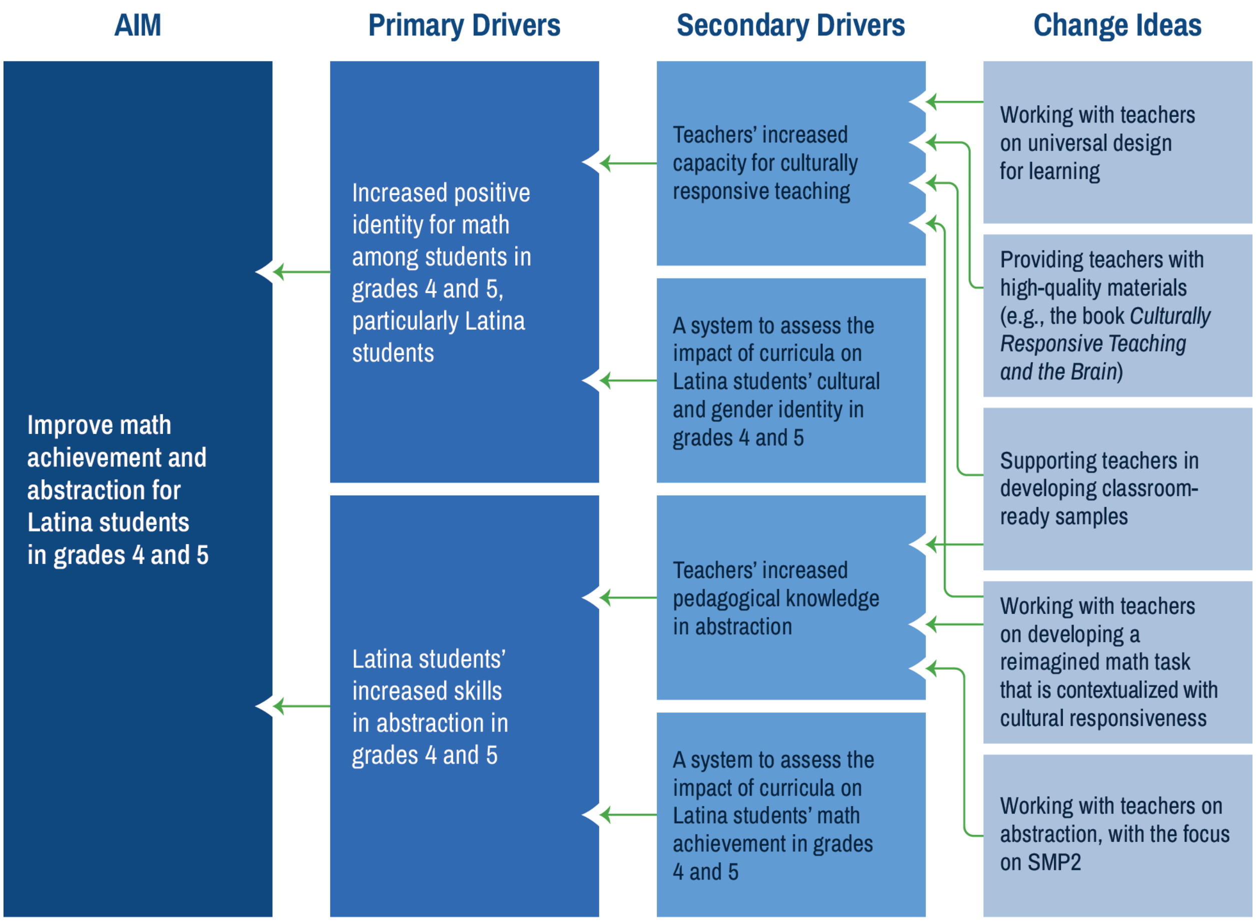
Change ideas: The secondary drivers guided the following tests (change ideas):

- working with teachers on universal design for learning (*secondary driver 1a*)
- providing teachers with high-quality materials (e.g., the book *Culturally Responsive Teaching and the Brain*) (*secondary driver 1a*)

[1] Computational thinking (CT) is a thought process that utilizes elements of abstraction, generalization, decomposition, algorithmic thinking, and debugging (Angeli et al., 2016, p. 49). A CT framework may include computational concepts, computational practices, and computational perspectives and approaches to assessing these dimensions through project portfolio analysis, artifact-based interviews, and design scenarios (Brennan & Resnick, 2012).

- supporting teachers in developing classroom-ready samples (*secondary drivers 1a and 2a*)
- working with teachers on developing a reimagined math task that is contextualized with cultural responsiveness (*secondary drivers 1a and 2a*)
- working with teachers on abstraction, with the focus on the Standards for Mathematical Practice 2 (reason abstractly and quantitatively) (*secondary driver 2a*)

Figure 1. Driver Diagram: Theory of Improvement



Silicon Valley Research Practice Partnership Design

Equitable access to instruction in CS is a concern for schools represented by the SVRPP and the surrounding areas. SVRPP's overall goal was to build capacity among SVRPP members and increase the network of schools to effectively study, implement, and refine CT classroom math tasks that develop the CT practices of abstraction and algorithmic thinking in order to promote the positive identity of Latina students regarding these subjects.

The SVRPP had the following project objectives:

- Further establish and support a research practice partnership (RPP) that provides teachers with experiences that allow them to develop the knowledge and skills needed for effective teaching of CT (abstraction) and assessment of this CT practice.
- Develop CT activities for students in grades 4 and 5 that are culturally responsive; promote positive identity among students, particularly Latinas; and focus on skill development, specifically in the area of abstraction.
- Assess the effectiveness of the curricula toward improving positive identity and math achievement in classrooms that serve predominantly underrepresented youth in grades 4 and 5.

The partnership scaled from six practitioners—two teachers with relevant expertise from each of the three partner school districts—and six research teams (Year 1) to 11 practitioners from four school districts and six research teams (Year 2). In its final year (Year 3), the partnership included 28 practitioners from eight school districts and six research teams.

The project timeline was as follows:

- In 2021–22 (Year 1 of the grant), the SVRPP refined the theory of improvement, developed reimagined math tasks for grades 4 and 5 that included abstraction, created student and teacher surveys as outcome measures, and developed a CT assessment that focused on abstraction.
- In 2022–23 (Year 2 of the grant), the SVRPP expanded by recruiting one new school district and five additional teachers. Additionally, promising aspects of the professional learning community (PLC) developed within the SVRPP were continually tested and improved. The SVRPP used its student and teacher surveys and student assessments to understand the impact of the SVRPP.
- In 2023–24 (Year 3 of the grant), the SVRPP recruited five additional schools, for a total of eight school districts and 28 teachers. The refined professional development developed and piloted with the Year 2 PLC was implemented during Year 3. In addition, there were more in-person PLCs during Year 3, and they developed outcomes that were more targeted. New teachers in the SVRPP developed additional reimagined math tasks with computer programming activities. Teachers adapted a rubric from Matthews et al. (2022) to guide their reimagined math task in order to comply with culturally responsive pedagogical strategies. See Appendix A for the adapted rubric.

Research Questions

The evaluation of the SVRPP is guided by the following four research questions:

1. What is the impact of the SVRPP in regard to CT and positive identity for computer science (PICS) on the skills and understanding of abstraction of students who identify as Latina in grades 4 and 5?
2. What is the impact of the SVRPP in regard to CT and PICS on the positive identity of students who identify as Latina in grades 4 and 5?
3. What is the impact of the SVRPP in regard to CT and PICS on the math achievement of students who identify as Latina in grades 4 and 5?
4. What are the culturally relevant instructional strategies for integrating CT with math that are being used to support positive identity for students who identify as Latina in grades 4 and 5?

This report provides the results for the 2022–23 school year and the first semester of the 2023–24 school year (Years 2 and 3 of the grant). Section 1 provides the results for research questions 1 and 2, Section 2 provides the results for research question 3, and Section 3 provides the results for research question 4. With the exception of research question 3, analyses for Years 2 and 3 of the grant are provided separately. The analysis for research question 3 is for only Year 2 because the state assessment data will not be available until after the 2023–24 school year. The analyses of all years are not combined because the SVRPP used Year 2 to refine the program, piloting the professional development in the PLCs and developing processes to help teachers implement the reimagined math tasks. Year 3 was the year that the program was implemented as envisioned by the SVRPP.

Section 1. Impact on Students Who Identify as Latina: Abstraction and Positive Identity

This section describes the evaluation of the impact of the SVRPP on the skills and understanding of abstraction of students who identify as Latina as measured by a CT assessment and the positive identity for math and CT of students who identify as Latina as measured by a student survey. This section starts with a discussion of the methodology, sample, and outcome measures. It concludes with the findings.

Methodology and Sample

A paired *t*-test was used to compare the difference in the means from the pre- and post-versions of the CT assessment and survey.

In 2022–23, a total of 251 students in grades 4 or 5 from 10 classes in four school districts participated in the study. Among these participants, 63 were Latina students, or approximately one fourth (25%) of the 251 students. Note that not all students finished both the pre- and post- versions of the survey and the CT assessment. Specifically, 222 students—58 (26%) of whom were Latina—finished the pre- and post- versions of the CT assessment, and 219 students—57 (26%) of whom were Latina—completed the pre- and post- versions of the survey. Table 1 displays the number of students who completed the pre- and post- versions of the survey and the CT assessment.

Table 1. Number of Students Who Completed the Pre- and Post- Versions of the Survey and the CT Assessment for the 2022–23 School Year

Instrument	Pre-	Post-	Pre- and post- (#)	Latina pre- and post- (#)	Latina pre- and post- (%)
Assessment	245	232	222	58	26%
Survey	245	231	219	57	26%

During the first semester of the 2023–24 school year, a total of 578 students in grades 4 or 5 from 21 classes in seven school districts participated in the study. Among these participants, 121 were Latina students, or approximately one fifth (21%) of the 578 students. Similar to the previous year, not all students finished both the pre- and post- versions of the survey and the CT assessment. Specifically, 490 students—118 (24%) of whom were Latina—finished the pre- and post- versions of the CT assessment, and 515 students—116 (23%) of whom were Latina—completed the pre- and post- versions of the survey. Table 2 displays the number of students who completed the pre- and post- versions of the survey and the CT assessment.

Table 2. Number of Students Who Completed the Pre- and Post- Versions of the Survey and the CT Assessment for the 2023–24 School Year

Instrument	Pre-	Post-	Pre- and post- (#)	Latina pre- and post- (#)	Latina pre- and post- (%)
Assessment	554	531	490	118	24%
Survey	578	540	515	116	23%

Outcome Measures

The impact on abstraction was measured by a CT assessment that covered abstraction, and the impact on positive identity was measured by a student survey that covered culturally responsive pedagogy and identity toward science, technology, engineering, and mathematics (STEM).

Student Computational Thinking Assessment Focusing on Abstraction

The CT assessment consisted of 13 items across four sets of questions and was based on a published validated instrument regarding elementary students' CT (Basu et al., 2021). Among the four sets of questions, one (Question 2) was copied directly from the original instrument and the other three were modified by the SVRPP researchers to ensure the content was relevant to the study participants.

To minimize practice effects and sensitization, the research team made minor changes to the questions between the pre- and post- versions of the assessment. For instance, the names of the people in the questions and the numbers to be calculated were changed. See Appendix A for the details of the questions and the rubrics for the pre- and post- versions.

Student Survey

The two constructs observed in the student survey were culturally responsive pedagogy and identity toward STEM.

The culturally responsive pedagogy construct consisted of 13 items, including questions related to the promotion of cultural competence (3 items), teacher–student relationships (3 items), student voice (3 items), and independent learning (4 items). The survey items were based on the book *Culturally Responsive Teaching and the Brain* by Hammond (2015).

The identity toward STEM construct consisted of 5 items. The items included questions related to student attitude toward math (3 items) and interest in jobs connected to STEM (2 items). These items were from a validated survey from Unfried et al. (2015).

Cronbach's alpha for the two constructs in the pre- and post-surveys from the current sample exceeded 0.7. See Appendix B for additional information about the analysis, including reliability statistics. See Appendix A for the details of the survey.

Findings

The SVRPP had a statistically significant impact on Latina students' skill and understanding of abstraction in grades 4 and 5.

As for the impact on Latina students' positive identity toward STEM, increased ratings were observed in the culturally responsive pedagogy construct between the pre- and post-surveys. However, these differences were not statistically significant.

Impact on Latina Students' Skill and Understanding of Abstraction

During the 2022–23 school year, Latina students scored statistically significantly higher on the post–CT assessment (mean of post- = 9.72) than they did on the pre–CT assessment (mean of pre- = 7.90). Similarly, all students scored statistically significantly higher on the post–CT assessment (mean of post- = 10.28) than they did on the pre–CT assessment (mean of pre- = 8.51).

During the first semester of the 2023–24 school year, Latina students scored statistically significantly higher on the post–CT assessment (mean of post- = 10.47) than they did on the pre–CT assessment (mean of pre- = 8.13). Similarly, all students scored statistically significantly higher on the post–CT assessment (mean of post- = 10.76) than they did on the pre–CT assessment (mean of pre- = 8.80).

See Table 3 for more details.

Table 3. CT Assessment Paired Sample *t*-Tests for Latina Students and All Students for 2022–23 and 2023–24 School Years

Year	Latina students mean pre- (standard deviation)	Latina students mean post- (standard deviation)	Latina students mean difference (standard deviation)	All students mean pre- (standard deviation)	All students mean post- (standard deviation)	All students mean difference (standard deviation)
2022–23	7.90 (3.18)	9.72 (3.94)	1.83 (4.47)	8.51 (3.32)	10.28 (3.92)	1.77 (4.39)
2023–24	8.13 (2.38)	10.47 (3.53)	2.35 (4.02)	8.80 (2.85)	10.76 (3.69)	1.97 (4.22)

Note. 2022–23 school year: For the Latina mean difference (1.83), $p < 0.05$. For the all students mean difference (1.77), $p < 0.01$.The number of observations for Latina students is 58. The number of observations for all students is 222.

2023–24 school year: For the Latina mean difference (2.35), $p < 0.01$. For the all students mean difference (1.97), $p < 0.01$. The number of observations for Latina students is 118. The number of observations for all students is 490.

Source. Student assessments collected in the final study sample

Additional statistics are provided in Appendix B.

Impact on Latina Students' Positive Identity Toward STEM

The two constructs observed in the student survey, culturally responsive pedagogy and identity toward STEM, were used to measure the impact on Latina students' positive identity toward STEM.

During the 2022–23 school year, no statistically significant differences were observed in Latina students' ratings in the culturally responsive pedagogy or identity toward STEM constructs, although increased ratings were observed in the culturally responsive pedagogy construct between the pre- and post-surveys. The pattern among all students was similar, but identity toward STEM had statistically significant negative differences.

See Table 4 for more details.

Table 4. Student Survey Paired Sample *t*-Tests for Latina Students and All Students for the 2022–23 School Year

Construct	Latina students mean pre- (standard deviation)	Latina students mean post- (standard deviation)	Latina students mean difference (standard deviation)	All students mean pre- (standard deviation)	All students mean post- (standard deviation)	All students mean difference (standard deviation)
Culturally responsive pedagogy	3.98 (0.53)	4.11 (0.57)	0.14 (0.66)	4.07 (0.53)	4.12 (0.55)	0.05 (0.53)
Identity toward STEM	2.86 (0.72)	2.73 (0.77)	–0.13 (0.59)	3.15 (0.74)	3.04 (0.79)	–0.11 (0.59)

Note. The number of observations for Latina students is 57. The number of observations for all students is 219. For the all students mean difference, identity toward STEM is (–0.11), $p < 0.05$.

Source. Student assessments collected in the final study sample

During the 2023–24 school year, Latina students showed an improvement in their ratings on the culturally responsive pedagogy construct in the post-survey (mean of post- = 4.15) compared with the pre-survey (mean of pre- = 4.01). The difference was statistically significant. Additionally, their ratings on the identity toward STEM construct in the post-survey were marginally higher (mean of post- = 2.88) than those in the pre-survey (mean of pre- = 2.75). However, the difference was not statistically significant.

For all students, the analysis revealed statistically significant differences for both constructs between the pre- and post-surveys. Specifically, the post-survey ratings on the culturally responsive pedagogy construct showed an increase in the post-survey (mean of post- = 4.16) compared with the pre-survey (mean of pre- = 4.01). Similarly, the ratings on the identity toward STEM construct in the post-survey (mean of post- = 3.05) were higher compared with those of the pre-survey (mean of pre- = 2.95). And the improvements were statistically significant.

See Table 5 for more details.

Table 5. Student Survey Paired Sample *t*-Tests for Latina Students and All Students for the 2023–24 School Year

Construct	Latina students mean pre- (standard deviation)	Latina students mean post- (standard deviation)	Latina students mean difference (standard deviation)	All students mean pre- (standard deviation)	All students mean post- (standard deviation)	All students mean difference (standard deviation)
Culturally responsive pedagogy	4.01 (0.51)	4.15 (0.57)	0.14 (0.48)	4.01 (0.52)	4.16 (0.55)	0.15 (0.51)
Identity toward STEM	2.75 (0.81)	2.88 (0.96)	0.12 (0.77)	2.95 (0.04)	3.05 (0.04)	0.10 (0.79)

Note. The number of observations for Latina students is 116. The number of observations for all students is 515.

For the Latina mean difference (0.14) on culturally responsive pedagogy construct, $p < 0.01$; for the Latina mean difference (0.12) on identity toward STEM construct, $p < 0.1$.

For the all students mean difference on culturally responsive pedagogy construct (0.15), $p < 0.01$; for the all students mean difference (0.10) on identity toward STEM construct, $p < 0.01$.

Source. Student assessments collected in the final study sample

Additional statistics are provided in Appendix B.

Section 2. Impact on Students Who Identify as Latina: Math Achievement

This section provides the results of the impact of the SVRPP on math achievement as measured by the Smarter Balanced Assessment Consortium (SBAC) standards-based math assessment. This section starts with a discussion of the methodology, data, and the outcome measure. It concludes with the findings of the analysis. Appendix B provides additional analyses.

Methodology

This study used a quasi-experimental design in which students in grades 4 and 5 whose teachers participated in the SVRPP (treatment group) were matched to similar students in grades 4 and 5 whose teachers did not participate in the SVRPP (comparison group). The matching analysis was based on the Mahalanobis distance metric between the two values of the covariate vector, χ and χ':

$$\| \chi, \chi' \| = (\chi - \chi')\Omega_{\chi}^{-1}(\chi - \chi').$$

Each student in the treatment group was matched to the two closest students in the comparison group based on the matching variables. The matching variables included grade level, gender, race/ethnicity, special education status, free or reduced-price lunch status, and prior SBAC math assessment. The matching procedure matched only similar students in the treatment group within their school district and within their grade level to similar students in the comparison group. The impact analysis calculated the average treatment effect for the treatment group.

Once the matching was completed and the baseline equivalence was assessed, the matched treatment and comparison students were included in an ordinary least squares (OLS) regression model to determine the impact of the SVRPP on the SBAC math assessment. The covariates used for the OLS model were the same as the variables used for the matching model in order to ensure robustness and protect against misspecification in either model (Imbens & Wooldridge, 2009).

The model used was the following:

$$MathSBAC_i = \alpha + \beta_1(SVRPP_i) + \beta_2(MathSBAC\_P_i) + \beta_3(StudChar_i) + \varepsilon_i,$$

where $MathSBAC_i$ is student *i*'s post-test SBAC math assessment math achievement; β_1 is the binary treatment indicator (1 = the student was part of a SVRPP teacher's class; 0 = the student's teacher did not participate in the SVRPP); $MathSBAC\_P_i$ is the prior SBAC math assessment score before the teachers participated in the SVRPP; $StudChar_i$ is a vector of student characteristics that include grade level, gender, Hispanic status, special education status, and free or reduced-price lunch status; α is the intercept; $\beta_1 - \beta_3$ are parameters to be estimated from the data; ε_i is the independent and identically distributed error; and β_1 is the average difference between the students in the treatment and comparison groups on the SBAC math assessment after controlling for the covariates included in the model.

The regression includes a weight from the matching analysis. The weight is proportional to the number of times a student in the comparison group was matched. Each student in the treatment group was matched to two students in the comparison group, so each student in the comparison group received a weight of 0.50. Cluster-robust errors were used to allow for intragroup correlation at the teacher level (Hill & Reiter, 2006; Huber, 1967).

Sample

The analysis sample (Table 6) includes students during the 2022–23 school year, with a total of 237 students in grades 4 and 5 taught by 11 SVRPP teachers in four school districts. Among these participants, 57 were students who identified as Latina, or approximately one fourth (24%) of the 237 students. The analysis sample included all students in grades 4 and 5 taught by SVRPP teachers and similar students in grades 4 and 5 who were matched to the treatment group. The total sample size for the comparison group was the same as the size of the treatment group after the weights were applied.

Table 6. Sample Analysis

District	Number of SVRPP teachers	Number of students in treatment group	Number of Latina students in treatment group
School district 1	3	55	18
School district 2	3	63	17
School district 3	3	79	22
School district 4	2	40	0
All school districts	11	237	57

Outcome Measure

The SBAC math assessment was used as the outcome measure for this analysis. Students in grades 4 and 5 take the SBAC math assessment every spring, starting in grade 3 through grades 8 and 11 (California Assessment of Student Performance and Progress, n.d.). The SBAC math assessment is required by the state of California and is part of the federal accountability system.

Findings

Table 7 shows that Latina students taught by SVRPP teachers scored higher on the SBAC math assessment than did Latina students taught by non-SVRPP teachers. However, the difference is not statistically significant.

Similarly, when all students are included, students taught by SVRPP teachers scored higher than did the students taught by non-SVRPP teachers. However, the difference is not statistically significant. Appendix B includes the regression tables for both samples.

Table 7. Impact of the SVRPP on Student Scores on the SBAC Math Assessment, Latina Students

Sample	Adjusted treatment mean	Adjusted comparison mean	Difference (standard errors)	*p*-value
Latina students	2413.14	2410.16	2.99 (6.31)	0.64
All students	2466.49	2464.92	1.57 (5.10)	0.76

Note. The number of observations for the analysis with only Latina students is 114, including 57 students in the treatment group and 57 (weighted) students in the comparison. The number of observations for the analysis with all students is 474, including 237 students in the treatment group and 237 (weighted) students in the comparison group.

Source. Student assessment and demographic data collected from the participating school districts

Section 3. Culturally Relevant Instructional Strategies to Support Positive Identity

This section describes the impact of the culturally relevant instructional strategies to support students' positive identity as measured by a teacher survey that covered four themes of culturally responsive pedagogy and knowledge of CT. This section starts with a discussion of the methodology, data, and the outcome measures. It concludes with the findings of the analysis.

Methodology and Sample

A paired *t*-test was used to compare the difference in the means from the pre- and post-surveys.

The analysis sample includes teachers during the 2022–23 and 2023–24 school years. During the 2022–23 school year, there were a total of 11 SVRPP teachers who taught students in grades 4 and 5 in four school districts. Two teachers did not complete the survey. Nine teachers from four school districts completed a pre- and a post-survey. Two of the seven teachers identified as Latine. During the 2023–24 school year, there were a total of 28 SVRPP teachers: 9 were from the 2022–23 cohort who had continued into 2023–24, and 19 were new SVRPP teachers who taught students in grades 4 and 5 in seven school districts. Of those 19 teachers, 15 completed both a pre- and a post-survey. Of these 15 teachers, two identified as Latine. Table 8 provides details regarding the teachers' characteristics.

Table 8. Teacher Characteristics for the 2022–23 and 2023–24 School Years

Sample	Number of observations 2023–24	Percentage	Number of observations 2023–24	Percentage
Gender: Female	7	78%	14	93%
Gender: Male	2	22%	1	7%
Race: Latine	2	22%	2	20%
Race: Non-Latine	7	78%	13	80%
Highest education attained: Master's degree	7	78%	13	87%
Highest education attained: Bachelor's degree	2	22%	2	13%
Credential: Multiple subjects	8	89%	15	100%
Credential: Single subject	1	11%	0	0%

Outcome Measures

As with the student survey, the items in the teacher survey that included the culturally responsive pedagogy construct were based on the book *Culturally Responsive Teaching and the Brain* (Hammond, 2015). The survey included questions about teacher self-awareness and beliefs, teacher–student relationships, student independent learning, and student voice.

Additionally, the teacher survey included an additional construct on CT knowledge. Understanding the progression of teachers' CT knowledge is an important part of the SVRPP because the SVRPP focuses on working with teachers to help them develop CT knowledge and positive identity. This construct was added based on input from the SVRPP members.

Findings

During the 2022–23 school year, teachers' culturally responsive pedagogy and CT knowledge improved from the start of their participation in the SVRPP to after their participating in the SVRPP for one school year. The difference was statistically significant. See Table 9 for more details.

In the study sample, the Cronbach's alpha for each survey scale (measured either in the pre- or post-survey) exceeded 0.7 for both constructs, culturally responsive pedagogy and CT knowledge. See Appendix B for more details.

Table 9. Teacher Survey Findings for the 2022–23 School Year

Outcome measures	Mean of pre-survey (standard deviation)	Mean of post-survey (standard deviation)	Difference (standard deviation)	*t*-statistic
Culturally responsive pedagogy	4.25 (0.37)	4.57 (0.28)	0.32 (0.35)	2.75
CT knowledge	1.02 (2.03)	3.44 (1.98)	2.42 (2.27)	3.20

Note. The number of observations is 9. The degree of freedom is 8 for each measure. For the difference between the mean of the pre-survey and post-survey, culturally responsive pedagogy construct (0.32), $p < 0.05$. For the difference between the mean of the pre-survey and post-survey, CT knowledge construct (2.42), $p < 0.05$.

Source. Teacher survey responses data collected from the participating SVRPP members

During the first semester of the 2023–24 school year, teachers' culturally responsive pedagogy improved from the start of their participation in the SVRPP to after their participating in the SVRPP for one school year. The difference is statistically significant. Similarly, teachers' CT knowledge improved, but the difference was not statistically significant. See Table 10 for more details.

In the study sample, the Cronbach's alpha for each survey scale (measured either in the pre- or post-survey) exceeded 0.8 for both constructs, culturally responsive pedagogy and CT knowledge. See Appendix B for more details.

Table 10. Teacher Survey Findings for the 2023–24 School Year

Outcome measures	Mean of pre-survey (standard deviation)	Mean of post-survey (standard deviation)	Difference (standard deviation)	*t*-statistic
Culturally responsive pedagogy	4.43 (0.41)	4.71 (0.25)	0.28 (0.39)	2.78
CT knowledge	2.75 (2.33)	2.87 (2.15)	0.12 (3.43)	0.14

Note. The number of observations is 15. The degree of freedom is 14 for each measure. For the difference between the mean of the pre-survey and post-survey, culturally responsive pedagogy construct (0.28), $p < 0.05$.

Source. Teacher survey responses data collected from the participating SVRPP members

Discussion and Implication

The SVRPP started in 2021 during the COVID-19 pandemic with six teachers and expanded to 28 teachers by 2023. The SVRPP had to adapt quickly from an in-person to an online RPP. Even during the pandemic, the SVRPP continued to expand and met often.

The core aim of the SVRPP was for teachers to refine math tasks from their math curricula so that the tasks included abstraction concepts with culturally responsive pedagogies intended to improve math achievement and abstraction for Latina students in grades 4 and 5. Teachers were able to develop at least one reimagined math task during the 2022–23 school year and again in the 2023–24 school year. Teachers were able to implement at least one reimagined math task with a computer program each school year. Based on a pre- and post-assessment regarding CT, students of SVRPP teachers had increased their abstraction knowledge to a statistically significant extent by the end of the 2022–23 and 2023–24 school years.

Based on the student survey results of the 2022–23 school year, the SVRPP knew that there needed to be a rubric specifically about cultural responsiveness in the 2023–24 school year. This addition helped teachers make intentional cultural changes to the math task, which improved students' culturally responsive pedagogy from a pre- to a post-survey during the 2023–24 school year.

Teachers' culturally responsive pedagogy continued to improve during the 2022–23 and 2023–24 school years. Teachers' CT knowledge improved during the 2022–23 and 2023–24 school years, but the improvement during the 2023–24 school year was not statistically significant.

As for the impact the SVRPP had on math achievement during the 2022–23 school year, there was no statistically significant difference regarding the SBAC math assessment between students with SVRPP teachers and similar students with non-SVRPP teachers. An additional analysis will be conducted by the end of 2024 to understand the impact that the SVRPP had on math achievement during the 2023–24 school year.

The SVRPP has expanded to more school districts that surround Silicon Valley and continues to work with teachers to develop additional reimagined math tasks with computer programs. The commitment of the teachers and the researchers continues to increase teachers' knowledge of CT and implement culturally responsive pedagogies in the classroom. As the SVRPP continues to implement in more districts and refine the RPP and professional learning, SVRPP believes that, as WestEd has observed throughout the years of this grant, there will be a greater impact on students in the years to come.

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Appendix A. Assessment and Survey Tools

Student Computational Thinking Pre- and Post-Assessment

For both assessments, students were asked to provide their name, their teacher's last name, their grade, and the name of their school.

The total score for the rubric was up to 18 points.

Assessment Question 1

Scoring: There are 5 items in this question. For each item, a correct answer scores 1 point, and an incorrect answer scores 0. Total points for this question range from 0 to 5.

PRE-ASSESSMENT

For items a through e, students were asked to answer yes or no.

Lila and her recycling team collect 45 plastic bottles each day for 5 days. Please write a computer program to help the team calculate the total number of bottles collected. Which of these is an unknown quantity that must be represented in the computer program?

- **a.** number of bottles collected in one day
- **b.** number of days
- **c.** names of the members of the recycling team
- **d.** total number of bottles collected
- **e.** number of members on the recycling team

Answer key: Item d, *yes*; the rest, *no*.

POST-ASSESSMENT

For items a through e, students were asked to answer yes or no.

Cecily and her recycling team collect 35 cans each day for 7 days. Please write a computer program to help the team calculate the total number of cans collected. Which of these is an unknown quantity that must be represented in the computer program?

- **a.** number of members on the recycling team
- **b.** total number of cans collected
- **c.** number of days
- **d.** names of the members of the recycling team
- **e.** number of cans collected in one day

Answer key: Item b, *yes*; the rest, *no*.

Assessment Question 2

Scoring: This is a multiple-choice question with a single correct answer. A correct answer scores 3 points, and an incorrect answer scores 0. Total points range between 0 and 3.

PRE- AND POST-ASSESSMENT SETUP

Dana/Ellen and her friends are playing a “guess the picture” game. There are six pictures numbered P1 to P6. Dana/Ellen writes down one of the picture numbers on a piece of paper but does not tell her friends what the number is. Here are the six pictures:

P1

P2

P3

P4

P5

P6

Note. See Appendix C for descriptions of pictures P1 through P6.

PRE-ASSESSMENT

For items A through D, students were asked to select one item.

Dana selected P4. Using **the fewest hints** possible, which of the following sets of hints should Dana give her friends that would let them pick P4?

- **a.** The picture contains balloons, and the picture contains water.
- **b.** The picture contains one or more girls, and the picture contains balloons.
- **c.** The picture does not contain water, the picture contains a bicycle, and the picture contains balloons.
- **d.** The picture contains trees, the picture contains one or more girls, the picture contains balloons, and the picture contains a bicycle.

Answer key: C

POST-ASSESSMENT

For items A through D, students were asked to select one item.

Ellen selected P4. Using **the fewest hints** possible, which of the following sets of hints should Ellen give her friends that would let them pick P4?

- **a.** The picture contains balloons, and the picture does not contain water.
- **b.** The picture contains a bicycle, and the picture contains balloons.
- **c.** The picture does not contain water, the picture contains one or more girls, and the picture contains balloons.
- **d.** The picture does not contain water, the picture contains trees, and the picture contains one or more girls.

Answer key: B

Assessment Question 3

Scoring: There are 5 items in this question. For each item, a correct answer scores 1 point, and an incorrect answer scores 0. Total points for this question range from 0 to 5.

PRE-ASSESSMENT

For each of items a through e, students were asked to determine whether the item must be a variable or does not have to be a variable.

Marie is planning a birthday party with a budget of $50. Marie will invite 10 friends to the party. Marie wants to know how much money will be left over after she buys everything she needs for the party. Emily writes a computer program to calculate the leftover money. Which of the items below must be represented by a variable for her to write her computer program?

- **a.** name of restaurant
- **b.** names of guests attending
- **c.** cost of each party supply or food item bought
- **d.** total amount of money that Marie has to spend on the party
- **e.** total amount of money that Marie has left over after buying the supplies and food

Answer key: Items c and e must be a variable; the rest do not have to be a variable.

POST-ASSESSMENT

For each of items a through e, students were asked to determine whether the item must be a variable or does not have to be a variable.

Emily is planning a party with a budget of $100. Emily will invite 10 friends to the party. She wants to know how much money will be left over after she buys the party supplies and food for the party. Emily writes a computer program to calculate the leftover money. Which of the items below must be represented by a variable for her to write her computer program?

- **a.** names of guests attending
- **b.** cost of each party supply item
- **c.** cost of each food item
- **d.** total amount of money that Ellen has to spend on the party
- **e.** total amount of money that Ellen has left over after buying the supplies and food

Answer key: Items b, c, and e must be a variable; the rest do not have to be a variable.

Assessment Question 4

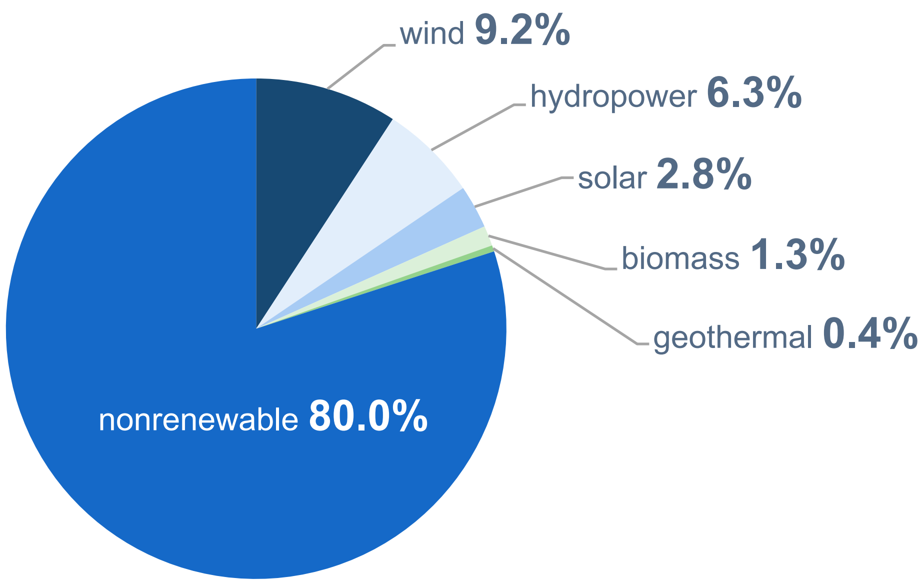
Scoring: Question 4.1 is a multiple-choice question with a single correct answer. A correct answer scores 2 points, and an incorrect answer scores 0. Total points range between 0 and 2.

Question 4.2 is a multiple-choice question with multiple correct answers. The score is given based on the number of correct choices included in the answer. Points will NOT be taken away if the answer includes incorrect choice(s). Total points range between 0 and 3.

PRE- AND POST-ASSESSMENT SETUP

A grade 4 class is learning about renewable energy. Renewable energy is energy that nature will replace and that does not pollute the air or water. Types of renewable energy include biomass, geothermal, hydropower, solar, and wind. Use the circle graph below to answer the questions.

U.S. Renewable Energy Portion of Total Energy Produced, 2021



PRE-ASSESSMENT

For question 4.1, items A through D, students were asked to select one item. For question 4.2, items a through e, students were asked to select all items that apply.

4.1. Which statement characterizes the overall pattern in this circle graph?

- **a.** Most energy produced in the United States in 2021 was produced by wind energy.
- **b.** Most energy produced by the United States in 2021 was produced by solar energy.
- **c.** Most energy produced by the United States in 2021 was nonrenewable energy.
- **d.** More solar energy was used in 2020 than in 2021.

Answer key: C

4.2. Which statements are true based on the information in this circle graph? Select all that apply.

- **a.** Wind energy and hydropower were the top two types of renewable energy in the United States in 2021.
- **b.** Solar energy is the best type of renewable energy.
- **c.** Nonrenewable energy includes wind and solar energy.
- **d.** There was more nonrenewable energy produced in the United States in 2021 than any other type of renewable energy.
- **e.** Biomass was the second lowest percentage of all renewable energy types in 2021.

Answer key: a, d, and e

POST-ASSESSMENT

For question 4.1, items A through D, students were asked to select one item. For question 4.2, items a through e, students were asked to select all items that apply.

4.1. Which statement characterizes the overall pattern in this circle graph?

- **a.** Most energy produced in the United States in 2021 was produced by wind energy.
- **b.** The biggest type of renewable energy produced by the United States in 2021 was wind energy.
- **c.** More renewable energy was produced than nonrenewable energy by the United States in 2021.
- **d.** More solar energy was used in 2020 than in 2021.

Answer key: B

4.2. Which statements are true based on the information in this circle graph? Select all that apply.

- **a.** Solar energy is the best type of renewable energy.
- **b.** Wind energy and hydropower were the top two types of renewable energy in the United States in 2021.
- **c.** Nonrenewable energy includes wind and solar energy.
- **d.** There was more nonrenewable energy produced in the United States in 2021 than any other type of renewable energy.
- **e.** Geothermal was the lowest percentage of all renewable energy types in 2021.

Answer key: b, d, and e

Student Survey

Students were asked to provide their first and last name, the name of their school, the name of their teacher, and their grade.

For each statement in the survey, students were asked to decide how much they agreed with the statement by indicating “strongly agree,” “agree,” “neutral,” “disagree,” or “strongly disagree.”

1. **Promotion of cultural competence**
   - My teacher teaches about diverse cultures and traditions.
   - Books used in this class show people of many different races/ethnicities.
   - My teacher asks about students' cultural backgrounds and experiences.
2. **Teacher–student relationships**
   - My teacher helps all students.
   - My teacher expects all students to do well in class.
   - I trust my teacher.
3. **Student voice**
   - My teacher asks me to share my thoughts.
   - My teacher asks students to help make decisions about class.
   - My teacher lets me show what I have learned in different ways.
4. **Independent learning**
   - I can share my thoughts, ideas, and/or solutions in the classroom without feeling embarrassed.
   - My teacher tells me when I am doing a good job and when I can improve.
   - My teacher helps me reach my goals.
   - My teacher expects all students to do well in class.
5. **Student attitude toward math**
   - I enjoy math.
   - I am sure I could do advanced work in math.
   - I would consider choosing a career that uses math.
6. **Your future:** Here are descriptions of jobs connected to math and science. Please decide how interested you are in them (choices: not at all interested, not so interested, interested, very interested).
   - **Math:** Math is how numbers work. I will learn computation, algorithms, and other ways to solve problems and summarize data. (accountant, applied mathematician, economist, financial analyst, mathematician, statistician, market researcher, stock market analyst)
   - **Computer science:** Computer science consists of the development and testing of computer systems, designing new programs, and helping others to use computers. (computer support specialist, computer programmer, computer and network

technician, gaming designer, computer software engineer, information technology specialist)

Teacher Survey

Teachers were asked to provide their name, the name of the their school, how many years they had taught math, their gender, their race/ethnicity, their highest level of education, their teaching credential, and their professional learning preferences.

1. Culturally responsive pedagogy

For each statement, teachers were asked to decide how much they agreed with the statement by indicating "strongly agree," "agree," "neutral," "disagree," or "strongly disagree."

Teacher self-awareness and beliefs

- I examine my own sociopolitical position.
- I examine my own culture.
- I believe that everyone's culture is an important part of the classroom environment.
- I believe in fostering a collectivist culture (that emphasizes the needs and goals of the group as a whole over the needs and desires of each individual) in my classroom.

Teacher–student relationships

- I strive to establish an authentic connection with students that builds mutual trust and respect.
- I view myself as an ally to students.
- I provide high and clear expectations for academic performance.
- I provide support for all students.

Independent learning

- I allow students to struggle productively.
- I provide students with honest critical feedback.
- I support students in monitoring their progress toward goals.
- My students are able to take risks in the classroom without feeling embarrassed.

Student voice

- I frequently invite students to share their thoughts.
- I view students as valuable members of the decision-making process in how the classroom is organized and run.

- I promote culture in the classroom by asking about students' cultural backgrounds and experiences.
- I invite students to display learning in a variety of different ways.

2. Standards for Mathematical Practice 2 (SMP2): Reason abstractly and quantitatively

Mathematically proficient students make sense of quantities and their relationships in problem situations. They bring two complementary abilities to bear on problems that involve quantitative relationships: the ability to decontextualize—to abstract a given situation and represent it symbolically and manipulate the representing symbols as if they have a life of their own, without necessarily attending to their referents—and the ability to contextualize, to pause as needed during the manipulation process in order to probe into the referents for the symbols involved. Quantitative reasoning entails habits of creating a coherent representation of the problem at hand; considering the units involved; attending to the meaning of quantities, not just how to compute them; and knowing and flexibly using different properties of operations and objects.

- Are you familiar with the Standards for Mathematical Practice? (choice: yes/no)
- How have you utilized SMP2 in your classroom?
- What is a barrier to implementing the SMP2 in your classroom?

3. Understanding of computational thinking

Computational thinking (CT) includes four key concepts:

- *decomposition*: breaking the problem down into smaller, more manageable parts
- *pattern recognition*: analyzing data and identifying similarities and connections among its different parts
- *abstraction*: identifying the most relevant information needed to solve the problem and eliminating the extraneous details
- *algorithmic thinking*: developing a step-by-step process to solve the problem so that the work is replicable by humans or computers

We would like to understand the extent to which you are familiar with CT. We are happy that you are participating in the project, and you are welcome regardless of your level of familiarity with CT. Please respond to the questions below as honestly as you can.

- Are you familiar with CT? (choices: yes/no) (If no, skip to next section.)
- How does CT relate to other disciplines besides computer science?
- How do you plan to implement CT principles in your classroom?

Please indicate your level of agreement with the following statements.

- I am interested in CT.
- I am interested in furthering my understanding about CT.
- I feel comfortable teaching CT in my class.
- The challenge of solving problems using CT appeals to me.
- Integrating CT concepts within classroom instruction is valuable for students' academic knowledge.

Template: Revising a Math Task Focused on Culturally Responsive Strategies, UDL, and Abstraction

This template is based on a form from Matthews, L. E., Jones, S. M., & Parker, Y. A., 2022, *Engaging in culturally relevant math tasks: Fostering hope in the elementary classroom*, Corwin.

Teacher	
School	
District	

Goals

- Identify an SMP2 math task from your curriculum and reimagine it to include culturally responsive, relevant, and sustaining pedagogies and apply the Universal Design for Learning (UDL) framework guidelines.
- Identify activities that students could use with the reimagined math task to develop their abilities to decontextualize (unpack) and recontextualize (repack) the information in the math task.
- Ensure activities that are part of the reimagined task support 'for the development of a positive identity in math and computer science in students who identify as Latina.
- Identify a possible qualitative or quantitative formative assessment to be used with the reimagined math task in order to assess students' ability to decontextualize the problem.

Steps

1. Choose a cognitively demanding task.
2. Evaluate the cultural relevance of the chosen task.

3. Analyze your task and brainstorm opportunities to meet the goals for cultural responsiveness, UDL, and improved student abilities in SMP 2.
4. Complete a revised lesson plan.
5. Reflect on your reimagined task.

Reference

Universal Design for Learning Guidelines + Computer Science / Computational Thinking

Step 1. Choose a cognitively demanding task.

Using the following rubric, choose a cognitively demanding task that has a minimum score of 13 and a score of 4 on part C, Depth of Understanding. For each level identified, give that many points. Add up the points for a total score.

A. Complexity of problem-solving

- Level 1: The math task involves basic operations with single-step problem-solving.
- Level 2: The math task requires multiple steps and involves basic mathematical concepts.
- Level 3: The math task involves multistep problem-solving with complex operations and requires application of various mathematical concepts.
- Level 4: The math task is highly complex, requiring advanced problem-solving strategies and a deep understanding of multiple mathematical concepts.

Points: ____________

B. Critical thinking skills

- Level 1: The math task involves basic recall and application of mathematical procedures.
- Level 2: The math task requires some logical reasoning and analysis to arrive at a solution.
- Level 3: The math task involves higher-order thinking skills such as making connections, comparing and contrasting, or identifying patterns.
- Level 4: The math task requires advanced critical thinking skills including synthesis, evaluation, or creative problem-solving approaches.

Points: ____________

C. Depth of understanding

- Level 1: The math task focuses on basic calculations and procedural understanding.
- Level 2: The math task requires a solid understanding of mathematical concepts and relationships.
- Level 3: The math task involves applying mathematical concepts to solve problems in varied contexts.
- Level 4: The math task requires a deep understanding of mathematical principles, including generalization or abstraction.

Points: ____________

D. Transferability of skills

- Level 1: The math task focuses primarily on applying skills within the given context.
- Level 2: The math task requires applying skills to solve problems in familiar or practical situations.
- Level 3: The math task involves transferring skills to solve problems in novel or realistic contexts.
- Level 4: The math task requires applying skills to solve complex problems across disciplines or real-world scenarios.

Points: ____________

E. Authenticity and relevance

- Level 1: The math task lacks real-world connections or relevance to students' lives.
- Level 2: The math task includes some connections to practical situations or familiar contexts.
- Level 3: The math task has clear real-world connections and relevance to students' lives or age-appropriate contexts.
- Level 4: The math task addresses complex real-world problems or extends beyond students' immediate experiences, challenging them to think beyond the obvious.

Points: ____________

Total task points: ____________

If the total is less than 13, please modify the task or choose a different task.

Step 2. Evaluate the cultural relevance of the chosen task.

Culturally Relevant and Cognitively Demanding Mathematics Task Rubric

Emerging

Requires considerable cognitive effort in mathematics.

- ☐ The task is mathematically rich and cognitively demanding. It requires considerable effort using multiple representations and strategies to develop a deep understanding of mathematics. Solution strategy is nonobvious. See rubric above.
- ☐ The task content draws from connections to other grade-level subjects, disciplines, and concepts.

Developing

Meets requirements for an emerging task AND is framed in a positive and affirming way.

- ☐ The goal of the task is relevant and empowers students.
- ☐ The intent of the task is related to one of the Hope Wheel verbs (mark which applies):
  - Love: Nurture. Care for. Embrace. Empathize. Sustain. Maintain. Grow. Appreciate.
  - Protest: Resist. Dismantle. Disrupt. Interrupt. Speak up. Stand up.
  - Restore: Salvage. Apologize. Repair. Illuminate. Amplify. Forgive.
  - Invest: Set up. Support. Mentor. Reallocate.
  - Inspire: Move. Empower. Model. Encourage.
  - Create: Innovate. Imagine. Establish. Frame. Design. Build.
- ☐ The task relates to the real world and provides an opportunity for students to focus on critical issues in their community.

Proficient

Meets requirements for a developing task AND is based on students' culture and community.

- ☐ The context and prompt affirms student and identity and belonging: "we care/we belong."
- ☐ The task highlights the power of culture and community: "we notice."
- ☐ The task focuses on how our culture is respected and valued.

Or

- ☐ The task deepens our understanding of ourselves and our culture: "we wonder."
- ☐ The task models care, love, and respect for our community and culture: "we respond."

Exemplary

Meets requirements for a proficient task AND targets cultural self-community empowerment and social justice.

- ☐ The task requires students to examine structure and assumptions of self, community, the world, and its relations in consideration of solutions and strategy limits.
- ☐ The task requires students to examine conditions of opportunity, justice, suffering, and inequity that would arise in their communities, school, and the world around them.
- ☐ The task utilizes mathematical sense making and the solution processes to help students develop informed perspectives and take action on real-world issues.

Step 3. Analyze your task and brainstorm opportunities to meet the goals for cultural responsiveness, UDL, and improved student abilities in SMP2.

Goal: Use this form to describe the current state of your task and subsequently your desired movement on the Culturally Relevant and Cognitively Demanding Mathematics Task Rubric (emerging to developing to proficient to exemplary).

Grade Level

- ☐ 4
- ☐ 5

Domain

- ☐ Operations and algebraic thinking
- ☐ Number and operations in base ten
- ☐ Number and operations—fractions
- ☐ Measurement and data
- ☐ Geometry

Standards for Mathematical Practice

Mathematical practices addressed in the original task: Mark all that apply. SMP2 must be included.

- ☐ 1. Make sense of problems and persevere in solving them.
- ☐ 2. Reason abstractly and quantitatively. *(required)*
- ☐ 3. Construct viable arguments and critique the reasoning of others.
- ☐ 4. Model with mathematics.

- ☐ 5. Use appropriate tools strategically.
- ☐ 6. Attend to precision.
- ☐ 7. Look for and make use of structure.
- ☐ 8. Look for and express regularity in repeated reasoning.

Relevant math vocabulary needed for the original lesson:

Level of cultural relevance of the ORIGINAL task (according to the rubric)

- ☐ Emerging
- ☐ Developing
- ☐ Proficient
- ☐ Exemplary

Original lesson plan (MUST be a cognitively demanding task)

Source and publisher:

Common Core standards addressed:

Learning targets (i.e., "Students will be able to . . ."):

Skills:

Concepts:

Use of abstraction in the original task (what do students need to know to unpack the problem, apply a concrete solution, and demonstrate understanding?):

Lesson plan: Include all activities that are part of the original task, and include all materials and assessments (formative or summative).

a. Materials:
b. Warmup:
c. Activity:
d. Synthesis:
e. Evaluate:

Why did you choose this original task? Please be specific and address the cultural relevance as well as the support of all students to access the learning in the original task.

Describe at least three Universal Design for Learning strategies you could use in the revised task:

1.
2.
3.

What aspect could you focus on to improve the cultural relevance of the reimagined task?

☐ Mirror/window (page 100)

☐ Funds of knowledge (pages 45–46)

☐ Social justice (pages 82–84)

☐ Culturally responsive–friendly mathematics content (page 31)

☐ Other (please explain)

Based on your answer above, brainstorm ways you could revise the cultural relevance of the math task to meet the needs of your students.

1.
2.
3.
4.

Brainstorming UNPACKING activities: What activities could you use in this part of the lesson? *(multiple means of representation)*

1.
2.
3.
4.

Brainstorming CONCRETE activities: What activities could you use in this part of the lesson? *(multiple means of engagement)*

1.
2.
3.
4.

Brainstorming REPACKING activities: What activities could you use in this part of the lesson? *(multiple means of expression)*

1.
2.
3.
4.

Step 4. Complete a Revised Lesson Plan

Common Core standards addressed (highlight any changes from the original task):

Vocabulary needed for REVISED lesson (highlight any terms added):

Lesson plan: Include all activities, materials, and assessments (formative or summative).

a. Materials:
b. Unpacking:
c. Concrete activity:
d. Repacking:
e. Assessment:

Level of cultural relevance of your REVISED task (according to the rubric):

- ☐ Emerging
- ☐ Developing
- ☐ Proficient
- ☐ Exemplary

Universal Design for Learning strategies: Include your detailed strategies for options of supporting all students in each box of the rubric. Refer to the UDL guidelines charts for ideas for each section.

Learning strategy	Engagement (why?)	Representation (what?)	Action and expression (how?)
Access	Recruiting interest:	Perception:	Physical action:
Build understanding	Sustaining effort and persistence:	Language and symbols	Expression and communication:

Internalize learning	Self-regulation:	Comprehension:	Executive functions:

Step 5. Reflect on your reimagined task.

1. How does your reimagined task improve learning and cultural responsiveness for all students?
2. How will your chosen strategies support students' ability to unpack and repack the information needed to complete the learning goal(s)?
3. How does your reimagined task support positive identity in math and computer science for students who identify as Latina?
4. How will you measure success?

UDL Guidelines

Universal Design for Learning Guidelines + Computer Science / Computational Thinking

Israel, M., Lash, T., Ray, M, & Marsland, B. (2019). *Universal design for learning within computer science education*. Creative Technology Research Lab, University of Florida.

Access

Multiple Means of ENGAGEMENT Affective networks The "WHY" of learning	**Multiple Means of REPRESENTATION** Recognition networks The "WHAT" of learning	**Multiple Means of ACTION & EXPRESSION** Strategic networks The "HOW" of learning
Provide options for **Recruiting interest** • Give students choices (choose project, software, topic). • Allow students to make projects relevant to culture and age. • Minimize possible common pitfalls for both computing and content. • Allow for differences in pacing and length of work sessions. • Provide options to increase or decrease sensory stimulation (e.g., listening to music with headphones or using noise canceling headphones).	Provide options for **Perception** • Model computing by using physical representations and with an interactive whiteboard or videos. • Give access to modeled code while students work independently. • Provide access to video tutorials of computing tasks. • Select coding apps and websites that allow students to adjust visual settings (e.g., font size, contrast) and that are compatible with screen readers.	Provide options for **Physical action** • Provide teacher's codes as templates. • Include CS Unplugged activities that show physical relationships of abstract computing concepts. • Use assistive technology such as larger/smaller mice and touch-screen devices. • Select coding apps and websites that allow coding with keyboard shortcuts in addition to dragging and dropping with a mouse.

Build

Multiple Means of ENGAGEMENT Affective networks The "WHY" of learning	**Multiple Means of REPRESENTATION** Recognition networks The "WHAT" of learning	**Multiple Means of ACTION & EXPRESSION** Strategic networks The "HOW" of learning
Provide options for **Sustaining effort and persistence** • Remind students of both computing and content goals. • Provide support or extensions to keep students engaged. • Teach and encourage peer collaboration by sharing products. • Utilize pair programming and group work with clearly defined roles. • Discuss the integral role of perseverance and problem-solving in computer science. • Recognize students for demonstrating perseverance and problem-solving in the classroom.	Provide options for **Language and symbols** • Teach and review content-specific vocabulary. • Teach and review computing vocabulary (e.g., code, animations, computing, algorithm). • Post anchor charts and provide reference sheets with images of blocks or with common syntax when using text.	Provide options for **Expression and communication** • Give options for unplugged activities and computing software and materials (e.g., pseudocode, Scratch, code.org, Alice). • Give opportunities to practice computing skills and content through projects that build on prior lessons. • Provide sentence starters or checklists for communicating in order to collaborate, give feedback, and explain work. • Create physical manipulatives of commands, blocks, or lines of code. • Provide options that include starter code.

Internalize

Multiple Means of ENGAGEMENT Affective networks The "WHY" of learning	**Multiple Means of REPRESENTATION** Recognition networks The "WHAT" of learning	**Multiple Means of ACTION & EXPRESSION** Strategic networks The "HOW" of learning
Provide options for **Self-regulation** • Communicate clear expectations for computing tasks, collaboration, and help seeking. • Develop ways for students to self-assess and reflect on their own projects and those of others. • Use assessment rubrics that evaluate both content and process. • Break up coding activities with opportunities for reflection such as turn-and-talks or written questions. • Acknowledge difficulty and frustration. Model different strategies for dealing with frustration appropriately.	Provide options for **Comprehension** • Activate background knowledge by making computing tasks interesting and culturally relevant. • State lesson content and computing goals. • Encourage students to ask questions as comprehension checkpoints. • Use relevant analogies and make cross-curricular connections explicit (e.g., comparing iterative product development to the writing process). • Provide graphic organizers to help students "translate" programs into pseudocode.	Provide options for **Executive functions** • Guide students to set goals for long-term projects. • Record students' progress (e.g., have planned checkpoints during lessons to record students' understanding and progress with computing skills and content). • Provide exemplars of completed products. • Embed prompts to stop and plan, test, or debug throughout a lesson or project. • Provide graphic organizers to facilitate planning, goal-setting, and debugging. • Provide explicit instruction regarding skills such as asking for help, providing feedback, and using problem-solving techniques. • Demonstrate debugging with think-alouds.

Appendix B. Additional Analysis

Student Computational Thinking Assessment Rubric

The total score of the assessment is up to 18 points.

Question 1 has 5 items. For each item, a correct answer scores 1 point, and an incorrect answer scores 0. Total points range between 0 and 5.

Question 2 is a multiple-choice question with a single correct answer. A correct answer scores 3 points, and an incorrect answer scores 0. Total points range between 0 and 3.

Question 3 has 5 items. For each item, a correct answer scores 1 point, and an incorrect answer scores 0. Total points for this question range between 0 and 5.

Question 4.1 is a multiple-choice question with a single correct answer. A correct answer scores 2 points, and an incorrect answer scores 0. Total points range between 0 and 2.

Question 4.2 is a multiple-choice question with multiple correct answers. The score is given based on the number of correct choices included in the answer. Points will NOT be taken away if the answer includes incorrect choice(s). Total points range between 0 and 3.

Student Survey Results

Table B1. Cronbach's Alpha for the Pre- and Post-Survey for Students

Themes	Pre-	Post-	Number of items
Culturally responsive pedagogy	0.81	0.87	13
Identity toward STEM	0.76	0.79	5

Table B2. Paired Sample *t*-Tests for Latina Students and All Students

	Latina students mean difference (standard deviation)	*t*-statistic	All students mean difference (standard deviation)	*t*-statistic
Culturally responsive pedagogy	0.13 (0.66)	1.56	0.05 (0.53)	1.32
Identity toward STEM	–0.12 (0.59)	–1.53	–0.11 (0.59)	–2.73

Note. Number of observations for Latina students is 57. The number of observations for all students is 217. The degrees of freedom for Latina students is 56 and for all students is 216. For the *t*-statistic for identity toward STEM (–2.73), $p < 0.05$.

Source. Student assessments collected in the final study sample

Student SBAC Math Assessment

Table B3. Ordinary Least Squares Regression Analysis Showing the Impact of the SVRPP on Student Scores on the SBAC Math Assessment, Latina Students

Characteristic	Estimate	Robust standard errors	*t*-statistic	*p*-value
SVRPP treatment	2.99	6.31	0.47	0.64
English Learner status	2.28	9.52	0.24	0.81
Special education	–27.82	10.27	–2.71	0.01
Free or reduced-price lunch	0.50	7.77	0.06	0.95
Grade 5	–30.76	7.48	–4.11	0.00
SBAC math assessment, 2021–22	0.68	0.05	12.83	0.00

Characteristic	Estimate	Robust standard errors	*t*-statistic	*p*-value
Intercept	810.69	128.74	6.30	0.00

Note. For the estimate of special education (–27.82), $p < 0.05$. For the estimates of grade 5 (–30.76), SBAC math assessment, 2021–22 (0.68), and intercept (810.69), $p < 0.01$.

Table B4. Ordinary Least Squares Regression Analysis Showing the Impact of the SVRPP on Student Scores on the SBAC Math Assessment, All Students

Variables	Estimate	Robust standard error	*t*-statistic	*p*-value
SVRPP treatment	1.57	5.10	0.31	0.76
Hispanic	–17.34	4.76	–3.64	0.00
Female	–9.15	3.91	–2.34	0.02
English Learner status	0.26	5.51	–0.05	0.96
Special education	–24.71	16.62	–1.49	0.14
Free or reduced-price lunch	–7.89	4.63	–1.70	0.09
Grade 5	–16.10	5.88	–2.74	0.01
Female missing indicator	–23.84	8.37	–2.85	0.01
SBAC math assessment, 2021–22	0.83	0.03	23.97	0.00
Intercept	490.51	86.97	5.66	0.00

Note. For the estimate of free or reduced-price lunch (–7.89), $p < 0.1$. For the estimates of female (–9.15), grade 5 (–16.10), and female missing indicator (–23.84), $p < 0.05$. For the estimates of Hispanic (–17.34), SBAC math assessment, 2021–22 (0.83), and intercept (490.51), $p < 0.01$.

Teacher Survey Results

Table B5. Cronbach's Alpha for the Pre- and Post-Survey for Teachers

Themes	Pre-	Post-	Number of items
Culturally responsive pedagogy	0.81	0.83	16
CT knowledge	1.0	0.78	4

Appendix C. Description of Figures

Pictures P1 Through P6 for Question 2 in the Student Pre- and Post-Assessment Regarding CT

Overview and Presentation

A grid of photos labeled P1 through P6:

- Photo P1: A girl holding a bunch of balloons, walking over stepping stones in a pond that is surrounded by trees.
- Photo P2: Advertising illustration of a monkey riding a bicycle down a path with a parrot sitting on the handlebars.
- Photo P3: A person in a gorilla suit sitting under trees in a forest and holding a bunch of balloons.
- Photo P4: Two young girls sitting at the base of a tree and reading a book together. A bicycle sits beside them with two balloons tied to the handlebars.
- Photo P5: A female college student standing between shelves of books in a library and leafing through a book.
- Photo P6: A man doing a trick on a mountain bike on a cliff that overlooks the ocean.

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