Programming the Acceleration of Computing Education (PACE) Framework for CS Systems Change

EIR Grant Findings Report

August 2025

Submitted to:
Education Development Center
300 5th Avenue, Suite 2010
Waltham, MA 02451

Submitted by:
Abt Global LLC
6130 Executive Boulevard
Rockville, MD 20852

About This Report

This report provides findings from the Abt Global independent evaluation of the *Programming the Acceleration of Computing Education (PACE) Framework for CS Systems Change* intervention. The PACE Framework was implemented in Massachusetts middle schools by the PACE team, a collaboration between Education Development Center, Inc. (EDC) and the Massachusetts Department of Elementary and Secondary Education (DESE). The evaluation was funded by EDC's Education Innovation and Research (EIR) Early-Phase Grant (Award No. U411C190275) from the U.S. Department of Education.

The views expressed in this report do not necessarily reflect the views or policies of the U.S. Department of Education.

Authors

Ellen Bobronnikov

Daniel Litwok

Kaitlyn Ciaffone

Anjali Pai

Citation

Bobronnikov, E., Litwok, D., Ciaffone, K., & Pai, A. (2025). *Programming the Acceleration of Computing Education (PACE) Framework for CS Systems Change.* EIR Grant Findings Report. Abt Global.

Abt Global LLC | 6130 Executive Boulevard | Rockville, MD 20852

Acknowledgements

We would like to thank Joyce Malyn-Smith, PACE Project Director and Principal Investigator; Brianna Roche, Neil Schiavo, and Katherine Shields, Evaluation Leads; and Deborah Boisvert, Nadia Foster, Beryl Hoffman, Kirsten Peterson, and Anne Wang, PACE team members, from the Education Development Center; as well as Anne DeMallie, Lien Hoang, Elana McDermott, Paula Moore, NJ Rees, and Kendra Winner from the Massachusetts Department of Elementary and Secondary Education, for their strong partnership. We are appreciative of all their efforts to collaborate and make the evaluation a success. We also thank Baker Franke from Code.org, who provided the study with the required teacher data based on their participation in the *Computer Science Discoveries*® training.

Additionally, we would like to thank Bruce Randel, from Century Analytics, for his technical assistance and support.[1]

Last, we would like to thank all current and former Abt staff who contributed to this evaluation. Amy Checkoway led the project for the first year; Nam Hà and Tori Morris contributed to analysis efforts; Andrew Cheshire and Bry Pollack contributed to graphic production, formatting and editing; and Allan Porowski ensured the quality of the study design and report.

[1] During the time Abt served as the external evaluator for the PACE evaluation it also held the Education Innovation and Research (EIR) Evaluation Technical Assistance support contract that provided evaluation support to the Fiscal Year 2019 cohort of EIR grantees. No one on the Abt evaluation team had a role on that contract. The Abt evaluation team received support from an EIR technical assistance liaison from Century Analytics, Inc. The Abt evaluation team did not have any information about other EIR grants or forthcoming resources and guidance not yet provided to other EIR grantees or their evaluators.

Contents

List of Exhibits

Executive Summary

Education Development Center (EDC) was awarded an Education Innovation and Research (EIR) Early-Phase Grant in 2019 to implement, refine, and evaluate the **Programming the Acceleration of Computing Education (PACE) Framework for Computer Science (CS) Systems Change**. This report presents findings from the EIR-funded independent evaluation of the PACE intervention conducted by Abt Global (Abt). SageFox Consulting Group led the initial design planning for the evaluation, and Abt took over as the independent evaluator after the first year.

PACE Overview

The PACE framework is a comprehensive district change model designed to support access to CS education for all middle school students. To achieve systemic change at the district level, the PACE intervention includes state- and district-level leadership commitments and consists of three key components: (1) district-level commitment to systemic CS instruction with teaching practices focused on providing access to all students, including the formation of and participation in district stakeholder councils (DSCs); (2) teacher training in the *Computer Science Discoveries*® (*CS Discoveries*) curriculum developed by Code.org; and (3) districtwide requirement for all middle school students to enroll in a high quality CS curriculum that meets the Massachusetts Department of Elementary and Secondary Education's (DESE's) Digital Literacy and Computer Science (DLCS) standards, which could be taught over a two- or three-year period.

The PACE logic model hypothesizes that the three key components of the PACE intervention will increase student understanding of CS principles, interest in CS, and participation in CS education for all students in the short term. In the medium and long term, PACE is hypothesized to increase student achievement and enrollment in high school CS courses and promote entry of more students into CS careers. These changes are expected to operate through district- and teacher-level mediators.

Evaluation Design

Six districts in Massachusetts implemented the PACE intervention. The proposal for PACE included a focus on recruitment of rural districts—four of the six were rural. This was significantly fewer districts than anticipated, but at a time when schools were facing significant COVID-19 pandemic-related disruptions, many districts were hesitant to implement a new curriculum.

Abt designed and conducted an independent evaluation of the implementation of PACE, which consisted of (1) a study of the fidelity of implementation of the PACE key components in the six participating districts ("treatment" districts), (2) a study examining the district-level mediating factors that are ultimately expected to affect student outcomes, and (3) a study of the impact of PACE on student achievement outcomes in these districts versus a set of matched districts with similar baseline characteristics ("comparison" districts).

- The **study of the fidelity of implementation** of the PACE key components within the six treatment districts assessed whether the three key components were implemented as designed during the study period. Abt and the PACE team developed a fidelity measure that set thresholds for adequate implementation of each of the key components based on the percentage of districts and teachers implementing each component as designed. Abt assessed fidelity of implementation using data collected by the PACE team from treatment districts as well as data collected by Code.org on teacher participation in *CS Discoveries* training and professional development.

- The **study of district-level mediating factors** examined whether treatment and comparison districts experienced changes during the study period in factors that are expected to be affected by the PACE intervention. The factors explored included the establishment of a CS course sequence in middle school and developing infrastructure for sustaining high school CS pathways. This study relied on two primary data sources:
    - To examine student enrollment in CS, the study used DESE's Student Course Schedule database, which includes information on all courses taken by students in Massachusetts public school districts.
    - To measure other district-level mediators, the study used a District Infrastructure Survey developed and administered annually to treatment and comparison districts. Analyses focus specifically on responses to data elements related to:
        - Establishment of a CS course sequence in middle school that has potential to lead into a high school CS pathway.
        - District leadership capacity to oversee high school CS pathways for students.
        - Structures and processes in place that support sustained CS prioritization.
        - Community resources in place that support CS education.
- The **study of the impacts on student achievement** used a district-level quasi-experimental design to compare average achievement on the grade 8 Massachusetts Comprehensive Assessment System (MCAS) between the treatment and comparison districts. Abt designed the impact study to meet What Works Clearinghouse (WWC) Group Design Standards (Version 5.0) under the assumption the study would be reviewed under the WWC Study Review Protocol (Version 5.1; What Works Clearinghouse (2024)). Because comparison students do not necessarily enroll in CS courses, the study examined outcomes in the mathematics and science achievement domains, which were only weakly aligned with the intervention.[2] The evaluation team prespecified two confirmatory outcomes that were measured using total points awarded for two MCAS "reporting subcategories" within the grade 8 content areas identified to be the most closely aligned to the skills taught in the *CS Discoveries* curriculum: geometry and life sciences.[3] These outcomes were selected because they were deemed to be most closely aligned to the intervention among the MCAS reporting subcategories—geometry because the programming through the *CS Discoveries* course requires students to work with Cartesian graphs, coordinates, and angles, and life sciences because it assesses students' ability to read tables, interpret data, and apply logic to reach conclusions. These outcomes had the benefit of being collected for both the treatment and comparison groups and coming from state assessments that have acceptable reliability metrics.

---

[2] A more direct measure of CS interest or aptitude would be considered overly aligned with the intervention. As a result, these measures were ruled out for the impact study.

[3] MCAS reporting subcategories measure knowledge and skills associated with a specific content area (https://www.doe.mass.edu/mcas/tech/2023-nextgen-tech-report.pdf).

Findings

Fidelity of Implementation of PACE Key Components

- Although the PACE key components were slightly modified to account for pandemic-related challenges, four out of six treatment districts were able to meet the adjusted fidelity thresholds for all three key components.

District-Level Mediating Factors

- All treatment districts established a CS course sequence in middle school; only one comparison district had high levels of CS enrollment in more than one middle school grade.
- Half of the treatment districts already had high levels of middle school CS enrollment for some portion of their middle school grades prior to implementing the PACE intervention.
- Most treatment districts had greater infrastructure to sustain high school CS pathways than did their matched comparison districts.

Impacts on Student Achievement

- PACE did not affect grade 8 MCAS geometry or life sciences reporting subcategories.
- PACE also did not affect any of the other math and science reporting subcategories[4] or overall grade 8 MCAS math and science scores.
- The lack of impacts on student achievement may be explained by the small number of districts included in the study and the lack of alignment between the intervention and the outcomes examined.

Discussion

Lessons learned during the course of the evaluation provide evidence upon which future PACE-like interventions could plan their design and implementation:

- Target recruitment to districts with existing CS infrastructure.
- Be prepared to adapt.
- Build flexibility into professional learning communities.
- Support sustainability of district stakeholder councils.

The evaluation also encountered evaluation-related challenges that are useful to document for future evaluations of CS interventions:

- Anticipate recruitment challenges for district-level interventions.
- Measure and document treatment and comparison experiences to explain impacts (or lack thereof).

[4] Other reporting subcategories assessed included number system and expressions/equations; functions; statistics and probability; Earth/space sciences; physical sciences; and technology and engineering.

- Anticipate that identifying CS outcome measures that meet WWC standards can be challenging.

Additional refinement of the intervention model to facilitate recruitment and implementation coupled with evaluation of a more closely aligned outcome measure will be important steps for future evaluations of PACE-like interventions to maximize their likelihood of demonstrating impact on student-level outcomes.

1. PACE Overview

Education Development Center, Inc. (EDC), in collaboration with the Massachusetts Department of Elementary and Secondary Education (DESE) ("the PACE team"), was awarded an Education Innovation and Research (EIR) Early-Phase Grant from the U.S. Department of Education in 2019. The project examines the **effectiveness of the *Programming the Acceleration of Computing Education (PACE)* framework** in a set of middle schools in Massachusetts. PACE aims to prepare all students with the computer science (CS) skills that are often necessary for academic and professional success by embedding CS coursework as a required component of the middle school curriculum. To improve access to CS instruction for all students, PACE emphasizes state- and district-level leadership commitments to sustainable systemic change and teacher training. PACE also requires CS curricula to meet DESE standards for digital literacy and CS (DLCS standards). With these standards in mind, the recommended curriculum is *CS Discoveries®*, an inquiry-based CS curriculum developed by Code.org. *CS Discoveries* has demonstrated effectiveness in raising student interest in CS and student achievement in basic CS knowledge and skills (Bort, Guha, & Brylow, 2018; McGee, Mcgee-Tekula, et al., 2018; McGee, Greenberg, et al., 2019).

The U.S. Department of Education requires EIR grantees to include an independent external evaluation as part of the project. This report is focused on the findings from the external evaluation of PACE. SageFox Consulting Group led the initial design planning for the external evaluation, and Abt Global (Abt) took over as the independent evaluator after the first year.

1.1 PACE Logic Model

The PACE logic model lays out the key components of the PACE intervention and the potential pathways (or mediators) through which the three key components may affect student outcomes in the short term, medium term, and long term (Exhibit 1.1).

PACE Key Components

The intervention consists of three key components: (1) district-level commitment to CS instruction with teaching practices to foster teaching that fully engages all students in CS, (2) teacher training in the *CS Discoveries* curriculum, and (3) districtwide implementation for all middle school students of the equivalent of a full year of high quality CS instruction.

Key Component 1: District-level commitment to systemic CS instruction for all students

The first key component begins with the formation of district stakeholder councils (DSCs) with representation from teachers, school administrators, district administrators, and support staff. Each district is expected to hold a series of at least five meetings per year during the first two years of implementation. During the first year of implementation, the five meetings focused on building leadership capacity through knowledge of CS and of systemic change management. The second year of DSC meetings focused on developing capacity and strategies to engage all students in CS. Districts were also encouraged to continue with their meetings after the second year of funding with ongoing assistance offered by the PACE team. Districts are also provided with a toolkit of materials to be used to integrate CS instruction with the district strategic plan in a way that promotes access for all students. All toolkit materials are provided on the PACE website.

Key Component 2: Teacher training in CS Discoveries *with enhanced supports*

The second key component focuses on teacher training. Teachers are expected to take a 35-hour, five-day Code.org training in the *CS Discoveries* curriculum in the summer prior to teaching their first course to middle school students. Teachers also take part in four workshops of two sessions each during their first academic year of teaching *CS Discoveries*. The PACE team, led by staff from EDC and DESE, also offers teachers on-demand support for implementing the new curriculum. This key component was also initially anticipated to include a requirement to implement a professional learning community (PLC) for teachers to engage with one another about the new curriculum. During the challenging period following the COVID-19 pandemic, however, teachers expressed a preference for optional, on-demand, one-to-one support, rather than a PLC, so this requirement was altered.

Key Component 3: Districtwide implementation of middle school high quality CS curriculum

The third key component of the PACE intervention focuses on the requirement for all students to be enrolled in a full-year equivalent of CS by the end of middle school as well as the development of a formalized course sequence that meets DESE's DLCS standards. Students in participating districts are expected to begin participation in the CS course in grade 6 or grade 7. For *CS Discoveries*, the course comprises a total of six units. Students who start in grade 6 take two units each year for three years. Students who start in grade 7 take three units each year for two years.

Mediators and Student Outcomes

Implementation of these key components is expected to influence district- and teacher-level mediators that are expected to affect student outcomes in the short term, medium term, and long term.

District-Level Mediators

The PACE requirement for a district-level commitment to CS instruction for all students is expected to influence four district-level mediators as follows:

1) Established CS course sequence in middle school that has potential to lead into a high school CS pathway[5]
2) Increased district leadership capacity to oversee high school CS pathways for students
3) Structures and processes in place that support sustained CS prioritization
4) Community resources in place that support CS education.

Teacher-Level Mediators

Implementation of the PACE intervention is also expected to lead to an increase in the number of teachers teaching CS, improved teacher practices for teaching CS content and for motivating students from all backgrounds in CS education, and increased confidence for teaching CS.

[5] For more on DESE's definition of a pathway, see https://www.doe.mass.edu/ccte/sec-supports/massgrad/pathways.html.

Exhibit 1.1: PACE logic model

KEY COMPONENTS

1. **District-level commitment to systemic CS instruction for all students**

- Establish district stakeholder councils (DSCs) with representation from teachers, school administrators, district administrators, and support staff
- Hold a series of meetings of DSCs to build leadership capacity through knowledge of CS and of systemic change management
- Professional development on teaching practices focused on providing access to CS instruction for all students delivered by PACE team (Year 2)
- Toolkit as a roadmap to integrating a CS pathway with the district strategic plan in a way that promotes access for all students

2. **Teacher training in *CS Discoveries* with enhanced supports**

- Comprehensive CS professional development delivered by Code.org during the summer (Year 1)
- Ongoing professional development support delivered by Code.org throughout the school year (Year 1)
- On-demand support offered to teachers by PACE team

3. **Districtwide implementation of middle school high quality CS curriculum**

- Requirement established for all students to be enrolled in a full year equivalent of CS by the end of middle school
- Formalized middle school CS course sequence that meets DESE's digital literacy and computer science (DLCS) standards

MEDIATORS

District

Building CS Course Sequence in Middle School

- Established CS course sequence in middle school that has potential to lead into a high school CS pathway

Developing Infrastructure for Sustaining High School CS Pathways

- Increased district leadership capacity to oversee high school CS pathways for students
- Structures and processes in place that support sustained CS prioritization
- Community resources in place that support CS education

Teacher

- Increased number of teachers teaching CS
- Improved teacher practices for teaching CS content
- Improved teaching practices focused on all students in CS courses
- Increased CS teaching confidence

SHORT-TERM OUTCOMES

- Increased student understanding of CS principles
- Increased student interest in CS
- Participation and progression of all students in CS education

MEDIUM-TERM OUTCOMES

- Increased student achievement
- Increased enrollment in high school CS courses

LONG-TERM OUTCOMES

- Meet workforce demands for more students entering CS careers

Student Outcomes

Finally, the intervention is expected to lead to increased student understanding of CS principles, increased interest in CS, and participation and progression in CS education in the short term; increased student achievement and enrollment in high school CS courses in the medium term; and increased ability to meet workforce demands for more students entering CS careers in the long term.

1.2 Evaluation Overview

Abt designed and conducted an independent evaluation of the PACE program that included (1) an assessment of the fidelity of implementation of PACE in the six participating districts, (2) a study of district-level mediating factors, and (3) a quasi-experimental impact study designed to meet What Works Clearinghouse (WWC) Group Design Standards (Version 5.0). The fidelity of implementation assessment focuses on understanding whether the key components of PACE as shown in the first column of the logic model (Exhibit 1.1) were implemented in treatment districts. The study of district-level mediating factors attempts to understand whether treatment districts successfully achieved the district-level mediating factors shown in the second column of the PACE logic model. Finally, the impact study focuses on understanding whether there is evidence suggesting that PACE *caused* changes in student achievement outcomes as predicted by the logic model.

1.3 Research Questions

To provide important context for understanding the impact study, the evaluation first studied the **fidelity of implementation** of the PACE intervention in treatment districts:

RQ1. To what extent are the key components of the PACE intervention model implemented with fidelity each year?

RQ2. How does implementation fidelity vary across districts and key components of the program?

Next, the study of **district-level mediating factors** focused on building a CS course sequence in middle school and developing infrastructure for sustaining high school CS pathways, with a focus on both the experiences of study participants in treatment districts and any differences between treatment and comparison districts:

RQ3. To what extent did district-level mediators change for treatment districts after PACE implementation? To what extent did these differ between treatment and comparison districts during the intervention period?

Last, the impact study focused on measuring the **impact of PACE on student achievement**. It included two "confirmatory" questions that would be used to assess overall effectiveness of the intervention as well as one "exploratory" question that would study other outcomes of interest but would not be used to assess overall effectiveness.

RQ4. What is the effect of PACE on middle school achievement in geometry relative to districts in a business-as-usual condition? (confirmatory outcome)

RQ5. What is the effect of PACE on middle school achievement in life sciences relative to districts in a business-as-usual condition? (confirmatory outcome)

RQ6. What is the effect of PACE on middle school achievement in other measures of math and science relative to districts in a business-as-usual condition? (exploratory outcomes)

1.4 District Eligibility and Recruitment

Treatment Districts and Teachers

The PACE team originally planned to recruit approximately 15 urban and rural districts over the course of the program. The proposal for PACE included a focus on recruitment of rural districts. The original eligibility criteria required that *CS Discoveries* be administered to all middle school students beginning in grade 7 and continue through grade 8. However, given the timing of recruitment during the COVID-19 pandemic, when districts were already facing many challenges with student attendance and learning loss in core subjects, recruiting districts willing to implement a new CS course for all middle school students was difficult.

To increase recruitment, the eligibility criteria for treatment districts were relaxed from the originally defined criteria. The PACE team allowed districts to (1) administer another CS curriculum as long as the team determined that the curriculum was of high quality and, if it did not cover DESE's DLCS standards, the district supplemented the curriculum with additional units and lessons to ensure the standards were covered; (2) administer the course beginning in grade 6 with students covering 2 units in grade 6, 2 in grade 7, and 2 in grade 8; and (3) allow districts with limited capacity to begin implementing the intervention with only a subset of students participating in the course, as long as those students participated in the full course. Thus, districts were deemed eligible to be included in the treatment group if they met the following modified criteria:

- The PACE intervention was administered beginning in either grade 6 or 7 and continued through grade 8 for a subset of students in the district.
- Either *CS Discoveries* or a comparable high quality curriculum were delivered as part of the intervention.

With these eligibility criteria, a total of six Massachusetts districts were recruited, five of which started implementation in school year (SY) 2020–21 and one of which started implementation in SY 2022–23 (Exhibit 1.2).[6] In four of the districts, students took *CS Discoveries* or an alternative course beginning in grade 7; in the other two districts the coursework began in grade 6. The six districts included a total of 15 teachers.

As PACE was funded as a project that prioritized rural districts, its award stipulated that rural districts must comprise 50 percent plus one of the cases in the overall sample. Four of the six districts were rural.

---

[6] Treatment District 5 began implementation in SY 2020-21 but did not begin implementation of *CS Discoveries* until SY 2021-22. Two districts, Treatment Districts 3 and 6, offered a CS curriculum that was different from *CS Discoveries.* Treatment District 3 offered a CS course aligned to *Project Lead the Way* and supplemented it to meet all *CS Discoveries* standards. Treatment District 6 offered the *iBlocks* curriculum, and ultimately it was not able to supplement the curriculum to meet all *CS Discoveries* standards. Also, in Treatment District 6, only one of two middle schools offered any CS instruction, which met the relaxed criteria but not the original requirement that all students in a district take the course.

For the five districts whose first full year of implementation was SY 2020-21, the study of fidelity of implementation focuses on district and teacher activities beginning in SY 2020–21.[7] However, in these districts the impact study focuses on students who began their CS instruction in SY 2021–22 (referred to as a student "cohort"). The focus on this cohort of students was necessary to ensure that pre-intervention achievement data from the preceding school year would be available for analysis and that all students in the cohort received a high quality CS curriculum.[8] For the remaining (sixth) district, all studies focus on district and teacher activities and on students starting the CS instruction in SY 2022–23, the year that PACE implementation began there.

Exhibit 1.2: Study period of districts participating in the PACE intervention

District	First Year of Intervention	Student Cohort Included in Impact Study		
		First Year	Final Year	Grades Students Took CS Course
Treatment District 1	SY 2020–21[1]	SY 2021–22	SY 2022–23	7-8
Treatment District 2	SY 2020–21[1]	SY 2021–22	SY 2022–23	7-8
Treatment District 3	SY 2020–21	SY 2021–22	SY 2022–23	7-8
Treatment District 4	SY 2020–21	SY 2021–22	SY 2023–24	6-8
Treatment District 5	SY 2020–21	SY 2021–22	SY 2023–24	6-8
Treatment District 6	SY 2022–23	SY 2022–23	SY 2023–24	7-8

Key: CS=computer science. SY=school year.
Notes:
[1] Treatment Districts 1 and 2 both began implementing the intervention by holding an in-person DSC meeting in early 2020. Implementation then paused due to the COVID-19 pandemic and resumed the following school year. As a result, these districts began implementation in SY 2019-20 but the first full year of the intervention was SY 2020-21.

Exhibit 1.3 reports demographic characteristics of 10 of the 15 teachers who implemented PACE in the six treatment districts and responded to a baseline survey administered as part of their Code.org summer training (five teachers are missing data because they did not respond to these questions on the survey). All teacher respondents identified as White; they ranged in age from 32 to 62 years; four teachers did not have formal education in CS. Prior teaching experience ranged from 7 to 32 years and 0 to 19 years of experience teaching CS. Lastly, five teachers had not received any prior CS professional development before the *CS Discoveries* summer workshop.

[7] Treatment Districts 1 and 2 both began implementing the intervention by holding an in-person DSC meeting in early 2020. Implementation then paused due to the COVID-19 pandemic and resumed the following school year. As a result, these districts began implementation in SY 2019-20 but the first full year of the intervention was SY 2020-21.

[8] Due to the cancellation of test administrations in response to the COVID-19 pandemic, spring 2020 Massachusetts Comprehensive Assessment System test (MCAS) data were not available.

Exhibit 1.3: PACE teacher characteristics

District/Teacher	Age[1]	Race	Highest Level of CS Education	Years Teaching	Years Teaching CS	Total Time in CS PD before *CS Discoveries* Training
Treatment District 1						
Teacher 1	57	White	No formal CS education	32	1	None
Teacher 2	48	White	No formal CS education	22	2	16-35 hours
Treatment District 2						
Teacher 1	41	White	CS college coursework	15	11	Less than 6 hours
Teacher 2	58	White	No formal CS education	17	0	None
Teacher 3	55	White	No formal CS education	9	0	None
Teacher 4	32	White	CS college coursework	6	0	None
Treatment District 3						
Teacher 1	57	White	CS bachelor's degree	7	6	36-80 hours
Treatment District 4						
Teacher 1	62	White	CS master's degree	N/A[2]	0	Less than 6 hours
Treatment District 5						
Teacher 1	47	White	CS college coursework	24	19	36-80 hours
Treatment District 6						
Teacher 1	34	White	CS college coursework	11	0	None

Key: CS=computer science. PD=professional development.
Source: Code.org teacher summer baseline survey
[1] Age was calculated using year of birth and the date teachers took the summer baseline survey.
[2] Treatment District 4, Teacher 1 did not respond to the question used to determine years of teaching experience.

Comparison Districts

WWC Group Design Standards require the impact study to measure outcomes for treatment districts relative to a comparison group. To construct this comparison group, Abt identified one comparison district for each of the six treatment districts.[9] The procedure for identifying comparison districts required matched comparison districts to have the same urbanicity designation from the National Center for Education Statistics as well as the same "middle school configuration," referring to whether the middle school and high school were combined in one building or separate.

For each treatment district, the five districts that met the two required criteria and were the most similar on other observed characteristics[10] were identified as potential comparison districts. The names of the five potential comparison districts for each treatment district were shared with the PACE team, which then

[9] Abt's original design called for matching multiple comparison districts to each treatment district. However, after recruitment for the intervention resulted in a smaller sample of treatment districts than anticipated, Abt modified that design as described here.

[10] Abt identified potential comparison districts using the SY 2018–19 MCAS math scaled score as well as demographic characteristics including sex, race/ethnicity, English learners, economic disadvantage, and total enrollment.

recruited the comparison districts to participate in the study. The only requirement of participation for comparison districts was annual completion of the District Infrastructure Survey (see Section 3.1).

One comparison district for each treatment district agreed to participate. During the time period of the evaluation, comparison districts were expected to continue their "business-as-usual" CS practices, which consisted of varying levels of engagement with CS coursework or practices.[11] Some of the comparison districts participated in other CS interventions, including *Project Lead The Way* and *CSforALL*, The findings from the District Infrastructure Survey provide some insight into CS practices in the selected comparison districts during this time period (see Section 3.3). Characteristics of teachers in comparison districts were not collected.

1.5 Report Organization

The remainder of this report is organized in accordance with the logic model (Exhibit 1.1). Chapter 2 examines the fidelity of implementation of the PACE key components in the six treatment districts. Chapter 3 examines the district-level mediating factors that are ultimately expected to affect student outcomes. Chapter 4 provides findings from the impact study of PACE on student achievement outcomes in treatment versus comparison districts. Chapter 5 summarizes our conclusions across analyses.

The report also includes several appendices: Appendix A contains the District Infrastructure Survey instrument. Appendix B includes the full findings from the District Infrastructure Survey for treatment districts over time, from SY 2019–20 to SY 2023–24. Appendix C includes findings from the District Infrastructure Survey for treatment and comparison districts from SY 2021–22 to SY 2023–24. Appendix D includes findings based on course enrollment data in high school grades. Appendix E includes the impact study design supplemental details. Appendix F includes the impact study supplemental tables.

[11] In the five years preceding the start of the evaluation, the state of Massachusetts implemented several CS initiatives. One example of these initiatives was a K–12 Digital Literacy and Computer Science (DLCS) Curriculum Framework (Massachusetts DESE, 2016), which is a sequential guide to providing students with CS knowledge and skills that prepare them for postsecondary education and competitive careers. The state also created a licensure program for its new Grade 5–12 DLCS Teaching License and was strongly encouraging school districts to implement the DLCS standards and aspiring grade 5–12 CS teachers to become licensed. Notably, many of these initiatives rely on individual teachers choosing to take the professional development programs necessary to offer CS courses in their schools and reach more students, leading to highly variable implementation of CS programs across K–12 districts.

2. Fidelity of Implementation of PACE Key Components

Key Takeaways

- Although the PACE key components were slightly modified to account for pandemic-related challenges, four out of six treatment districts were able to meet the adjusted fidelity thresholds for all three key components.

Abt assessed the fidelity of implementation of the PACE intervention across the entire implementation period, from SY 2020–21 through SY 2023–24. That is, did the treatment districts deliver the three key components described in the logic model as the PACE team intended? The results of this analysis are both useful for future refinements of PACE and also provide context for interpreting the findings that follow. If the fidelity of implementation analysis concludes that the PACE intervention was implemented as intended, future implementers of PACE will have a better understanding of the steps to be taken to attempt to replicate any subsequent impacts. If the fidelity of implementation analysis concludes that the PACE intervention was not implemented as intended, this could be a potential explanation for findings that are inconsistent with the hypothesized logic model, such as a lack of subsequent impacts.

2.1 Data Sources

Two primary sources contributed the data used to assess the fidelity of implementation of PACE in treatment districts:

- The PACE team collected data annually from each treatment district on the total number of middle school students who took the CS course offered, the number of each stakeholder type who participated in DSC meetings and the dates they participated in those meetings, and whether or not the district executed the following aspects of PACE each year:
  - Has a formalized middle school course sequence that allows students to complete the *CS Discoveries* (or equivalent) course by the end of middle school
  - Has an established requirement for all students to be enrolled in a full-year equivalent of CS by the end of middle school
  - Requires *CS Discoveries* (or equivalent) in middle school/junior high.
- Code.org collected data on teacher characteristics, teacher participation in summer *CS Discoveries* training (number of days out of a total of five), and teacher participation in academic-year workshops of two sessions each (number of sessions across four workshops).

2.2 Analytic Approach

Abt and the PACE team jointly developed fidelity of implementation criteria and set thresholds for adequate implementation of each component.

Key Component 1: District-level commitment to CS instruction for all students

Three district-level conditions were required to have implemented Key Component 1 with fidelity:

1. Form a DSC with representation from at least three of the four key stakeholder groups (teachers, school administrators, district administrators, and support staff[12]);
2. Hold at least four DSC meetings in the first year and share relevant documents in each meeting; and
3. Have participation of at least three of the four key stakeholder groups in the year 2 training on teaching practices focused on access to CS instruction for all students.

Districts are also provided with a toolkit of materials that can be used to integrate CS instruction with district strategic plans in a way that promotes access for all students. All toolkit materials are included on the PACE website. Use of the toolkit was not separately assessed in the fidelity of implementation review as the toolkit was available to all districts on the website.

Key Component 2: Teacher training in CS Discoveries

Three teacher-level conditions were required to have implemented Key Component 2 with fidelity:

1. At least half of the teachers in each district participate in at least four days of the five-day summer *CS Discoveries* training;
2. At least half of the teachers in each district participate in at least three of the four academic-year workshops; and
3. Teachers are offered on-demand support for implementing the new curriculum.

This key component was initially anticipated to include a requirement to implement a PLC for teachers to engage with one another about the new curriculum and the elevated commitment to CS. During the post-pandemic period, however, no teachers chose to participate in a PLC, so this requirement was removed, replaced with the offer of on-demand support.

Key Component 3: Districtwide implementation of middle school CS Discoveries *or a comparable CS curriculum*

Two district-level conditions were required to have implemented Key Component 3 with fidelity:

1. Establish a requirement that all students be enrolled in a full-year equivalent of CS by the end of middle school; and

2. Formalize a middle school CS course sequence that meets DESE's DLCS standards.

2.3 Findings

This section reports on the fidelity of implementation across the six treatment districts for each of the three PACE key components over the study implementation period (SY 2020-21 to SY 2023-24).

Overall, four of the six treatment districts met the fidelity of implementation thresholds for Key Component 1. All but one treatment district met the thresholds for Key Components 2 and 3.

---

[12] Support staff typically included counselors, community liaisons, or other non-teacher, non-administrator school staff.

Key Component 1: District-level commitment to CS instruction for all students

All six districts formed DSCs including the required type of staff. All DSCs included teachers, school administrators, and district administrators; and five of the six DSCs also included support staff representation (Condition 1). Most of the DSCs included teachers, principals, counselors, librarians, and technology coordinators. Some DSCs also included instructional coaches, parents, and in one district, a student representative.

Three of the six districts conducted five DSC meetings in the first year, two conducted six meetings, and one conducted seven meetings (Condition 2).

All six districts trained on teaching practices for providing access to CS instruction for all students. Four of the six districts' DSCs included representation from at least three of the four key stakeholder groups at a minimum of four DSC training meetings (Condition 3). In two of the four districts, teachers, school administrators, and support staff participated; in the other two, district administrators also participated. Treatment District 6 held six DSC meetings in their first year of implementation and three DSC meetings in its second year that focused on training to provide access to CS instruction for all students.

All six districts were considered to have met Conditions 1 and 2 for Key Component 1 by forming a DSC with at least three of the four key stakeholder groups and holding at least four DSC meetings in their first year of implementation. Four of the six districts met Condition 3 by holding at least four DSC meetings focused on providing access to CS instruction for all students, with at least three of the four key stakeholder groups in their second year of implementation.

Exhibit 2.1: Fidelity of implementation for Key Component 1

Treatment District	District Stakeholder Councils (Condition 1)	Build Leadership Capacity (Condition 2)	PD on Teaching Practices for CS for All Students (Condition 3)	District-Level Score
	Year 1 (of implementation for each cohort) **1**=DSC is formed and includes at least one member representing at least 3 of each of the 4 key groups **0**=DSC is not formed	**Year 1** (of implementation for each cohort) **1**=At least 4 meetings are held with DSCs **0**=All other outcomes	**Year 2** (of implementation for each cohort) **1**=At least 1 member from 3 of the 4 key groups attended at least 4 DSC meetings **0**=All other outcomes	**Adequate** = 100% of districts with a score of 2 in Year 1 of implementation; and = 100% of districts with a score of 3 across both years of implementation
1	1	1	1	Met threshold
2	1	1	1	Met threshold
3	1	1	0	Did not meet threshold
4	1	1	1	Met threshold
5	1	1	1	Met threshold
6	1	1	0	Did not meet threshold
	% Districts with Adequate Implementation			67%
	Achieved Sample-Level Adequate Implementation Threshold?			Did not meet threshold

Key: CS=computer science. DSC=district stakeholder council. PD=professional development.

Key Component 2: Teacher training in CS Discoveries

Teachers were expected to take the 35-hour Code.org training in *CS Discoveries* over a five-day period in the summer prior to teaching their CS course and then participate in four academic-year workshops, each split into two sessions. Of 15 teachers, 11 participated in at least four days of the *CS Discoveries* summer training prior to participating in the intervention that coming school year (Condition 1). One teacher was able to complete only one day of summer training. In Treatment District 6, none of the three CS teachers participated in the *CS Discoveries* summer training prior to participating in the intervention.[13] However, this district did not teach the *CS Discoveries* course in either year of implementing the intervention. Instead, the teachers engaged in *iBlocks* and *Sphero* training, which were the curricula used in this district.

More than half of all teachers (eight of 15 teachers) participated in at least one of the two sessions for three of the four academic-year workshops during their first year teaching the *CS Discoveries* course (Condition 2).

Finally, all districts were offered on-demand support by the PACE team (Condition 3).

All but one district was considered to have implemented Key Component 2 with fidelity by having all teachers participate in at least four of the five days in the summer workshops, at least half of their teachers participate in at least three academic year workshops, and by being offered on-demand support.

[13] One teacher from Treatment District 6 participated in the *CS Discoveries* summer training in summer 2023, after their first year participating in the intervention.

Exhibit 2.2: Fidelity of implementation for Key Component 2

Treatment District	Comprehensive CS PD (Condition 1)	Ongoing PD Support (Condition 2)	Teacher-Level Score	% Teachers with Adequate Implementation	On-Demand Support Offered to Districts (Condition 3)	District-Level Score
	All Years 1=Teacher ever received at least 4 of 5 days of CS PD; 0= All other outcomes	**All Years** 1=Teachers receive at least 1 of 2 sessions within at least 3 of the 4 workshops of PD support during their first year teaching the CS course; 0=All other outcomes	Condition 1 + Condition 2	2=Adequate implementation	**All Years** 1=On-demand support offered; 0=On-demand support not offered	**Adequate** = 50% of teachers with score of 2; and = On-demand support offered (score of 1)
1				100%	1	Met threshold
Teacher 1	1 (5 days)	1 (4 workshops; 8 sessions)	2			
Teacher 2	1 (5 days)	1 (4 workshops; 8 sessions)	2			
2				50%	1	Met threshold
Teacher 1	1 (5 days)	1 (4 workshops; 8 sessions)	2			
Teacher 2	1 (5 days)	0 (1 workshop; 1 session)	1			
Teacher 3	1 (5 days)	1 (4 workshops; 6 sessions)	2			
Teacher 4	0 (1 day)	0 (0 workshops; 0 sessions)	0			
3				50%	1	Met threshold
Teacher 1	1 (5 days)	1 (3 workshops; 4 sessions)	2			
Teacher 2	1 (5 days)	0 (0 workshops; 0 sessions)	1			
4				50%	1	Met threshold
Teacher 1	1 (5 days)	1 (4 workshops; 8 sessions)	2			
Teacher 2	1 (5 days)	0 (0 workshops; 0 sessions)	1			
5				100%	1	Met threshold
Teacher 1	1 (5 days)	1 (4 workshops; 4 sessions)	2			
Teacher 2	1 (5 days)	1 (4 workshops; 8 sessions)	2			
6				0%	1	Did not meet threshold
Teacher 1	1 (5 days)	0 (1 workshop; 2 sessions)	1			
Teacher 2	0 (0 days)	0 (0 workshops; 0 sessions)	0			
Teacher 3	0 (0 days)	0 (0 workshops; 0 sessions)	0			
	% Districts with Adequate Implementation					83%
	Achieved Sample-Level Adequate Implementation Threshold?					Met threshold

Key: CS=computer science. PD=professional development.

Key Component 3: Districtwide implementation of middle school high quality CS curriculum

Students in participating districts begin participation in the *CS Discoveries* course or another course aligned to DESE's DLCS standards in either grade 6 or 7. The *CS Discoveries* course had a total of six units. Students who began in grade 6 were expected to take two units each year for three years, and students who began in grade 7 were expected to take three units each year for two years.

Five of the six districts established a requirement that all students be enrolled in a full-year equivalent of CS by the end of middle school (Condition 1).[14] The sixth district established a requirement that all students be enrolled in a full-year equivalent of CS in just one of its two middle schools.

In four of six districts, a course sequence was established for all students to be able to take *CS Discoveries*. A fifth district used the *Project Lead the Way* CS curriculum or equivalent course and added supplemental units to ensure alignment with DESE's DLCS standards (Condition 2). In the final district, one school used the *iBlocks* curriculum and the other school used the *Sphero* curriculum. While covering aspects of DESE's DLCS standards, neither of these curricula are fully aligned. The district did not add supplemental units to ensure alignment with DESE's DLCS standards (Condition 2), though both schools supplemented with activities from *Hour of Code* and *Hummingbird*.

Five of the six districts were considered to have implemented Key Component 3 with fidelity.

Exhibit 2.3: Fidelity of implementation for Key Component 3

Treatment District	Student Enrollment in Full-Year Equivalent of CS (Condition 1) **All Years** **1**=Requirement established for students to be enrolled in a full-year equivalent of CS by the end of middle school **0**=No requirement established for students to be enrolled in a full-year equivalent of CS by the end of middle school	Formalized CS Course Sequence with Standards-Based Curriculum (Condition 2) **All Years** **1**=All students are able to take a CS course sequence aligned to DESE's DLCS standards by the end of middle school **0**=Not all students are able to take a CS course sequence aligned to DESE's DLCS standards by the end of middle school	District-Level Score **Adequate** = score of 2
1	1	1	Met threshold
2	1	1	Met threshold
3	1	1	Met threshold
4	1	1	Met threshold
5	1	1	Met threshold
6	0	0	Did not meet threshold
	% Districts with Adequate Implementation		83%
	Achieved Sample-Level Adequate Implementation Threshold?		Met threshold

Key: CS=computer science. DESE= Massachusetts Department of Elementary and Secondary Education. DLCS=Digital Literacy and Computer Science. MCAS=Massachusetts Comprehensive Assessment System.

[14] One of the districts had enough teachers for all students to take the course in some years (i.e., the for the cohort of students in the impact sample), but it did not have a sufficient number of teachers for later cohorts of students to continue taking the course in SY 2023-24. The district indicated it intends to hire additional teachers to restore the CS requirement for all middle school grades.

3. District-Level Mediating Factors

Key Takeaways

- All treatment districts established a CS course sequence in middle school; only one comparison district had high levels of CS enrollment in more than one middle school grade.
- Half of the treatment districts already had high levels of middle school CS enrollment for some portion of their middle school grades prior to implementing the PACE intervention.
- Most treatment districts had greater infrastructure to sustain high school CS pathways than did their matched comparison districts.

The PACE program logic model (Exhibit 1.1) hypothesizes that implementation of the program's key components influences student outcomes by shifting certain district- and teacher-level mediators. This chapter focuses on district-level mediators by studying them both within treatment districts over time and between treatment districts and their matched comparison districts. This report does not study teacher-level mediators because teacher-level data on mediators were not collected for the evaluation.

Of note, the data used for these descriptive analyses were not designed to be reliable measures of the district-level mediating factors shown in the PACE logic model. As a result, analyses in this chapter should be interpreted with caution. Abt's independent evaluation of PACE was designed to measure fidelity of implementation via implementation of key components (reported in Chapter 2) and the resulting impact on student achievement outcomes (reported in Chapter 4). Chapter 3 aims to connect those two analyses by describing available measures of district-level mediators.

3.1 Data Sources

Analyses in this chapter are based on two data sources: (1) Student Course Schedule data from DESE and (2) a District Infrastructure Survey that was developed and administered annually by EDC to administrators in treatment and comparison districts.

Student Course Schedule Data

DESE's Student Course Schedule (SCS) database provides a record for each course in which a student enrolls. The database also includes variables that summarize course details such as the local course code; a subject-area course code defined at the state level; and the course term, level, and credit available. Analyses in this chapter use its data to study the enrollment in CS courses during middle school (as a proxy for building a CS course sequence in middle school) in treatment and comparison districts, both prior to and following PACE implementation.

Abt received extracts from DESE databases for school years 2018-19 through 2023-24. Data used in this chapter were collected at the end of each school year.

District Infrastructure Survey

Based on a framework that helped key stakeholders construct a CS education implementation plan,[15] the District Infrastructure Survey aimed to assess district commitments to CS. The first part of the survey consists of 18 items about district commitments to CS grouped into the following categories: continuous improvement, district status,[16] CS leadership, CS teacher capacity and development, CS partnerships, and community engagement in CS. In SY 2021-22, EDC added a second part to the survey, consisting of seven items related to PACE goals and strategies. All survey items were scored on a scale from 1 to 4, with 1 indicating weak or no evidence and 4 indicating strong evidence. See Appendix A for a copy of the District Infrastructure Survey.

The survey was administered to treatment districts from SY 2019–20 (one year before the earliest cohorts began PACE implementation) through SY 2023–24 (the last year that any cohort was implementing PACE). To enable comparisons between treatment and comparison districts, the District Infrastructure Survey was also administered to comparison districts from SY 2021–22 through SY 2023–24.

3.2 Analytic Approach

All analyses of the district-level mediating factors are descriptive in nature. Due to the small number of data points in each of these datasets, analyses in this chapter do not include statistical tests.

Enrollment in CS Courses

As a measure of building a CS course sequence in middle school, this chapter reports on the percentage of middle school students who enrolled in any CS course, separately by grade. Abt identified CS courses using the state-defined subject-area course code. These codes "identify the organization of subject matter and related learning experiences provided for the instruction of students" (DESE, 2024c, p. 11). Both "prior-to-secondary" courses and "secondary" courses have codes that label them as "Computer and Information Sciences." The percentage of middle school students who enrolled in any CS course was defined as the total number of students who enrolled in any course identified by DESE as "Computer and Information Sciences" courses divided by the total number of students enrolled in the grade.[17]

Though DESE data have the benefit of being available for all students in treatment and comparison districts, they come with some caveats. First, the data may not include all courses that study districts considered to be CS.[18] For example, as part of PACE implementation in Treatment District 6, the district taught a class on game design based on the *iBlocks* curriculum. The class was classified as an engineering course rather than as "Computer and Information Sciences." As a result, the results that follow show Treatment District 6 as not having any middle school students enrolled in CS courses. As well, the SCS

---

15 The framework was the SCRIPT (Strategic CSforALL Resource & Implementation Planning Tool); see https://www.csforall.org/projects_and_programs/script/.

16 "District status" questions ask about computer science materials, curriculum selection, and content refinement in the district.

17 Constructing a percentage requires the total number of students enrolled in the grade as a denominator. The total number of students enrolled in each grade in the district was calculated from the Student Information Management System, a separate DESE database.

18 EDC expected that *CS Discoveries* would have its own dedicated subject-area course code in the SCS database, but no courses in the treatment or comparison districts had this course code during the study period.

data only measure student enrollment, not student participation in the course. It is possible that some students enrolled in the course did not participate in the course in its entirety.

Perceptions of District-Level Mediators

District responses to elements of the District Infrastructure Survey provide measures of the four district-level mediators from the PACE logic model (Exhibit 1.1).[19] Abt generated a summary measure for each of the four mediators by calculating each district's average response to a subset of survey items aligned with each mediator. The average value of each mediator was calculated across all years during which the intervention was implemented (in treatment districts) or all years during which the intervention was implemented in the matched treatment district (for comparison districts). Exhibit 3.1 displays the survey items that were determined to be most strongly aligned to each of the four district-level mediators.

Exhibit 3.1: Mapping of District Infrastructure Survey items to PACE district-level mediators

Mediator	Survey Items
1 – Established CS course sequence in middle school that has potential to lead into a high school CS pathway	• How well are CS classes sequenced and aligned in your district? • All middle grades students receive CS instruction. • CS is provided in sequential middle school years at a minimum of 75 instructional hours per year.
2 – Increased district leadership capacity to oversee high school CS pathways for students	• Implementation of inclusive CS pathway planning. • CS pathways are integrated with district strategic plan.
3 – Structures and processes in place that support sustained CS prioritization	• How well does your district select CS curricula? • What role does district-level leadership play in the planning and development of CS curriculum? • Which of the following best describes your district's plan for CS education? • Which of the following best describes the way CS education is implemented in your district? • Which of the following best describes the district-level resources for the CS teacher working groups in your district? • There is a district-level CS taskforce that includes representation from major stakeholder groups.
4 – Community resources in place that support CS education	• Which of the following best describes the local partners (including informal education) that engage with CS education in your district? • Which of the following best describes the professional learning partners that engage with CS education in your district? • Which of the following best describes the ways the local workforce engages with CS education in your district?

Key: CS=computer science.

[19] See Appendices B and C for analyses of responses to all items on the District Infrastructure Survey. Appendix B studies survey responses within treatment districts over time. Appendix C studies survey responses between treatment districts and their matched comparison districts.

3.3 Findings

Building CS Course Sequence in Middle School

All treatment districts established a CS course sequence in middle school; only one comparison district had high levels of CS enrollment in more than one middle school grade.

Five out of six treatment districts (Districts 1, 2, 3, 4, and 5) had close to 100% of middle school students enrolled in a CS course by the end of the implementation period (Exhibit 3.2). In three of these districts, the high levels of enrollment across grades reflect an increase in student enrollment in CS courses during the implementation period relative to the pre-implementation years. Only one comparison district (Comparison District 4) shows a meaningful increase in CS enrollment during the PACE implementation period, although this increase occurs in a single year and does not persist into the following years (Exhibit 3.3).

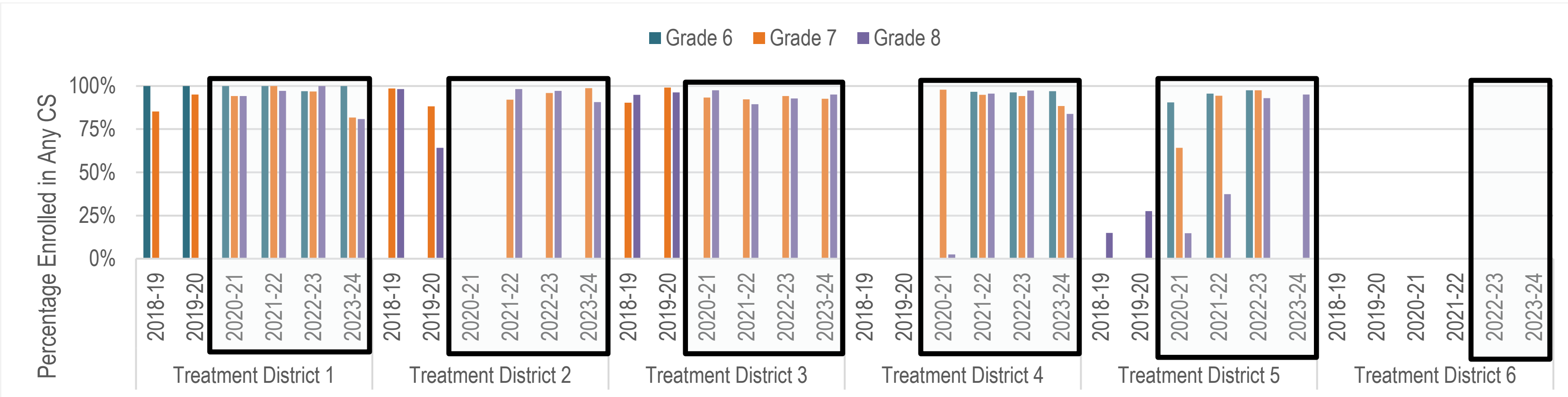
The findings based on course enrollment are largely consistent with those from the District Infrastructure Survey (Exhibit 3.4). Four of the six treatment districts had average levels of "establishing CS course sequence in middle school" above 3 points on the four-point scale, and the other two districts had average levels above 2 points. In all cases, average levels for the treatment districts are higher than their matched comparison districts.

A separate aspect of the district-level mediator asks whether the middle school course sequence has potential to lead into a high school CS pathway. Appendix D includes a parallel analysis to Exhibits 3.2 and 3.3 with a focus on high school enrollment in CS. While not a formal assessment of a high school CS pathway, some high school grades in treatment districts experienced increases in CS enrollment during the period of PACE implementation.

Half of the treatment districts already had high levels of middle school CS enrollment for some portion of their middle school grades prior to implementing the PACE intervention.

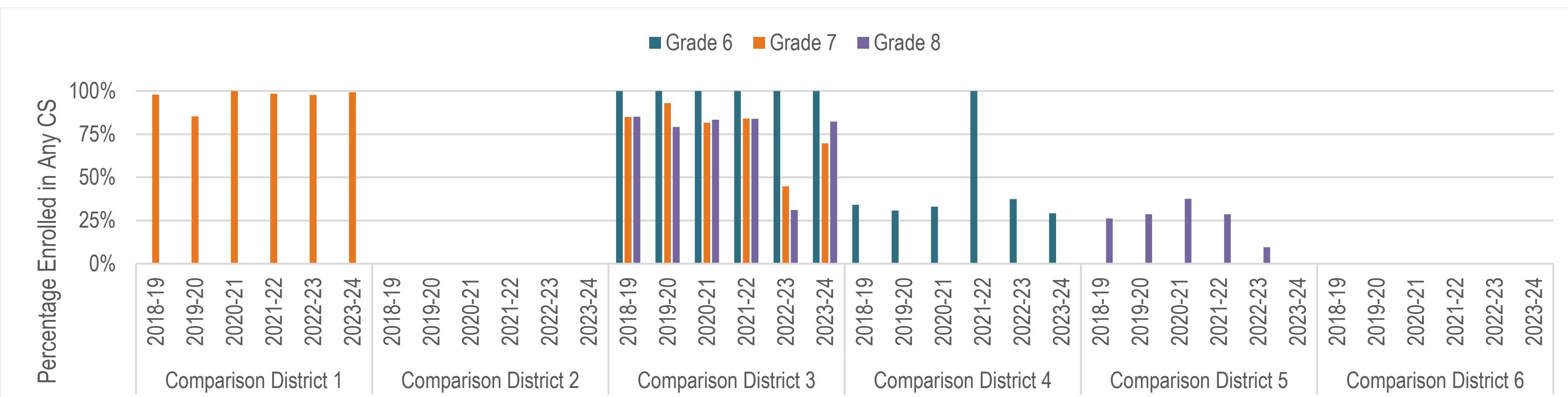
More than 75 percent of all students across most middle school grades in Treatment Districts 1, 2, and 3 had enrolled in a CS course in SY 2018-19 and SY 2019-20, prior to the PACE implementation period (Exhibit 3.3). This observation suggests that existing capacity for CS instruction was a correlate for implementing the PACE intervention and participating in the study.

Exhibit 3.2: Percentage enrollment in any "Computer and Information Science" course by grade in PACE districts (middle school)



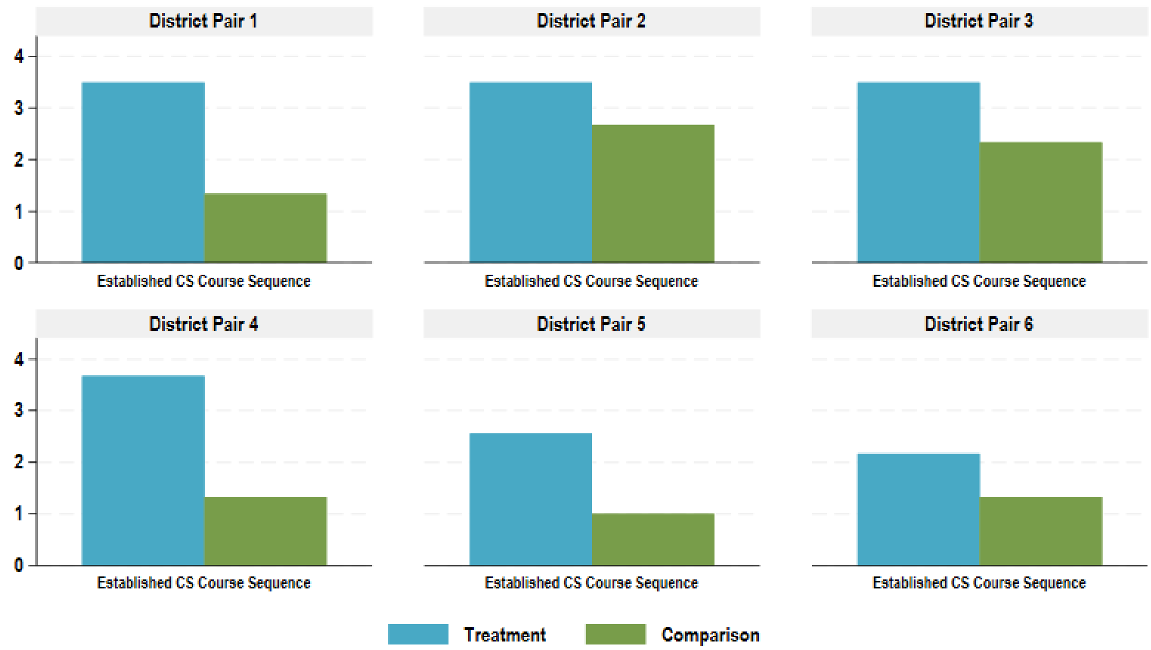
Notes: The exhibit shows the percentage of students enrolled in any course identified by DESE as "Computer and Information Sciences" separately for grades 6-8 across SY 2018-19 – 2023-24. Black boxes indicate years of PACE implementation. Data are missing from Treatment District 2 in SY 2020-21 due to an administrative error.

Exhibit 3.3: Percentage enrollment in any "Computer and Information Science" course by grade in comparison districts (middle school)



Notes: The exhibit shows the percentage of students enrolled in any course identified by DESE as "Computer and Information Sciences" separately for grades 6-8 across SY 2018-19 – 2023-24. Comparison districts appear in Exhibit 3.3 such that their position corresponds to their matched treatment district in Exhbit 3.2.

Exhibit 3.4: District Infrastructure Survey results for treatment and comparison districts on establishing CS course sequence in middle school



Notes: Each item on the District Infrastructure Survey has a four-point response scale (see Appendix A). Exhibit reports the average levels of responses across items corresponding to each mediator (see Exhibit 3.1).

Developing Infrastructure for Sustaining High School CS Pathways

The second category of district-level mediators focuses on the development of districtwide infrastructure for sustaining high school CS pathways. This includes building district capacity to oversee high school CS pathways, the establishment of structures and processes to sustain the prioritization of CS education, and the development of community partnerships to support CS education.

Most treatment districts had greater infrastructure to sustain high school CS pathways than did their matched comparison districts.

During the intervention period, Treatment Districts 1, 3, 4, and 5 exceeded their matched comparison districts in their reported capacity to oversee high school CS pathways for students, implement structures and processes that support sustained CS prioritization, and develop community supports for CS education. Within these four district pairs, the largest differences between treatment and comparison districts were on whether districts had built the capacity to oversee high school CS pathways.

Treatment District 6 exceeded its matched comparison in both capacity to oversee high school CS pathways for students and implement structures and processes that support sustained CS prioritization, but not in developing community partnerships to support CS education.

Exhibit 3.5: District Infrastructure Survey results for treatment and comparison districts on developing infrastructure for sustaining high school CS pathways

Notes: Each item on the District Infrastructure Survey has a four-point response scale (see Appendix A). Exhibit reports the average levels of responses across items corresponding to each mediator (see Exhibit 3.1).

3.4 Discussion

Analyses of mediators are useful for connecting fidelity of implementation to the impact analysis. Evidence from the Student Course Schedule data and District Infrastructure Survey suggests that most treatment districts were more successful than their matched comparison districts in both building a CS course sequence in middle school and developing infrastructure for sustaining high school CS pathways. While these mediators are only a subset of those that appear in the PACE logic model, they are key channels through which PACE was hypothesized to affect students' short-term and intermediate-term outcomes.

4. Impacts on Student Achievement Outcomes

Key Takeaways

- PACE did not affect grade 8 MCAS geometry or life sciences reporting subcategories.
- PACE also did not affect any of the other math and science reporting subcategories or overall grade 8 MCAS math and science scores.
- The lack of impacts on student achievement may be explained by the small number of districts included in the study and the lack of alignment between the intervention and the outcomes examined.

The PACE program logic model (Exhibit 1.1) hypothesizes that implementation of the PACE intervention will affect short-term, medium-term, and long-term outcomes. This chapter reports the results of the quasi-experimental impact study Abt used to estimate the PACE intervention's effectiveness on students' math and science achievement, which are medium-term outcomes.[20] Abt designed the impact study to meet What Works Clearinghouse (WWC) Group Design Standards (Version 5.0) under the assumption the study would be reviewed under the WWC Study Review Protocol (Version 5.1; What Works Clearinghouse (2024)).

4.1 Data Sources

The student assessment outcomes for the impact study come from the Massachusetts Comprehensive Assessment System (MCAS), an annual standardized assessment administered by DESE. DESE provided Abt with restricted student-level data from MCAS assessments for SY 2018-19 through SY 2023-24.

The grade 8 MCAS consists of three assessments: English language arts, mathematics, and science. For each assessment, DESE defines a set of reporting subcategories, which are groupings of MCAS items aligned to the same class of state standards. None of these assessments or reporting subcategories is well aligned to a computer science intervention such as PACE. However, MCAS data have two key benefits: first, they are collected for both the treatment and comparison groups; and second, they have acceptable reliability metrics as required by the WWC Study Review Protocol. DESE reports reliability statistics separately for each reporting subcategory in its annual technical appendix.

Abt determined that the geometry and life sciences reporting subcategories were most closely aligned to the intervention and prespecified the scores for these reporting subcategories as the confirmatory outcomes for the impact study. Abt assessed the face validity of these outcomes by consulting with a computer science teacher in Massachusetts with more than 20 years of teaching experience and with a DESE expert on the PACE team. They concluded that geometry is the math reporting subcategory that is most aligned to the intervention because the programming through the *CS Discoveries* course requires students to work with Cartesian graphs, coordinates, and angles. They determined that life sciences is the

[20] The impact study did not address short-term or long-term outcomes because data were not available on these outcomes for students in both treatment and comparison districts. It also did not study enrollment in high school CS courses for the set of students who experienced the full intervention in middle school because data were not available to follow most of those students into high school.

science reporting subcategory that is most aligned to the intervention because it assesses students' ability to read tables, interpret data, and apply logic to reach conclusions.

Following DESE procedures, Abt constructed reporting subcategory scores by summing the total points earned by a student across all questions in a reporting subcategory.[21] The latest available data from DESE shows that both the geometry and life sciences reporting subcategories met WWC criteria for reliability in 2023 (Cronbach's alpha of 0.85 for geometry and 0.70 for life sciences), the first year of data used for outcomes in the impact study (DESE, 2024d, Tables M-14 and M-15). The reliability for these reporting subcategories between 2021 and 2023 has been consistently greater than the WWC threshold of 0.60 (DESE, 2023, Tables N-14 and N-15; DESE, 2022, Tables M-12 and M-13), suggesting that the 2024 reporting subcategories should also have acceptable reliability.[22]

In addition to these confirmatory outcomes, Abt also analyzed impacts on a broader set of exploratory outcomes. These outcomes included all other grade 8 math and science reporting subcategories: number system and expressions/equations, fractions, statistics and probability, Earth/space sciences, physical sciences, and technology and engineering. They also included the overall math and science scaled scores, which are calculated by DESE and rescale the raw scores onto a common metric.[23]

Baseline Measures

Per WWC standards, a quasi-experimental impact study must establish baseline equivalence to demonstrate similarity of the treatment and comparison groups prior to implementation of the intervention. The impact study assessed baseline equivalence using student-level MCAS math scaled scores from the spring preceding their receipt of the PACE intervention in treatment districts. The baseline measure for treatment districts that implemented PACE beginning in grade 7 was the grade 6 MCAS math scaled score. The baseline measure for treatment districts that implemented PACE beginning in grade 6 was the grade 5 MCAS math scaled score. To make these baseline measures comparable, the scores were standardized to a common scale. The standardized scores are centered at the statewide grade-level mean for the school year in which baseline was assessed and scaled using the statewide grade-level standard deviation for that school year.

4.2 Analytic Approach

This section provides an overview of the quasi-experimental design used to assess the overall impact of PACE on student achievement outcomes.[24]

[21] Abt mapped MCAS questions to reporting subcategories using DESE releases of test items. For example, to calculate reporting subcategory scores from the 2024 assessment, Abt used the "Reporting subcategory" column from DESE's release of Spring 2024 test items (DESE, 2024a).

[22] Actual reliability for these reporting subcategories in 2024 has not yet been released by DESE. Reliability statistics are typically published in the *Next-Generation MCAS and MCAS-Alt Technical Report*, which should be released by DESE for SY 2023–24 later in 2025.

[23] See any *Next-Generation MCAS and MCAS-Alt Technical Report* for additional detail on calculation of scaled scores.

[24] Many of these details were pre-registered in the Registry of Efficacy and Effectiveness Studies (REES; #13900.1v1) before Abt began collecting outcome data. See Appendix E for additional technical details.

Study Sample

The impact study includes students in each of the matched treatment and comparison districts who experienced the entire PACE intervention. For districts that implemented PACE beginning in grade 7, these students were enrolled in the district in grade 7 in the year that implementation began there and in grade 8 the following year. For districts that implemented PACE beginning in grade 6, these students were enrolled in the district in grade 6 in the year that implementation began there and remained enrolled in the district through grade 8.[25]

The analytic sample, which consists of 820 students from treatment districts and 755 students from comparison districts, is limited to students with non-missing baseline and outcome data.[26]

Approach

The impact study uses a quasi-experimental design to estimate the impact of PACE on middle school math and science achievement relative to students in matched comparison districts conducting business as usual. To account for observed differences that could explain differences in achievement between the two groups of students, the impact study used a two-level hierarchical linear model that clustered students within districts and included the following student-level covariates: standardized baseline MCAS math scaled score, sex, race/ethnicity, student disability, English learner status, and a measure of low income.[27] The model also included indicators for matched treatment/comparison blocks as well as random effects for districts (see Appendix E for additional technical details).

4.3 Findings

This section reports the impact study findings. Following best practices for analysis of quasi-experimental evaluations, it first assesses baseline equivalence between students in the treatment districts and comparison districts. It then reports findings for student achievement (the two confirmatory outcomes as well as additional exploratory outcomes). All analyses of student achievement report a single, pooled estimate that reflects the average impact of PACE across students in all study districts. See Appendix F for detailed findings from the impact study.

---

[25] Some students are excluded from the analytic sample due to their having moved into or out of study districts during the course of the study. Across all study districts, 1,914 students were enrolled (987 treatment, 927 comparison) in the relevant grade at the start of the intervention period. By the second year of the intervention in all districts, 150 students had left the study districts (70 treatment, 80 comparison). By the third year of the intervention (in districts that began implementation in grade 6), another 47 students had left the study districts (28 treatment, 19 comparison). The 197 students who began in a study district but did not remain there until grade 8 were dropped from the analytic sample. In addition, there are 177 students who joined a study district after the first year of the intervention, who are also omitted from the analytic sample.

[26] A total of 142 students were omitted from the analytic sample due to either missing baseline data or missing outcome data for the study's two confirmatory outcomes.

[27] The pre-registered analysis plan also stated an intent to include three district-level covariates in the analytic model: district urbanicity, number of middle schools in the district, and total number of students enrolled in the district. These district-level covariates were excluded from Abt's analysis because of the small number of districts in the analytic sample.

Baseline Equivalence

Abt assessed baseline equivalence using a modified version of the impact model to estimate treatment-comparison differences in the baseline achievement measure. The assessment used a multilevel model with students nested within districts where the baseline achievement measure was modeled as a function of an indicator for treatment districts as well as a series of indicators for each of the six match blocks.

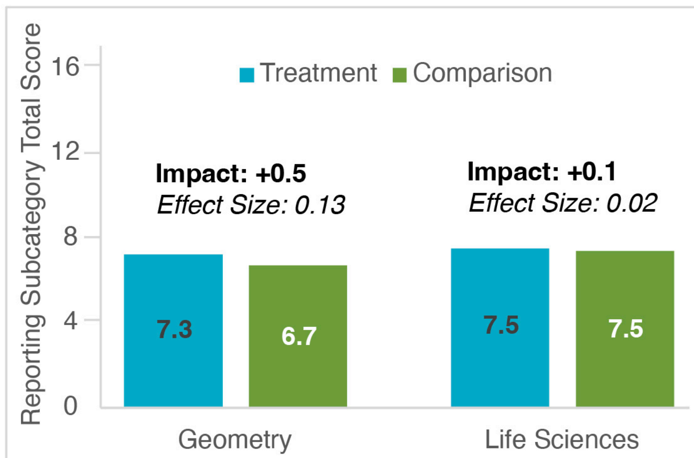
The estimated standardized difference in baseline MCAS scores was −0.02, indicating **the district-level matching succeeded in establishing baseline equivalence** between treatment and comparison districts.

PACE Impacts

PACE did not affect geometry and life sciences reporting subcategory scores.

Grade 8 students could earn a total of 16 possible points for the geometry reporting subcategory and 14 points for life sciences. On average, grade 8 students in treatment districts earned a total of 7.3 and 7.5 points in the MCAS geometry and life sciences reporting subcategories, respectively. These total scores were modestly larger than the average scores earned by grade 8 students in comparison districts (6.7 and 7.5 points, respectively). The impact estimates of 0.5 and 0.1 points are both statistically indistinguishable from zero.

Exhibit 4.1: Impact analysis for confirmatory student assessment outcomes



Notes: See Appendix F for detailed output. Reported impact does not equal difference in means due to rounding.

In addition to the overall impact for all students, the impact study also analyzed whether impacts on geometry and life sciences varied for subgroups defined by student sex and study cohort (see Appendix F). There was no evidence of an impact for either boys only or girls only and no evidence of a meaningful difference in impacts between boys and girls. Similarly, there was no evidence of an impact for any cohort of students or a meaningful difference in impacts between cohorts. However, there is wide uncertainty associated with these estimates. Given the relatively small analytic sample for the impact study, only large subgroup impacts or impact differentials would have emerged as statistically significant.

PACE did not affect other measures of math and science achievement.

Across all other reporting subcategories in the grade 8 math and science MCAS, differences in mean scores for students in treatment districts and students in comparison districts were not statistically significant (Appendix Exhibit F.4).[28] The differences in mean overall MCAS math and science scaled

[28] Other reporting subcategories assessed included number system and expressions/equations; functions; statistics and probability; Earth/space sciences; physical sciences; and technology and engineering.

scores were also not statistically significant. While coefficients were positive, , the magnitude of differences in means across all exploratory measures of math and science achievement was substantively small—all effect sizes were smaller than 0.15 standard deviations.

5. Discussion

The PACE intervention is a districtwide initiative that aims to support the adoption of CS instruction for all middle school students. Although the COVID-19 pandemic created challenges with recruiting districts, the PACE intervention was implemented in six districts in the state of Massachusetts during the 2020–21 through 2023–24 school years, with funding through an Early-Phase EIR grant. This concluding discussion consists of a findings summary, lessons learned for future PACE-like interventions, and lessons learned for future evaluations of CS interventions.

Findings Summary

Despite pandemic-related challenges, four of six treatment districts were able to implement PACE with fidelity. Most treatment districts showed greater progress than their matched comparison districts did in establishing a CS course sequence in middle school and developing infrastructure for sustaining high school CS pathways. However, treatment districts did not see any significant impacts on students' MCAS scores in the geometry and life sciences, which were identified to be the domains most closely aligned to the PACE instruction. These non-significant impacts may be explained by the small sample of districts and the weak alignment of the outcomes measured versus the intervention and therefore may not fully capture the effect of PACE on its primary target outcome, improved CS interest and knowledge.

Lessons Learned for Future PACE-Like Interventions

Lessons learned during the course of this external evaluation provide evidence for future PACE-like interventions to consider in their design and implementation:

- ***Target recruitment to districts with existing CS infrastructure*** – Several of the treatment districts had pre-existing CS infrastructure, a characteristic that could help future PACE-like interventions target their recruitment efforts. Such targeting is critical given the recruitment challenges experienced by this study. Specifically, four of the six treatment districts implemented the PACE intervention in schools that combined middle and high schools, serving grades 6 or 7 through grade 12. As well, three of the six treatment districts already had high levels of middle school CS enrollment for some portion of their middle school grades prior to implementing the PACE intervention.

- ***Be prepared to adapt*** – Each of the six treatment districts agreed to implement the PACE intervention with different existing infrastructure and a different vision for CS instruction in its schools. As a result, the six studied districts had different goals and implemented the intervention differently. Future PACE-like interventions should expect to encounter unique district-specific challenges to implementation and be prepared to adapt the intervention accordingly.

- ***Build flexibility into professional learning communities*** – PACE initially planned to require districts to implement professional learning communities (PLCs) for teachers, but they struggled to gain traction in the post-pandemic period. However, more recently the PACE team has established communities of practice that have been well attended. These experiences suggest that future PACE-like interventions should design PLCs to be adaptable in response to teacher demand.

- ***Support sustainability of district stakeholder councils*** – Participation in district stakeholder council (DSC) meetings declined over the course of the intervention. Districts were most successful in implementing the DSC requirement with fidelity in year 1 and less successful in year 2. This suggests that future programs relying on a district stakeholder council model spanning multiple years should carefully design the supports and incentives with a focus on continued time investment, tailoring them to participating districts as appropriate.

Lessons Learned About Evaluations of CS Interventions

This evaluation also encountered evaluation-related challenges that are useful to document for future evaluations of CS interventions:

- ***Anticipate recruitment challenges for district-level interventions*** – Though the evaluation initially targeted a sample of 15 treatment districts, the final analytic sample included only six districts. An underpowered evaluation can detect only very large impacts as statistically significant. Future PACE-like interventions should plan for recruitment challenges and high rates of attrition to ensure their evaluation is adequately powered.

- ***Measure and document treatment and comparison experiences to explain impacts (or lack thereof)*** – Understanding the experiences of both the treatment and comparison groups is critical for understanding either what led to an observed impact or why an expected impact did not materialize. Chapter 3 of this report studied some of the hypothesized district-level mediators, but future evaluations could incorporate additional measures of CS instruction (at both the teacher and student levels) to provide more detail on the difference between the experiences of those in treatment and comparison districts.

- ***Anticipate that identifying CS outcome measures that meet WWC standards can be challenging*** – There were two distinct, but important, challenges to identifying a confirmatory outcome measure for this evaluation. First was the issue of potential overalignment. Because treatment districts implemented CS instruction but comparison districts did not necessarily offer all students CS instruction, any CS-focused outcome could be considered overaligned with the intervention. This would invalidate the outcome from WWC review. Second, there was no standardized assessment of CS completed by all students in both the treatment and comparison districts. As a result of these two challenges, in order to meet WWC criteria the evaluation had to use outcome measures that were only weakly aligned with the intervention.

Conclusion

In an increasingly digital society, effective CS instruction will become a critical component of school curricula. As a result of PACE, six school districts in Massachusetts made a commitment that all students would leave middle school with a grounding in CS and established District Leadership Councils to guide the process of building a CS pathway within their district. Those six school districts served over 3,000 middle school students in SY 2022-23 alone. Although not evident via impacts on student-level achievement outcomes, the PACE intervention succeeded in building CS course sequences in middle school and developing infrastructure for sustaining high school CS pathways in six districts between SY 2020-21 and SY 2023-24. Additional refinement of the intervention model to facilitate recruitment and implementation coupled with evaluation of a more closely aligned outcome measure will be important steps for future evaluations of PACE-like interventions to maximize their likelihood of demonstrating impact on student-level outcomes.

Appendix A. District Infrastructure Survey Instrument

Background Info

Education Development Center (EDC) is conducting research on middle school computer science (CS) education in Massachusetts. Their research examines the impact of certain interventions being rolled out in districts across the state, including the Programming the Acceleration of Computing & Equity (PACE) program.

Your participation in this study is entirely voluntary. You should read the information below and ask questions about anything you do not understand, before deciding whether or not to participate.

How long will the survey take to complete?
The survey should take no longer than 30 minutes to complete. If there are questions that you are unable to answer and need to pause to reference materials or information it may add to total completion time.

What is the purpose of this study?
This study is part of the Systemic Change to Improve Equity in Computer Science Student Achievement project using the Programming the Acceleration of Computing and Equity Framework for Computer Science Systems Change (PACE) Framework1, sponsored by the U.S. Department of Education.

Broadly, the PACE Framework project focuses on building supports and systems needed to impact student outcomes in K-12, particularly in terms of their interest and skill level in CS. The PACE Framework will address these needs with an innovative, state-endorsed, and equity-focused systems change model that unites middle school district and school leaders, teachers, staff, and parents in reconfiguring how districts prepare all students with the CS skills that are increasingly required for academic and professional success.

How will my data be used?

The responses you provide will be synthesized by the research team and used to enhance CS planning at the district stakeholder meetings. This information will not be shared with any other school or entity. We may share or produce reports containing anonymous, aggregate data (representing all responses) publicly.

Are there benefits to being involved in this study?

You would help contribute to developing a deeper understanding of model practices for engaging students in rigorous computer science education in middle school settings. The responses you provide will be synthesized by the research team and used to enhance CS planning at the district stakeholder meetings. This research is expected to help us to understand what factors are most influential in students outcomes. The findings generated by this project will likely provide important insights to all middle-school CS teachers as well.

What are the risks of being involved in this study?

We expect that any risks, discomforts, or inconveniences will be minor and we believe that they are not likely to happen. If discomforts become a problem, you may discontinue your participation.

Can I stop being in the study?

You do not have to be in this study if you do not want to. If you agree to be in the study, but later change your mind, you may drop out at any time. There are no penalties or consequences of any kind if you decide that you do not want to participate.

What if I have questions?

If you have any questions concerning your rights as a research subject, you may contact the project PI, Joyce Malyn-Smith at jmsmith@edc.org or 617-259-2386

Statement of Voluntary Consent

By indicating "I consent" below I am agreeing to I understand the procedures described above. My questions have been answered to my satisfaction, and I agree to participate in this study.

○ I consent

○ I do not consent

What best describes your role?

○ Teacher
○ Administrator

Which best describes your role as a teacher?

○ Computer science teacher
○ Teacher (other subject)
○ Technology/Tech integration Specialist
○ Librarian
○ N/A or Other ________

Which best describes your role as an administrator?

○ District administrator
○ Building administrator
○ Curriculum & instruction administrator
○ Computer science administrator
○ Special education administrator
○ Other ________

What grade range(s) do you work with? (select all that apply)

☐ Pre-K
☐ Elementary (K - 5)

- ☐ Middle (6 - 8)
- ☐ High (9 - 12)
- ☐ Other ______

District Info

What is your name?

______

What is the name of your district? (begin typing district name to search)

______

Are there any major initiatives (including, but not limited to computer science) underway in your school/district this year? (select all that apply)

- ☐ Digital Now
- ☐ Project Lead the Way
- ☐ School to Work
- ☐ Career and Technical Education (CTE)
- ☐ Social Emotional Learning (SEL)
- ☐ Literacy Mathematics
- ☐ Project Based Learning
- ☐ Workforce Development
- ☐ SCRIPT
- ☐ None of these initiatives are underway in my district
- ☐ Other ______

Continuous Improvement

The following questions pertain to the continuous improvement initiatives in place in your district.

Continuous improvement is an applied science that emphasizes innovation, rapid and iterative cycle testing in the field, and scaling in order to generate learning about what changes produce improvements in particular contexts (Institute for Healthcare Improvement, 2015). The outcomes of each cycle inform the revision, development, and fine-tuning of practices.

For each of the questions below, please indicate which option best describes the continuous improvement initiatives that are in place in your district.

Does your district have a continuous improvement initiative in place?

- ◯ Our district has a data-based continuous improvement initiative and the initiative itself is also subject to continuous improvement processes
- ◯ Our district has a data-based continuous improvement initiative
- ◯ Our district has a continuous improvement initiative, but does not use data to inform decisions
- ◯ No continuous improvement initiative

Does your district have systematic engagement in the continuous improvement initiative?

- ◯ Teachers and staff have access to continuous improvement planning documents and reports. Continuous improvement teams include individuals from all levels (support, classroom, building, central office) of the district. An organized professional learning community exists for continually improving CS education in the district

- ◯ Our district has regular continuous improvement meetings. Continuous improvement practices are developed during in-service trainings
- ◯ Our district has infrequent continuous improvement meetings. There is no coherent team addressing CI initiatives.
- ◯ No systematic engagement in the continuous improvement initiative

District Status

This section asks about computer science materials, curriculum selection, and content refinement in your district.

The selection of appropriate, sequential, and vision-aligned computer science materials and curricula is done through a process that engages teachers and leaders. The selection process includes focus on sustainability, rigor, and inclusion of diverse students in the consideration of the curriculum and supporting materials.

For each of the questions below, please indicate which option best describes the computer science instruction in place in your district.

How well does your district select computer science curricula?

- ◯ The selected CS curricula is sequential and student learning builds each year in alignment with national standards and other district initiatives. There is a process for both grade level and multiple grade teams to meet and discuss or refine the curriculum based on individual needs of schools/students.
- ◯ One or more CS curricula is selected with communication between teachers and across grades. Selected CS curricula address a majority of relevant state or national CS Education standards or K-12 CS Framework concepts and practices.
- ◯ Some CS taught in schools and the CS curriculum is selected by individual teachers with no communication for pathway options.
- ◯ No CS curriculum selected for any grade levels.

How well are computer science classes sequenced and aligned in your district?

○ The vision and 12th grade outcomes for students are clearly defined and all teachers of CS can describe how their curriculum fits in a multiyear sequence to arrive at those outcomes. Additionally, advanced pathways or electives exist for students who would like to pursue either more rigor (advanced placement or dual enrollment) or a specific flavor of CS (media arts or web design).

○ Curricular activities are aligned to K-12 DLCS standards or the K12 CS framework. Activities are sequential and connected to the vision/outcomes for the school or district.

○ CS curricular activities are developmentally appropriate for students, but are disconnected and do not have a clear sequence to 12th grade for students.

○ There is no alignment or progression to any CS activities that occur in the district. (Schools may engage in one-off activities like Hour of Code, but do not sequence the activities for student learning).

How well are diverse learners supported with CS materials in your district?

○ Working groups of CS/content teachers and special education teachers proactively review curricula and materials for accessibility and potential bias. Together, the teams produce guidance documents for all teachers with best practices in the project based computer science classroom. The teams apply Universal Design for Learning (UDL) principles used in other disciplines for potential areas of relevance.

○ Teachers use Universal Design for Learning principles when creating CS materials for diverse learners. The teachers are connected to appropriate special educators and the teams have district support for necessary material development and refinement.

○ Individual teachers create CS materials for diverse learners based upon a limited understanding of students in their class.

○ There is no support for the creation or identification of CS materials for diverse learners.

CS Leadership

The selection of appropriate, sequential, and vision-aligned computer science materials and curricula is done through a process that engages teachers and leaders. The selection process includes focus on sustainability, rigor, and inclusion of diverse students in the consideration of the curriculum and supporting materials.

For each of the questions below, please indicate which option best describes the ways your district works to support CS instruction.

What role does district-level leadership play in the planning and development of CS curriculum?

- ◯ District leadership proactively establishes a clear vision and plan that includes incentives for plan execution and engagement with CS education activities.
- ◯ District leadership actively participates in vision and goal setting activities for CS and coordinates across schools for coherent CS objectives.
- ◯ District leadership recognizes CS education efforts but is not engaged in coordination or shared planning processes (if they exist).
- ◯ District leadership does not play a role in CS education efforts in the schools.

What role does school-level leadership play in the planning and development of CS curriculum?

- ◯ Leadership teams make use of data about CS education enrollment and student performance to guide discussions of CS education. The leadership team actively encourages the participation of teacher leaders, and collaborates with other schools for best practices and shared experiences. Schools feel connected to CS education outcomes and supported in the pursuit of those outcomes for specific needs of school populations.
- ◯ A representative sample of school leaders participate in vision and goal setting activities for CS, and all schools have leaders who are aware of district CS activities and given opportunities to provide feedback on initiative priorities based on individual school needs.
- ◯ School leadership recognizes CS education efforts but is not engaged in coordination or a shared planning process in their school.
- ◯ School leadership does not play a role in CS education efforts in their school.

What role does school personnel (support teachers and staff) play in the planning and development of CS curriculum?

- ◯ Library media specialists, special educators, and guidance counselors are provided opportunities to engage in CS education PD as appropriate for their roles. They also regularly communicate with teachers and leadership teams about CS education plans and useful connections to their work.

◯ Library media specialists are aware of and participate in CS education activities in the school. Special educators are engaged in CS education planning, weighing in about curricular and tool choices and how they impact diverse learners. Guidance counselors are supported with information about pathways for students who are interested in CS, as well as the benefits of CS as a minor for students with other interests.

◯ School personnel are aware of CS education efforts but are not engaged in coordination or shared planning processes.

◯ School personnel do not play a role in CS education efforts in the schools.

Which of the following best describes your district's plan for computer science education?

◯ A CS education plan exists that is updated regularly and has the ability for individual schools to use locally with different implementation. The plan was created with a shared process. The plan is actionable, flexible as necessary for multiple schools, and aligned with the district goals.

◯ A CS education plan exists that was created with a shared process. The plan is actionable, flexible as necessary for multiple schools, and aligned with the district goals.

◯ A CS education plan exists, but does not use a shared process for its creation, and is not specific, actionable, or aligned with district vision for CS education.

◯ The school district does not have a documented plan for CS education efforts.

Which of the following best describes the way computer science education is implemented in your district?

◯ Data is regularly collected and shared to help drive planning process and updated goals. The implementation of CS education in the district is goal- and vision-aligned. There is coordination of pathways and progressions for students across grades. All students are engaged in CS education efforts especially traditionally under-represented minority groups and at-risk populations.

◯ The implementation of CS education in the district is goal and vision aligned. There is coordination of pathways and progressions for students across grades. All students are engaged in CS education efforts especially traditionally under-represented minority groups and at-risk populations. However, there is no regularly collected data that is incorporated into the process.

◯ The implementation of CS education is teacher-led with little coordination for pathways or progressions. Electives may be offered at individual schools, but no connected sequence of courses exist.

◯ There is no implementation of CS education within the district.

Which of the following best describes the computer science outcomes that have been set by the district?

◯ Community level outcomes exist regarding parent education, community engagement, and informal learning opportunities for students. Student level outcomes exist aligned to state/national standards where appropriate. Teacher level outcomes exist related to Teacher development.

◯ Student level outcomes exist aligned to state/national standards where appropriate. Teacher level outcomes exist related to Teacher development. There are no community level outcomes.

◯ Course or program level outcomes exist. (e.g. offer a class, run an hour of code)

◯ There are no defined outcomes for CS education within the district.

CS Teacher Capacity and Development

All teachers have an understanding of the CS education initiatives in the district, and opportunities for integrated CS projects. Teachers with responsibility for CS content have clearly defined opportunities to learn computer science and expand their pedagogical fluency. There are well defined incentives for participating in such professional development opportunities.

For each of the questions below, please indicate which option best describes the computer science capacity building in your district.

Which of the following best describes the computer science teacher professional development in your district?

◯ Teacher CS professional development is chosen to align with district vision and goals, and teachers are supported in the selection and attendance of the PD.

○ Teachers are supported in their selection of CS professional development opportunities and are connected to each other for coherent pathways and grade level consistency.

○ Teachers independently identify CS professional development opportunities and participate in CS orientation PD at their own discretion.

○ Teachers have not participated in CS education PD or have not had prior CS education experience.

Which of the following best describes the computer science teacher working groups in your district?

○ There are K-12 working groups for sequential CS education planning in the district, and outcomes from these groups are shared in district communication. Teacher working groups use student data and artifacts to drive teacher development. Meetings are scheduled and participation is part of incentive structures for teacher performance rating and there is a consistently high attendance rate.

○ Teachers participate in CS working groups both at a local and national level as a part of their professional learning network (PLN). Teachers are supported and recognized for this work with PD hours or other standard district incentives for professional learning.

○ Participation in CS teacher working groups is entirely driven by individual teachers and mostly consists of participation in national communities such as CSTA or CSforALL Teachers.

○ There is no participation by teachers in working groups focused on CS education.

Which of the following best describes the district-level resources for the computer science teacher working groups in your district?

○ The district supports working groups of administrators and teachers in order to create relevant feedback frameworks for CS education and provide training for their implementation. District-level resources for administrators connect to best practices research for CS education.

○ Administrators work with teachers or district teams to understand the relevant goals and best practices in CS education for use in teacher observation and feedback.

○ Teacher feedback is aligned to best practices in CS education by individual administrators.

○ There is no support for administrators in the observation and teacher feedback and evaluation process for CS teachers or lessons containing CS content.

CS Partnerships

Partners are engaged entities who are connected to the district or schools through formal or informal partnerships. They represent trusted entities that can be used to provide opportunities for students or teachers.

For each of the questions below, please indicate which option best describes the computer science partnerships at your district.

Which of the following best describes the local partners (including informal education) that engage with computer science education in your district?

- ◯ Local partners are included in the district planning and revision processes. Informal enrichment opportunities are included as a part of student pathway options, and efforts are made to engage local partners in curricular efforts for students and learning opportunities for teachers. Local partners are connected with teachers for PD opportunities (teachers participating in informal activities) or for content specialists who can engage with teachers for knowledge and resource sharing.
- ◯ Local partners are engaged by the school district for awareness and integration into any CS education plans. Communications for students and parents include enrichment opportunities from local partners in addition to classroom based opportunities.
- ◯ The district/teachers are aware of some local partners (e.g. Girl Scouts, community centers, etc.) who offer enrichment activities, and activities may be advertised in the school.
- ◯ Local partners are not engaged with CS education efforts.

Which of the following best describes the professional learning partners that engage with computer science education in your district?

- ◯ Professional learning partners are used not only by individual teachers, but as a part of larger development plans. Information from partners is used in CS education plan development and revision, and district activities are shared in relevant networks as exemplars and for feedback.
- ◯ Engagement with professional learning partners is recognized by the district and CS education plan as a positive, and incentivized part of teacher development. Teachers new to computer science receive information about relevant partners in mentoring or advising sessions.
- ◯ Teachers in the district are aware of, and make use of professional learning partners for continued development. Examples could include participating in teacher associations (CSTA)

discussion boards (Code.org, CSforAll Teachers) or social network communities (twitter chats, facebook groups).

◯ The district or teachers have not identified any professional learning partners outside the district for support.

Community Engagement in CS

The engagement of the local community is an important part of sustainability for CS education efforts.

For each of the questions below, please indicate which option best describes the level of community engagement with computer science initiatives in your district.

Which of the following best describes the ways families engage with computer science education in your district?

◯ Teachers and guidance counselors not only share the parent resource, but also regularly review it for updates. The resource may include a calendar for partners and community members to add items (such as hackathons, summer workshops, etc.). Evening and weekend events are planned to engage families in CS education opportunities.

◯ There is a developed resource for parents offering clarity around the CS education plan of the district, in-school pathways for students, extra curricular activities, and partner opportunities for enrichment.

◯ Individual teachers or guidance counselors discuss CS education options with parents or families during back to school nights, open houses, or parent teacher conferences. District communications including flyers and newsletters include information about CS education efforts.

◯ Families are not engaged or informed of CS offerings or student pathways.

Which of the following best describes the ways the local workforce engages with computer science education in your district?

◯ Local workforce efforts engage with individual schools to provide materials for student pathways, and clarity for guidance counselors in recommending student experiences. The school community (teachers, students, parents, guidance, and administrators) understand the regional workforce efforts and leverage appropriate resources to supplement district resources.

◯ Local workforce efforts are connected or consulted by the district in the development of CS education plans. Curricular selection and enrichment activities are designed to not only prepare students for college but also for potential career readiness opportunities locally. Local industry is engaged in opportunities to support district efforts through employee volunteer programs, support for events or initiatives, and engagement in district plans.

◯ Individual teachers may connect to local workforce efforts, but there is little to no alignment between community workforce development and CS education programs. There may be connections to local industry for one-time events or gifts, but little connection between these interactions and the larger goals or plans of the district.

◯ Local workforce efforts are not engaged or connected to the CS education efforts of the district.

Block 6

CS Goals and Strategies. To what extent have these strategies and goals been established in your district? (Select a single response that reflects your assessment of the current status in your district)

	Not at all (Nothing is planned or underway)	A little (Planning is underway but few or no actions have been taken)	Somewhat (Steps have been taken and are continuing)	To a great extent (Goals have been reached and strategies are well-establiahed)
All middle grades students receive CS instruction	◯	◯	◯	◯
Equity strategies are employed to support interest and persistence in CS among traditionally underrepresented student groups	◯	◯	◯	◯
Implementation of inclusive CS pathway planning.	◯	◯	◯	◯
CS is provided in sequential middle-	◯	◯	◯	◯

	Not at all (Nothing is planned or underway)	A little (Planning is underway but few or no actions have been taken)	Somewhat (Steps have been taken and are continuing)	To a great extent (Goals have been reached and strategies are well-establiahed)
school years at a minimum of 75 instructional hours per year				
There is a district-level CS taskforce that includes representation from major stakeholder groups	○	○	○	○
CS pathways are integrated with district strategic plan	○	○	○	○
Information/ technology specialists support CS teachers	○	○	○	○

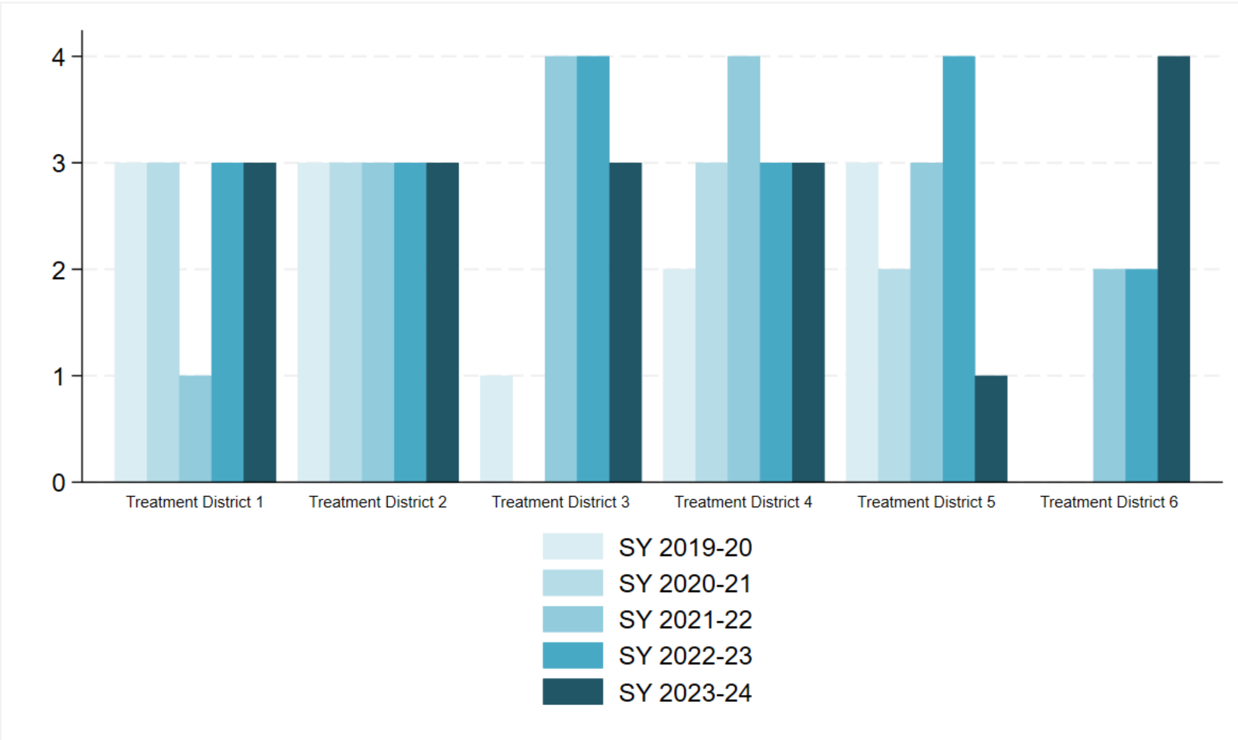
Block 4

Is there any other information about the computer science initiatives in your district that you would like to share with the PACE team?

Appendix B. District Infrastructure Survey Findings – Treatment Districts Over Time

This appendix presents findings from the District Infrastructure Survey for treatment districts over time from SY 2019–20 to SY 2023–24. Questions about the extent to which PACE strategies and goals have been met (Exhibits B.19 through B.25) were not asked in SY 2019–20 or SY 2020–21. Survey questions and response items in this appendix appear verbatim from the survey.

Exhibit B.1: "Does your district have a continuous improvement initiative in place?"



Answers:

4 = Our district has a data-based continuous improvement initiative and the initiative itself is also subject to continuous improvement processes.

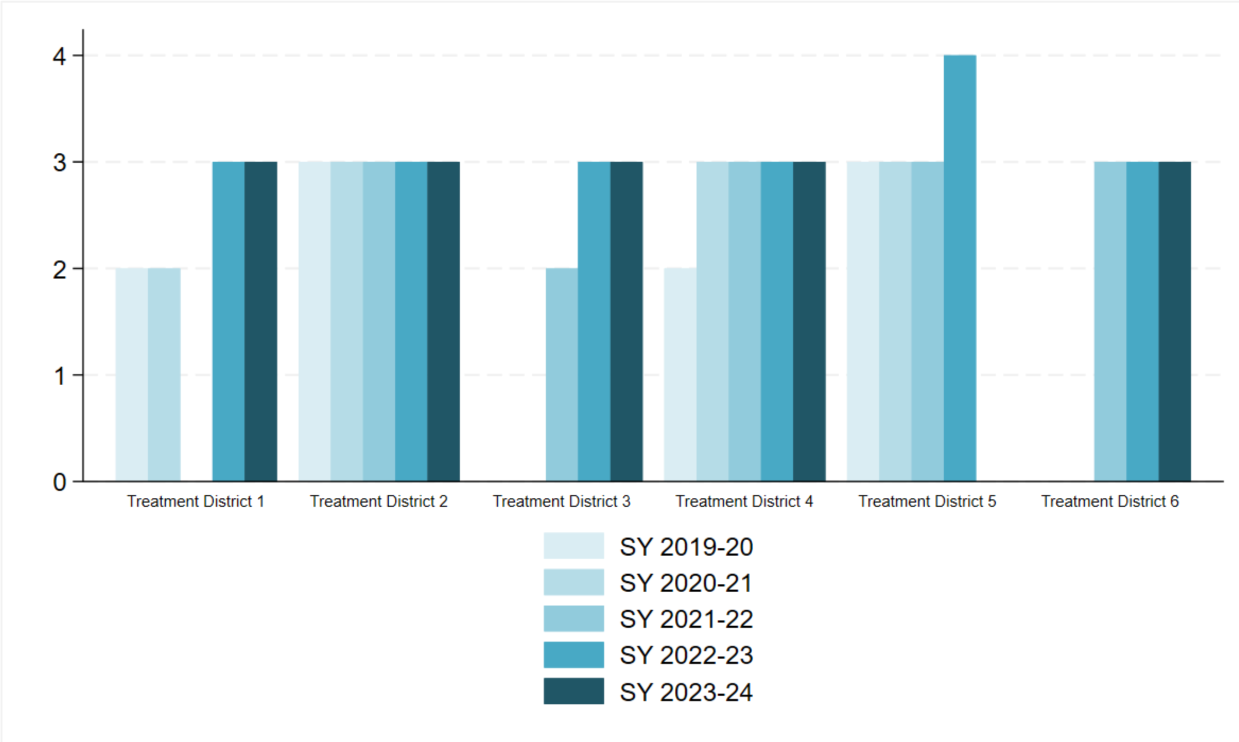
3 = Our district has a data-based continuous improvement initiative.

2 = Our district has a continuous improvement initiative, but does not use data to inform decisions.

1 = No continuous improvement initiative.

Note: Treatment District 3 did not complete the District Infrastructure Survey in SY 2020–21 and Treatment District 6 did not complete the District Infrastructure Survey in SY 2019-20 or 2020-21.

Exhibit B.2: "Does your district have systematic engagement in the continuous improvement initiative?"



Answers:

4 = Teachers and staff have access to continuous improvement planning documents and reports. Continuous improvement teams include individuals from all levels (support, classroom, building, central office) of the district. An organized professional learning community exists for continually improving CS education in the district.

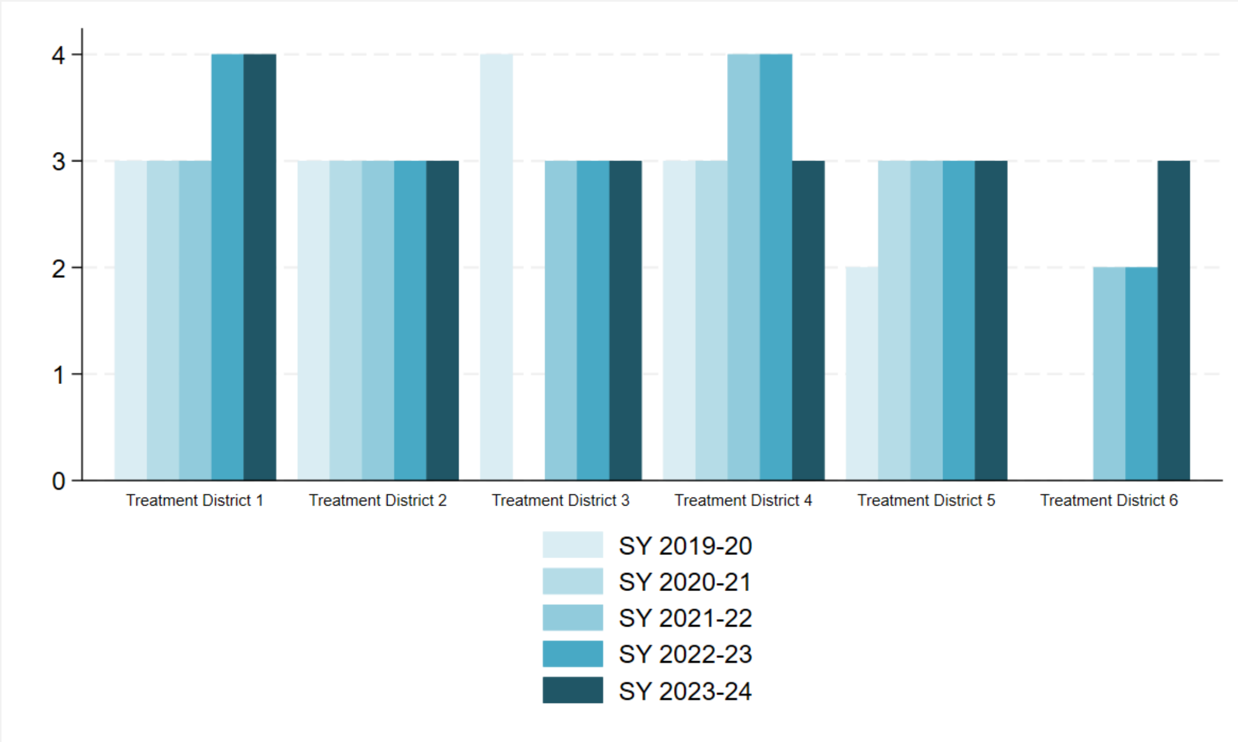
3 = Our district has regular continuous improvement meetings. Continuous improvement practices are developed during in-service trainings.

2 = Our district has infrequent continuous improvement meetings. There is no coherent team addressing continuous improvement initiatives.

1 = No systematic engagement in the continuous improvement initiative

Note: Treatment District 3 did not complete the District Infrastructure Survey in SY 2020–21 and Treatment District 6 did not complete the District Infrastructure Survey in SY 2019-20 or 2020-21.

Exhibit B.3: "How well does your district select computer science curricula?"



Answers:

4 = The selected CS curricula is sequential and student learning builds each year in alignment with national standards and other district initiatives. There is a process for both grade level and multiple grade teams to meet and discuss or refine the curriculum based on individual needs of schools/students.

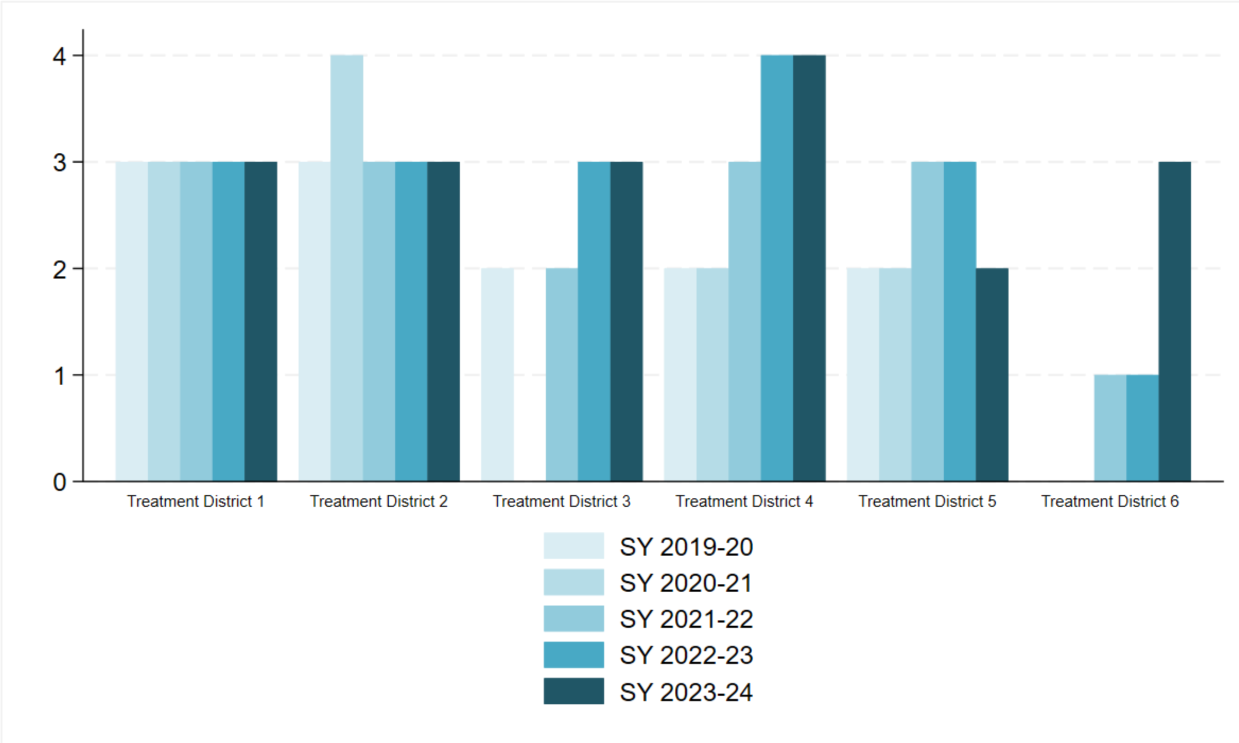
3 = One or more CS curricula is selected with communication between teachers and across grades. Selected CS curricula address a majority of relevant state or national CS Education standards or K-12 CS Framework concepts and practices.

2 = Some CS taught in schools and the CS curriculum is selected by individual teachers with no communication for pathway options.

1 = No CS curriculum selected for any grade levels.

Note: Treatment District 3 did not complete the District Infrastructure Survey in SY 2020–21 and Treatment District 6 did not complete the District Infrastructure Survey in SY 2019-20 or 2020-21.

Exhibit B.4: "How well are computer science classes sequenced and aligned in your district?"



Answers:

4 = The vision and 12th grade outcomes for students are clearly defined and all teachers of CS can describe how their curriculum fits in a multiyear sequence to arrive at those outcomes. Additionally, advanced pathways or electives exist for students who would like to pursue either more rigor (advanced placement or dual enrollment) or a specific flavor of CS (media arts or web design).

3 = Curricular activities are aligned to K-12 DLCS standards or the K12 CS framework. Activities are sequential and connected to the vision/outcomes for the school or district.

2 = CS curricular activities are developmentally appropriate for students but are disconnected and do not have a clear sequence to 12th grade for students.

1 = There is no alignment or progression to any CS activities that occur in the district. (Schools may engage in one-off activities like *Hour of Code*, but do not sequence the activities for student learning).

Note: Treatment District 3 did not complete the District Infrastructure Survey in SY 2020–21 and Treatment District 6 did not complete the District Infrastructure Survey in SY 2019-20 or 2020-21.

Exhibit B.5: "How well are diverse learners supported with CS materials in your district?"

Answers:

4 = Working groups of CS/content teachers and special education teachers proactively review curricula and materials for accessibility and potential bias. Together, the teams produce guidance documents for all teachers with best practices in the project-based computer science classroom. The teams apply Universal Design for Learning (UDL) principles used in other disciplines for potential areas of relevance.

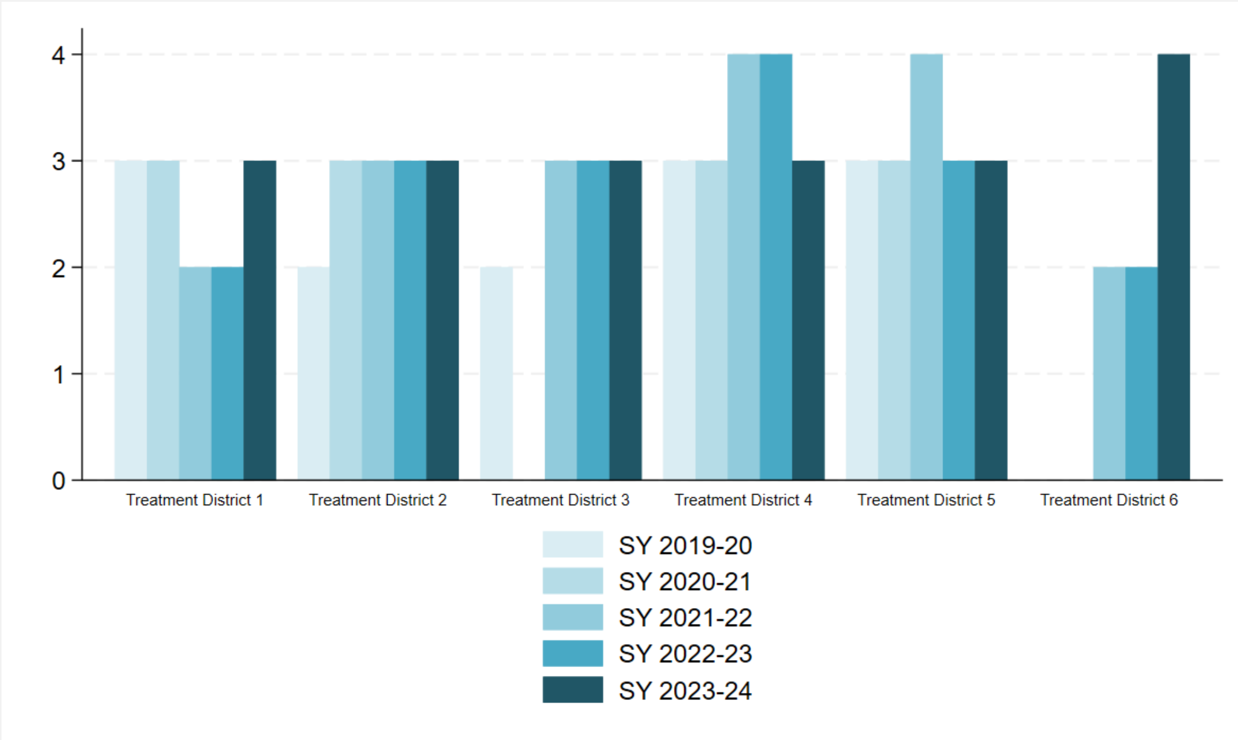
3 = Teachers use Universal Design for Learning principles when creating CS materials for diverse learners. The teachers are connected to appropriate special educators and the teams have district support for necessary material development and refinement.

2 = Individual teachers create CS materials for diverse learners based upon a limited understanding of students in their class.

1 = There is no support for the creation or identification of CS materials for diverse learners.

Note: Treatment District 3 did not complete the District Infrastructure Survey in SY 2020–21 and Treatment District 6 did not complete the District Infrastructure Survey in SY 2019-20 or 2020-21.

Exhibit B.6: "What role does district-level leadership play in the planning and development of CS curriculum?"



Answers:

4 = District leadership proactively establishes a clear vision and plan that includes incentives for plan execution and engagement with CS education activities.

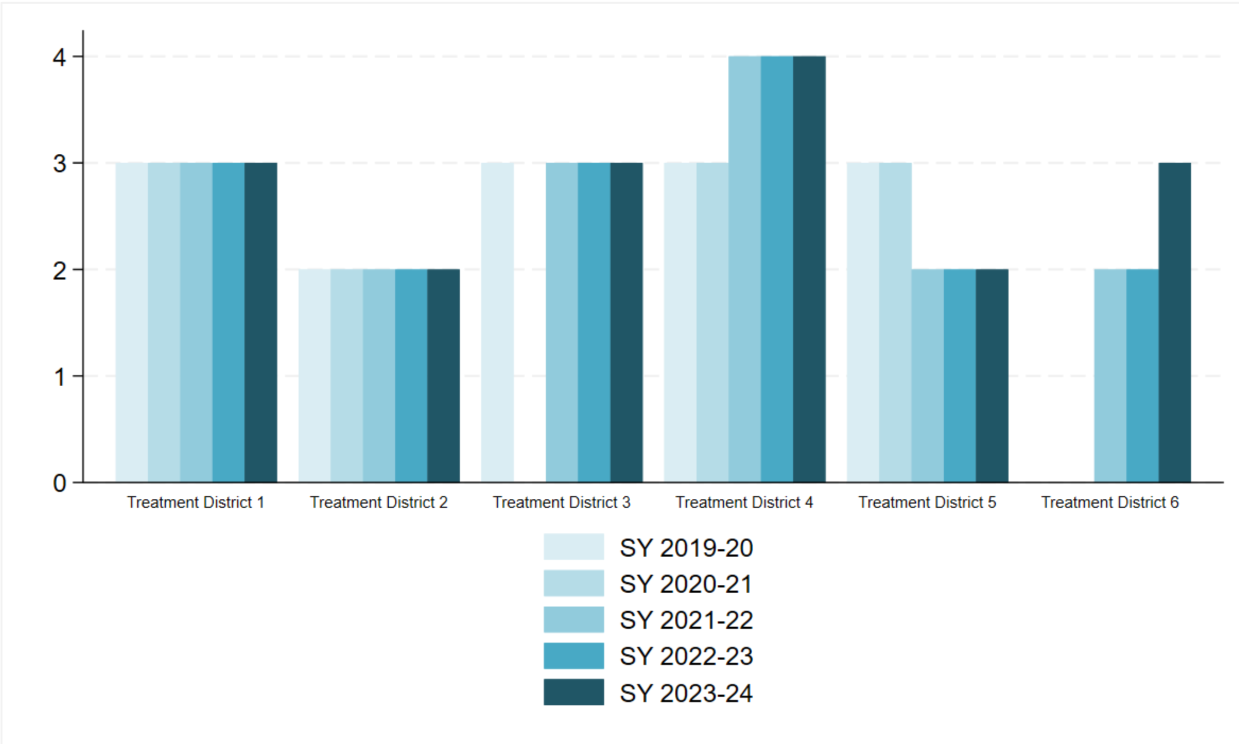
3 = District leadership actively participates in vision and goal setting activities for CS and coordinates across schools for coherent CS objectives.

2 = District leadership recognizes CS education efforts but is not engaged in coordination or shared planning processes (if they exist).

1 = District leadership does not play a role in CS education efforts in the schools.

Note: Treatment District 3 did not complete the District Infrastructure Survey in SY 2020–21 and Treatment District 6 did not complete the District Infrastructure Survey in SY 2019-20 or 2020-21.

Exhibit B.7: "What role does school-level leadership play in the planning and development of CS curriculum?"



Answers:

4 = Leadership teams make use of data about CS education enrollment and student performance to guide discussions of CS education. The leadership team actively encourages the participation of teacher leaders and collaborates with other schools for best practices and shared experiences. Schools feel connected to CS education outcomes and supported in the pursuit of those outcomes for specific needs of school populations.

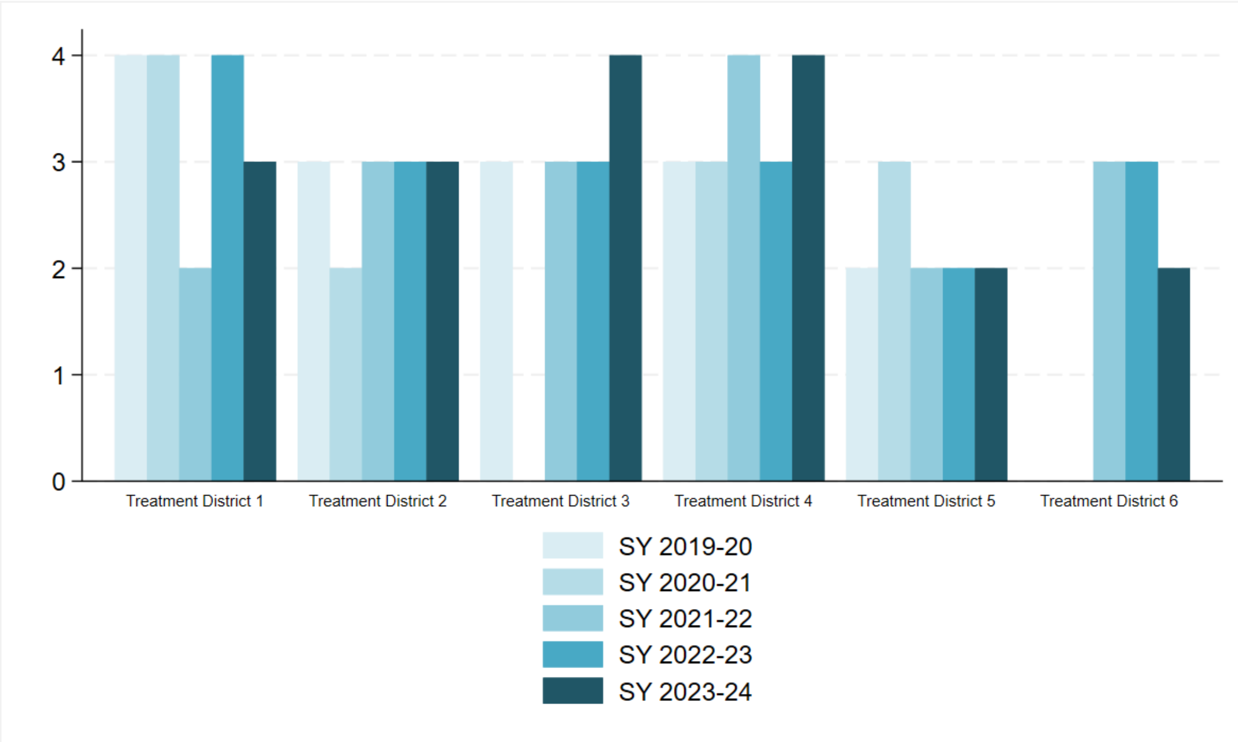
3 = A representative sample of school leaders participate in vision and goal setting activities for CS, and all schools have leaders who are aware of district CS activities and given opportunities to provide feedback on initiative priorities based on individual school needs.

2 = School leadership recognizes CS education efforts but is not engaged in coordination or a shared planning process in their school.

1 = School leadership does not play a role in CS education efforts in their school.

Note: Treatment District 3 did not complete the District Infrastructure Survey in SY 2020–21 and Treatment District 6 did not complete the District Infrastructure Survey in SY 2019-20 or 2020-21.

Exhibit B.8: "What role does school personnel (support teachers and staff) play in the planning and development of CS curriculum?"



Answers:

4 = Library media specialists, special educators, and guidance counselors are provided opportunities to engage in CS education PD as appropriate for their roles. They also regularly communicate with teachers and leadership teams about CS education plans and useful connections to their work.

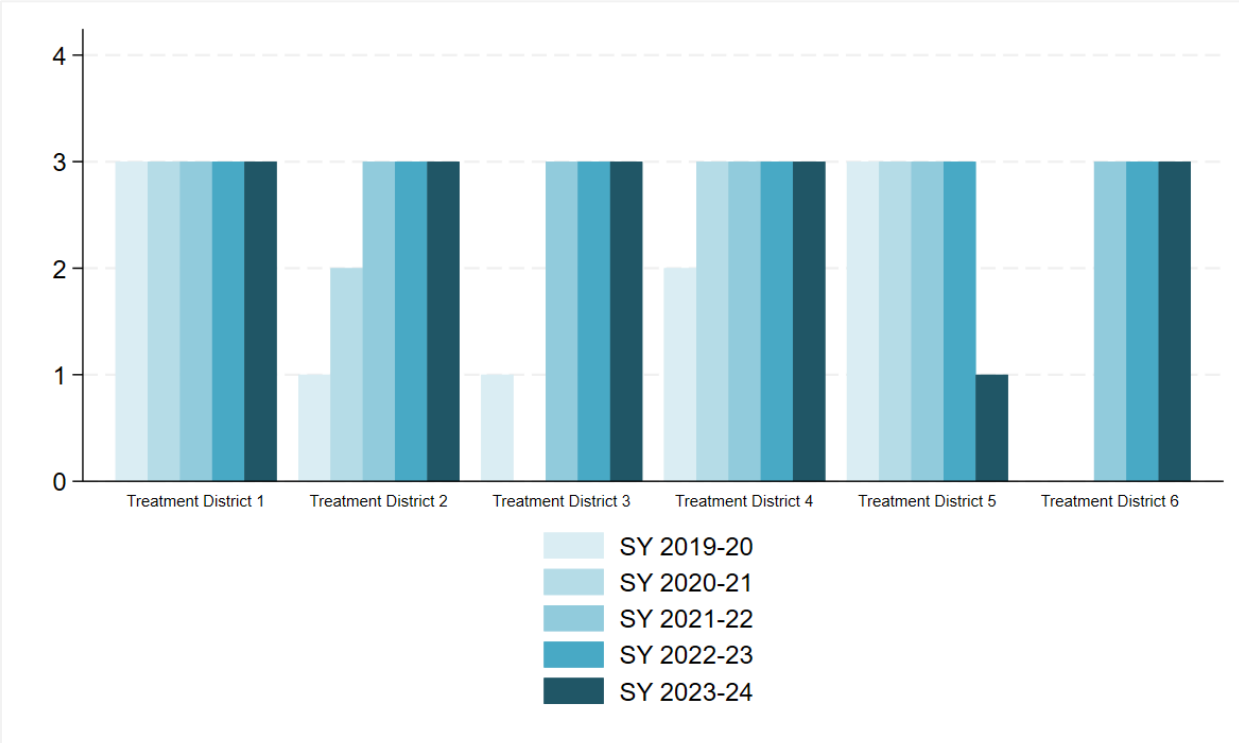
3 = Library media specialists are aware of and participate in CS education activities in the school. Special educators are engaged in CS education planning, weighing in about curricular and tool choices and how they impact diverse learners. Guidance counselors are supported with information about pathways for students who are interested in CS, as well as the benefits of CS as a minor for students with other interests.

2 = School personnel are aware of CS education efforts but are not engaged in coordination or shared planning processes.

1 = School personnel do not play a role in CS education efforts in the schools.

Note: Treatment District 3 did not complete the District Infrastructure Survey in SY 2020–21 and Treatment District 6 did not complete the District Infrastructure Survey in SY 2019-20 or 2020-21.

Exhibit B.9: "Which of the following best describes your district's plan for computer science education?"



Answers:

4 = A CS education plan exists that is updated regularly and has the ability for individual schools to use locally with different implementation. The plan was created with a shared process. The plan is actionable, flexible as necessary for multiple schools, and aligned with the district goals.

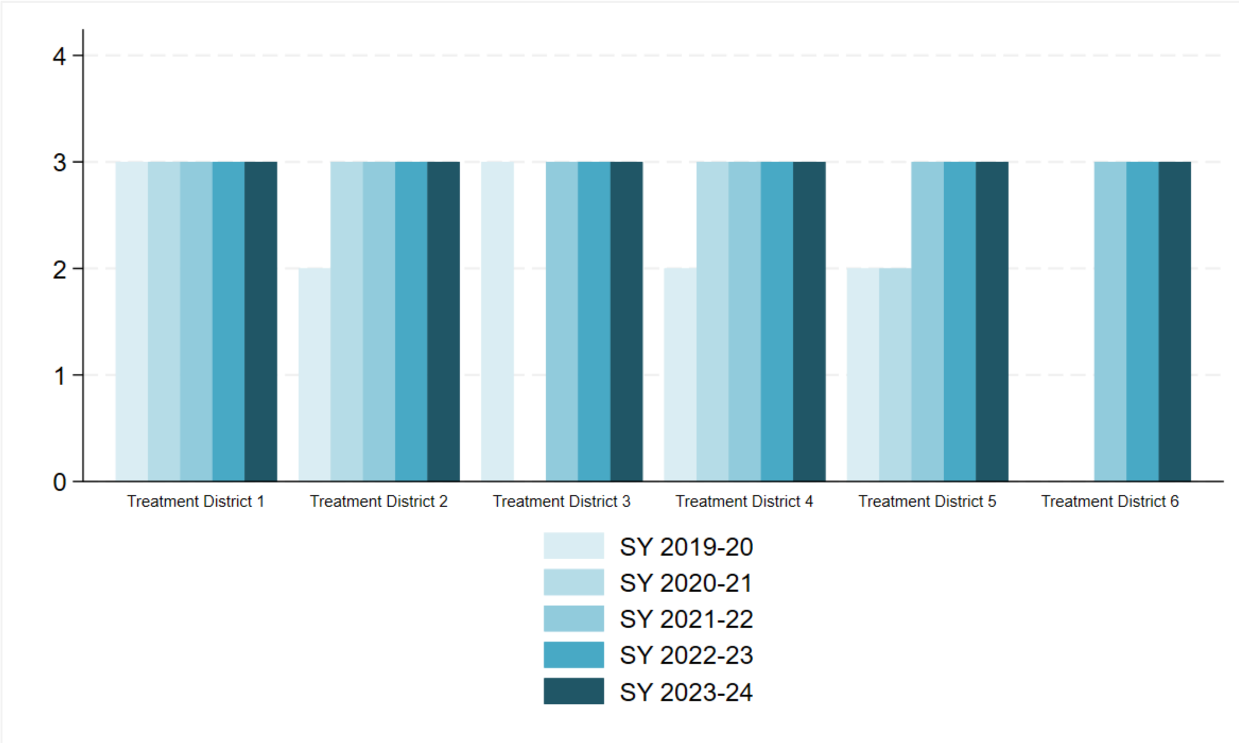
3 = A CS education plan exists that was created with a shared process. The plan is actionable, flexible as necessary for multiple schools, and aligned with the district goals.

2 = A CS education plan exists but does not use a shared process for its creation, and is not specific, actionable, or aligned with district vision for CS education.

1 = The school district does not have a documented plan for CS education efforts.

Note: Treatment District 3 did not complete the District Infrastructure Survey in SY 2020–21 and Treatment District 6 did not complete the District Infrastructure Survey in SY 2019-20 or 2020-21.

Exhibit B.10: "Which of the following best describes the way computer science education is implemented in your district?"

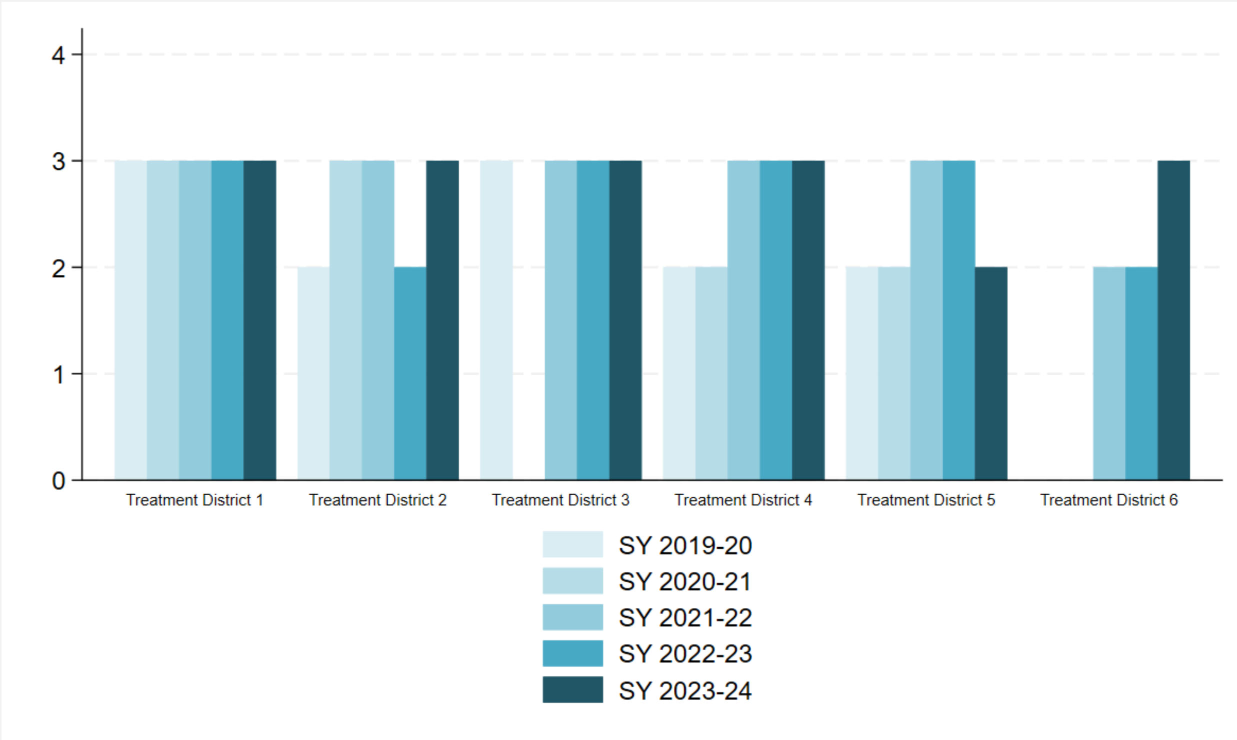


Answers:

- 4 = Data is regularly collected and shared to help drive planning process and updated goals. The implementation of CS education in the district is goal- and vision-aligned. There is coordination of pathways and progressions for students across grades. All students are engaged in CS education efforts especially traditionally under-represented minority groups and at-risk populations.
- 3 = The implementation of CS education in the district is goal and vision aligned. There is coordination of pathways and progressions for students across grades. All students are engaged in CS education efforts especially traditionally under-represented minority groups and at-risk populations. However, there is no regularly collected data that is incorporated into the process.
- 2 = The implementation of CS education is teacher-led with little coordination for pathways or progressions. Electives may be offered at individual schools, but no connected sequence of courses exist.
- 1 = There is no implementation of CS education within the district.

Note: Treatment District 3 did not complete the District Infrastructure Survey in SY 2020–21 and Treatment District 6 did not complete the District Infrastructure Survey in SY 2019-20 or 2020-21.

Exhibit B.11: "Which of the following best describes the computer science outcomes that have been set by the district?"



Answers:

4 = Community level outcomes exist regarding parent education, community engagement, and informal learning opportunities for students. Student level outcomes exist aligned to state/national standards where appropriate. Teacher level outcomes exist related to Teacher development.

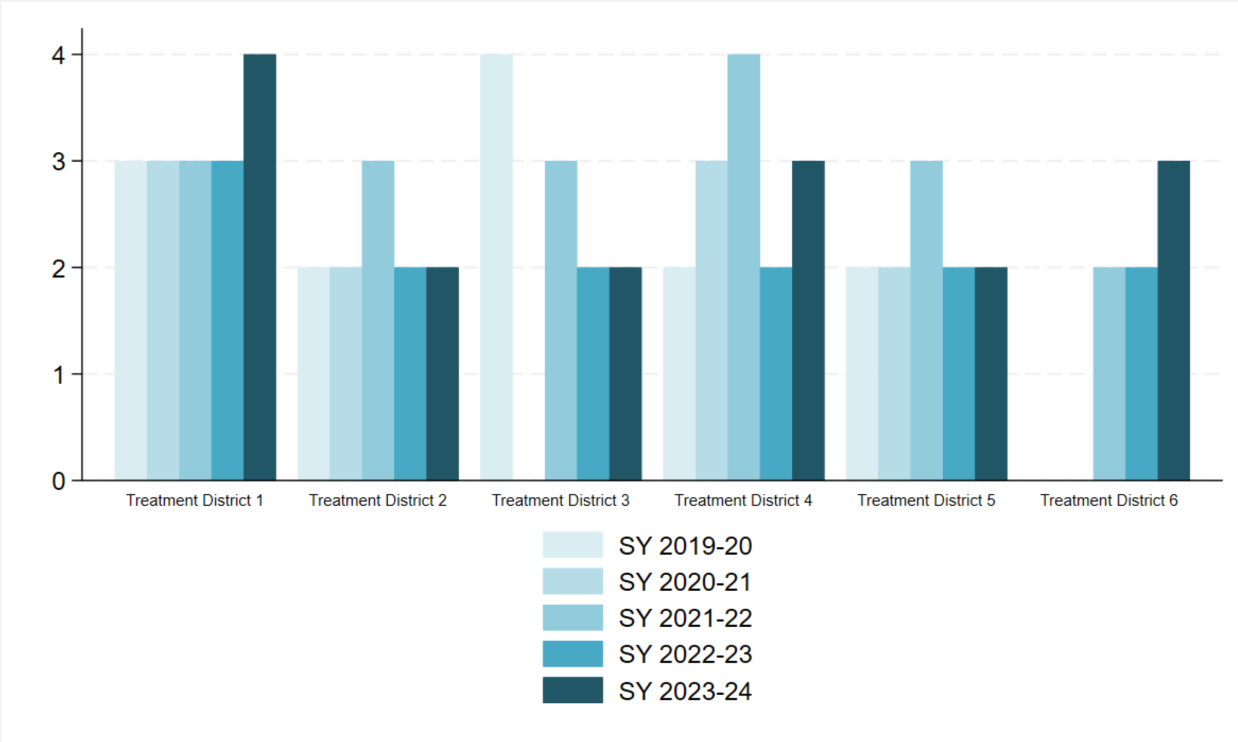
3 = Student level outcomes exist aligned to state/national standards where appropriate. Teacher level outcomes exist related to Teacher development. There are no community level outcomes.

2 = Course or program level outcomes exist. (e.g., offer a class, run an hour of code)

1 = There are no defined outcomes for CS education within the district.

Note: Treatment District 3 did not complete the District Infrastructure Survey in SY 2020–21 and Treatment District 6 did not complete the District Infrastructure Survey in SY 2019-20 or 2020-21.

Exhibit B.12: "Which of the following best describes the computer science teacher professional development in your district?"



Answers:

4 = Teacher CS professional development is chosen to align with district vision and goals, and teachers are supported in the selection and attendance of the PD.

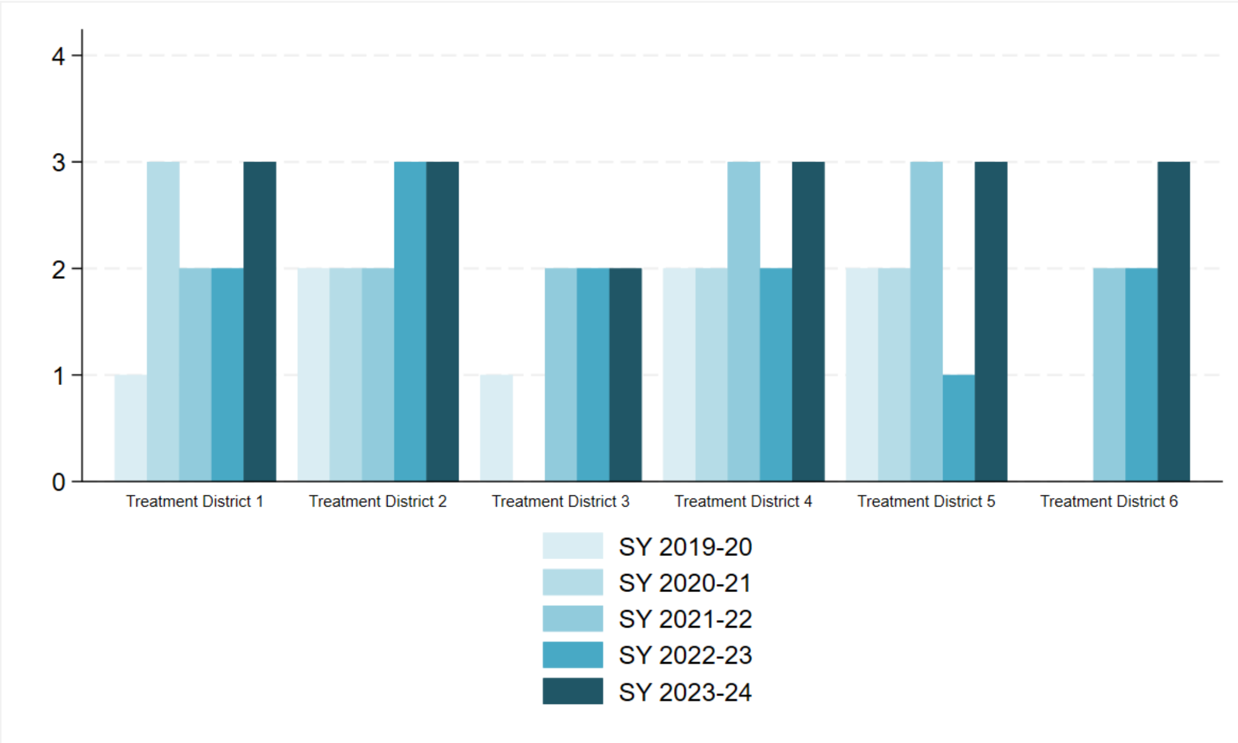
3 = Teachers are supported in their selection of CS professional development opportunities and are connected to each other for coherent pathways and grade level consistency.

2 = Teachers independently identify CS professional development opportunities and participate in CS orientation PD at their own discretion.

1 = Teachers have not participated in CS education PD or have not had prior CS education experience.

Note: Treatment District 3 did not complete the District Infrastructure Survey in SY 2020–21 and Treatment District 6 did not complete the District Infrastructure Survey in SY 2019-20 or 2020-21.

Exhibit B.13: "Which of the following best describes the computer science teacher working groups in your district?"



Answers:

4 = There are K-12 working groups for sequential CS education planning in the district, and outcomes from these groups are shared in district communication. Teacher working groups use student data and artifacts to drive teacher development. Meetings are scheduled and participation is part of incentive structures for teacher performance rating and there is a consistently high attendance rate.

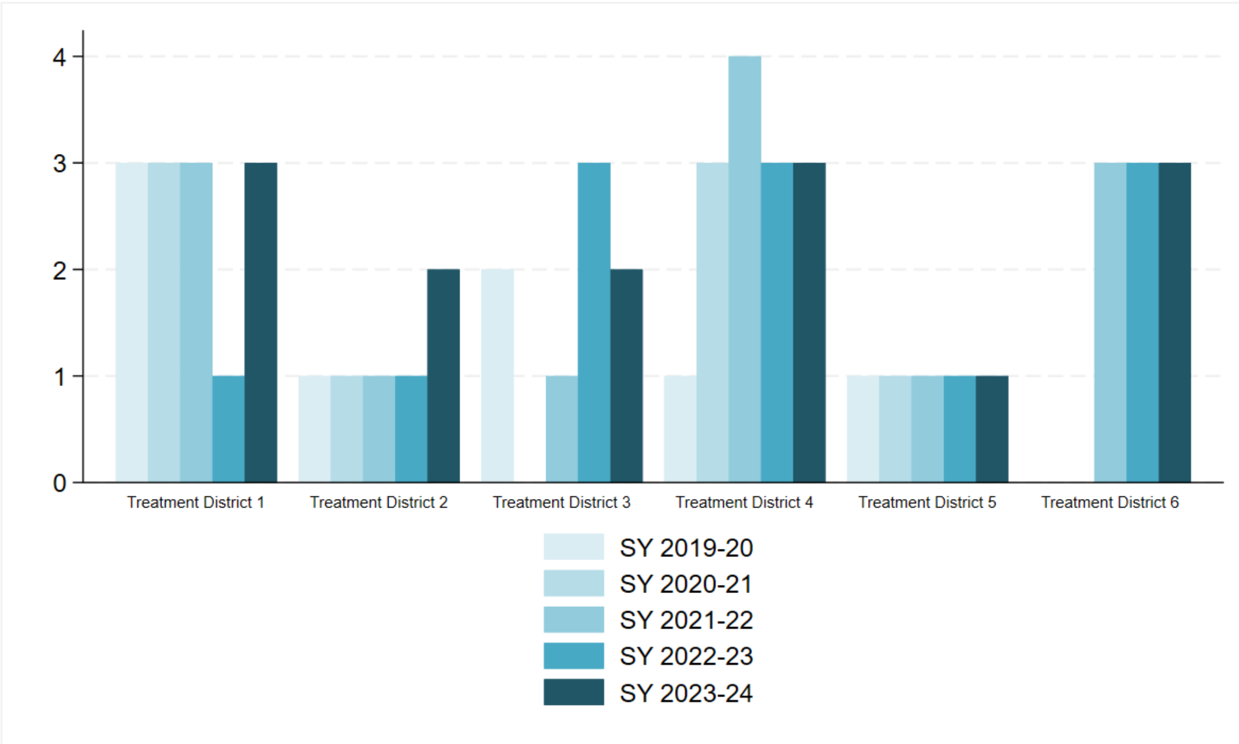
3 = Teachers participate in CS working groups both at a local and national level as a part of their professional learning network (PLN). Teachers are supported and recognized for this work with PD hours or other standard district incentives for professional learning.

2 = Participation in CS teacher working groups is entirely driven by individual teachers and mostly consists of participation in national communities such as CSTA or CS for ALL Teachers.

1 = There is no participation by teachers in working groups focused on CS education.

Note: Treatment District 3 did not complete the District Infrastructure Survey in SY 2020–21 and Treatment District 6 did not complete the District Infrastructure Survey in SY 2019-20 or 2020-21.

Exhibit B.14: "Which of the following best describes the district-level resources for the computer science teacher working groups in your district?"



Answers:

4 = The district supports working groups of administrators and teachers in order to create relevant feedback frameworks for CS education and provide training for their implementation. District-level resources for administrators connect to best practices research for CS education.

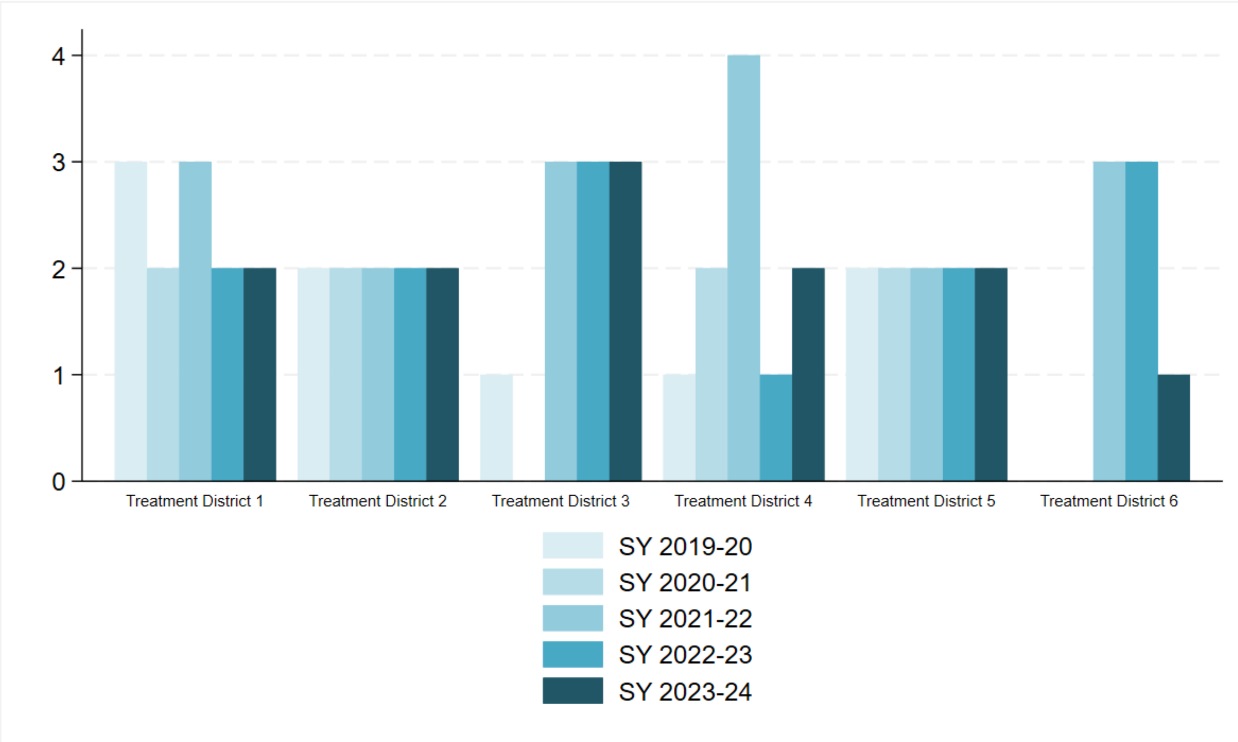
3 = Administrators work with teachers or district teams to understand the relevant goals and best practices in CS education for use in teacher observation and feedback.

2 = Teacher feedback is aligned to best practices in CS education by individual administrators.

1 = There is no support for administrators in the observation and teacher feedback and evaluation process for CS teachers or lessons containing CS content.

Note: Treatment District 3 did not complete the District Infrastructure Survey in SY 2020–21 and Treatment District 6 did not complete the District Infrastructure Survey in SY 2019-20 or 2020-21.

Exhibit B.15: "Which of the following best describes the local partners (including informal education) that engage with computer science education in your district?"



Answers:

4 = Local partners are included in the district planning and revision processes. Informal enrichment opportunities are included as a part of student pathway options, and efforts are made to engage local partners in curricular efforts for students and learning opportunities for teachers. Local partners are connected with teachers for PD opportunities (teachers participating in informal activities) or for content specialists who can engage with teachers for knowledge and resource sharing.

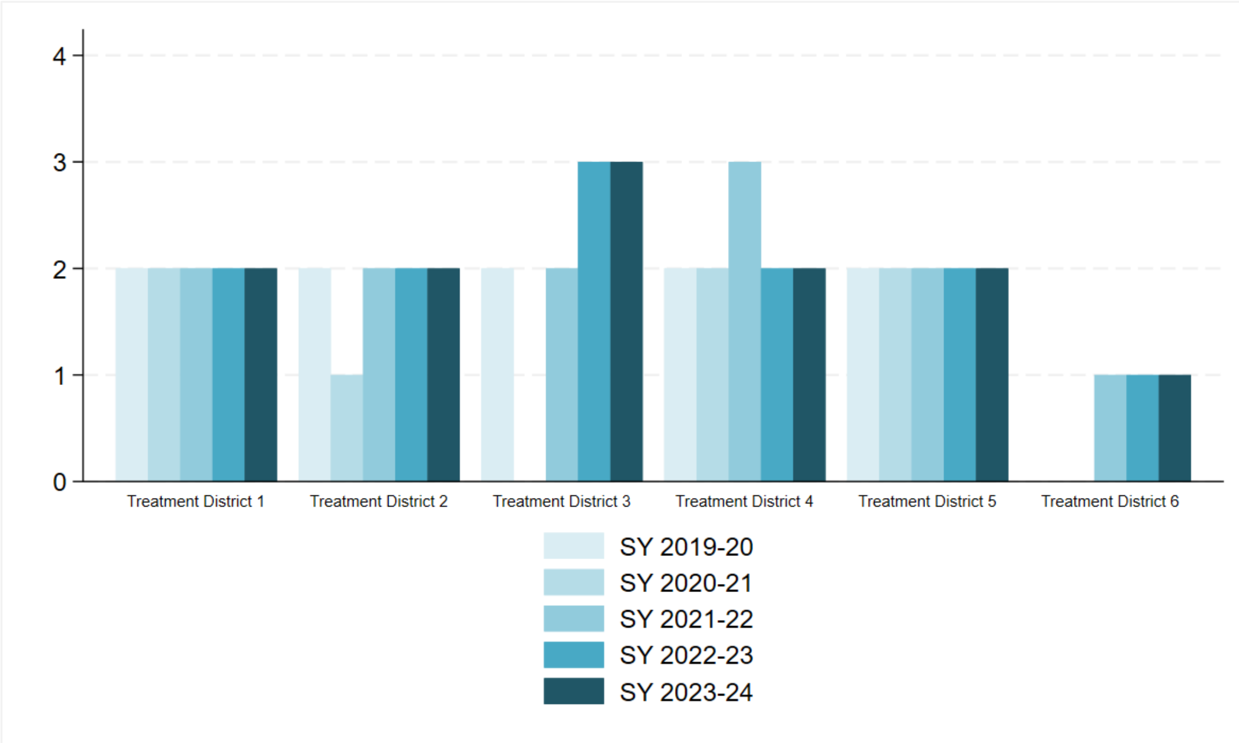
3 = Local partners are engaged by the school district for awareness and integration into any CS education plans. Communications for students and parents include enrichment opportunities from local partners in addition to classroom-based opportunities.

2 = The district/teachers are aware of some local partners (e.g., Girl Scouts, community centers, etc.) who offer enrichment activities, and activities may be advertised in the school.

1 = Local partners are not engaged with CS education efforts.

Note: Treatment District 3 did not complete the District Infrastructure Survey in SY 2020–21 and Treatment District 6 did not complete the District Infrastructure Survey in SY 2019-20 or 2020-21.

Exhibit B.16: "Which of the following best describes the professional learning partners that engage with computer science education in your district?"



Answers:

4 = Professional learning partners are used not only by individual teachers, but as a part of larger development plans. Information from partners is used in CS education plan development and revision, and district activities are shared in relevant networks as exemplars and for feedback.

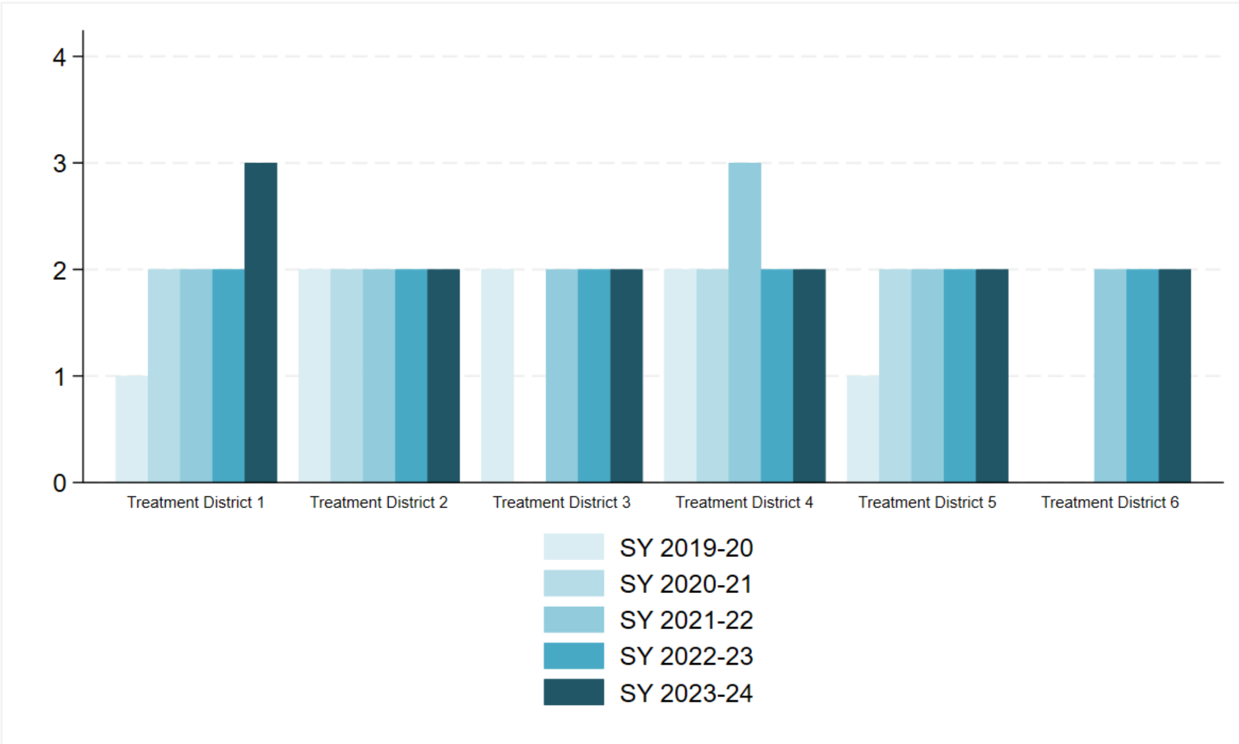
3 = Engagement with professional learning partners is recognized by the district and CS education plan as a positive, and incentivized part of teacher development. Teachers new to computer science receive information about relevant partners in mentoring or advising sessions.

2 = Teachers in the district are aware of and make use of professional learning partners for continued development. Examples could include participating in teacher associations (CSTA) discussion boards (Code.org, CS for All Teachers) or social network communities (twitter chats, Facebook groups).

1 = The district or teachers have not identified any professional learning partners outside the district for support.

Note: Treatment District 3 did not complete the District Infrastructure Survey in SY 2020–21 and Treatment District 6 did not complete the District Infrastructure Survey in SY 2019-20 or 2020-21.

Exhibit B.17: "Which of the following best describes the ways families engage with computer science education in your district?"



Answers:

4 = Teachers and guidance counselors not only share the parent resource, but also regularly review it for updates. The resource may include a calendar for partners and community members to add items (such as hackathons, summer workshops, etc.). Evening and weekend events are planned to engage families in CS education opportunities.

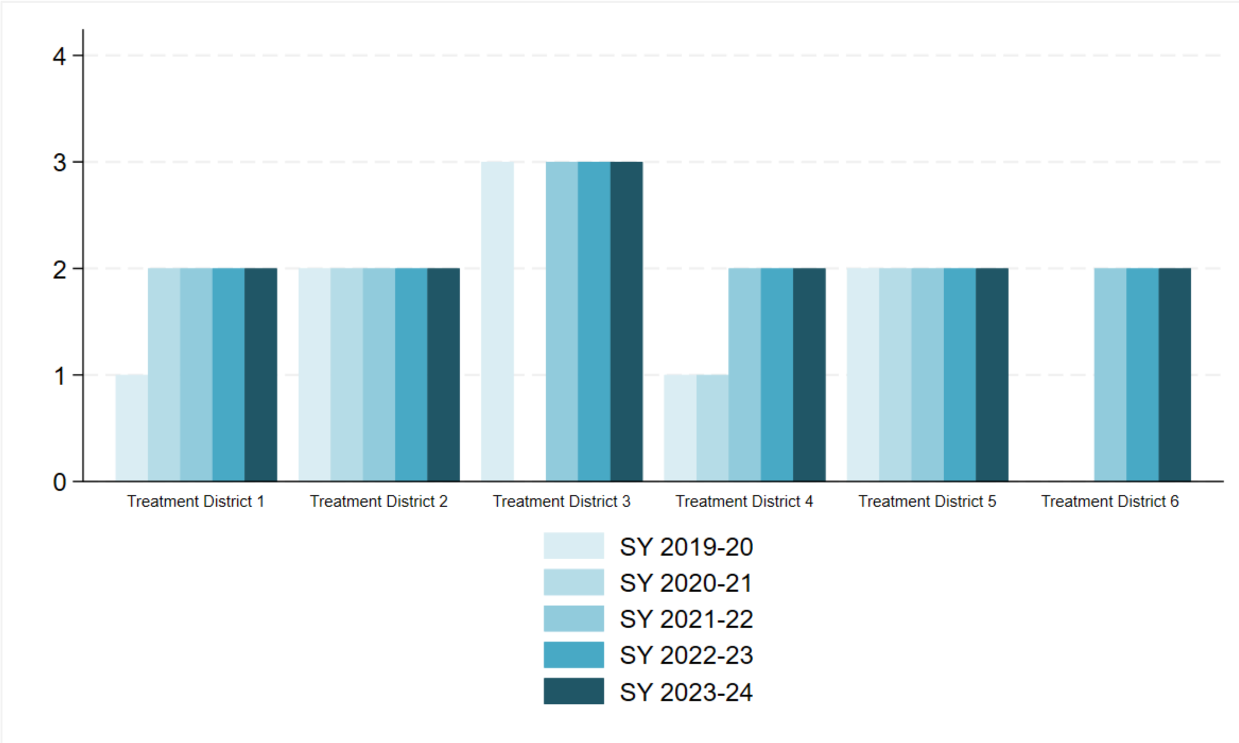
3 = There is a developed resource for parents offering clarity around the CS education plan of the district, in-school pathways for students, extracurricular activities, and partner opportunities for enrichment.

2 = Individual teachers or guidance counselors discuss CS education options with parents or families during back-to-school nights, open houses, or parent teacher conferences. District communications including flyers and newsletters include information about CS education efforts.

1 = Families are not engaged or informed of CS offerings or student pathways.

Note: Treatment District 3 did not complete the District Infrastructure Survey in SY 2020–21 and Treatment District 6 did not complete the District Infrastructure Survey in SY 2019-20 or 2020-21.

Exhibit B.18: "Which of the following best describes the ways the local workforce engages with computer science education in your district?"



Answers:

4 = Local workforce efforts engage with individual schools to provide materials for student pathways, and clarity for guidance counselors in recommending student experiences. The school community (teachers, students, parents, guidance, and administrators) understand the regional workforce efforts and leverage appropriate resources to supplement district resources.

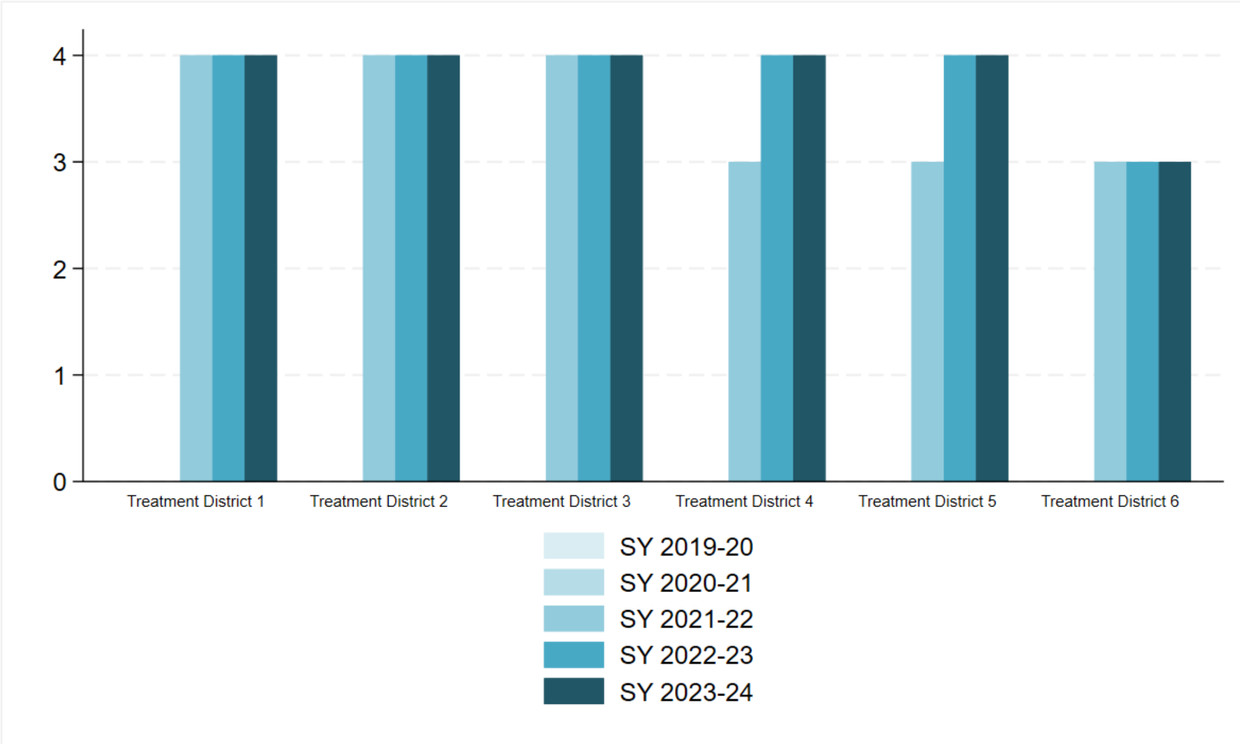
3 = Local workforce efforts are connected or consulted by the district in the development of CS education plans. Curricular selection and enrichment activities are designed to not only prepare students for college but also for potential career readiness opportunities locally. Local industry is engaged in opportunities to support district efforts through employee volunteer programs, support for events or initiatives, and engagement in district plans.

2 = Individual teachers may connect to local workforce efforts, but there is little to no alignment between community workforce development and CS education programs. There may be connections to local industry for one-time events or gifts, but little connection between these interactions and the larger goals or plans of the district.

1 = Local workforce efforts are not engaged or connected to the CS education efforts of the district.

Note: Treatment District 3 did not complete the District Infrastructure Survey in SY 2020–21 and Treatment District 6 did not complete the District Infrastructure Survey in SY 2019-20 or 2020-21.

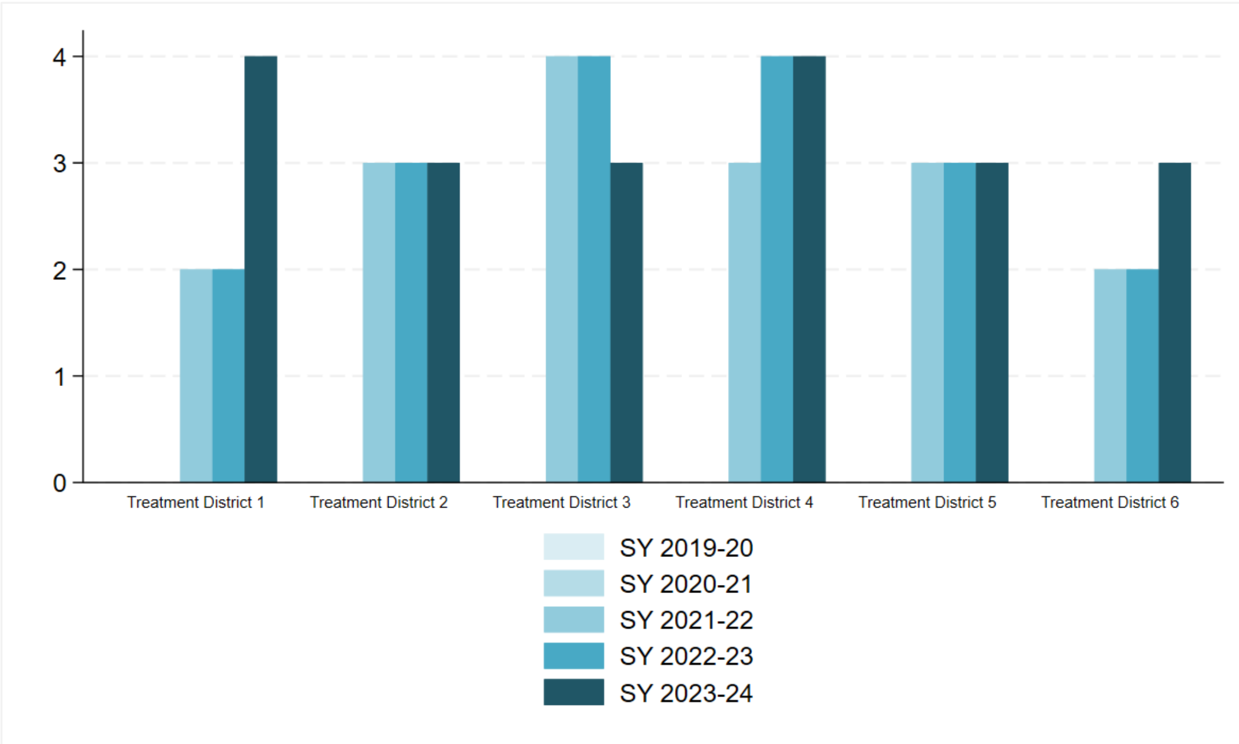
Exhibit B.19: "Extent to which all 7th and 8th grade students receive CS instruction?"



Answers:

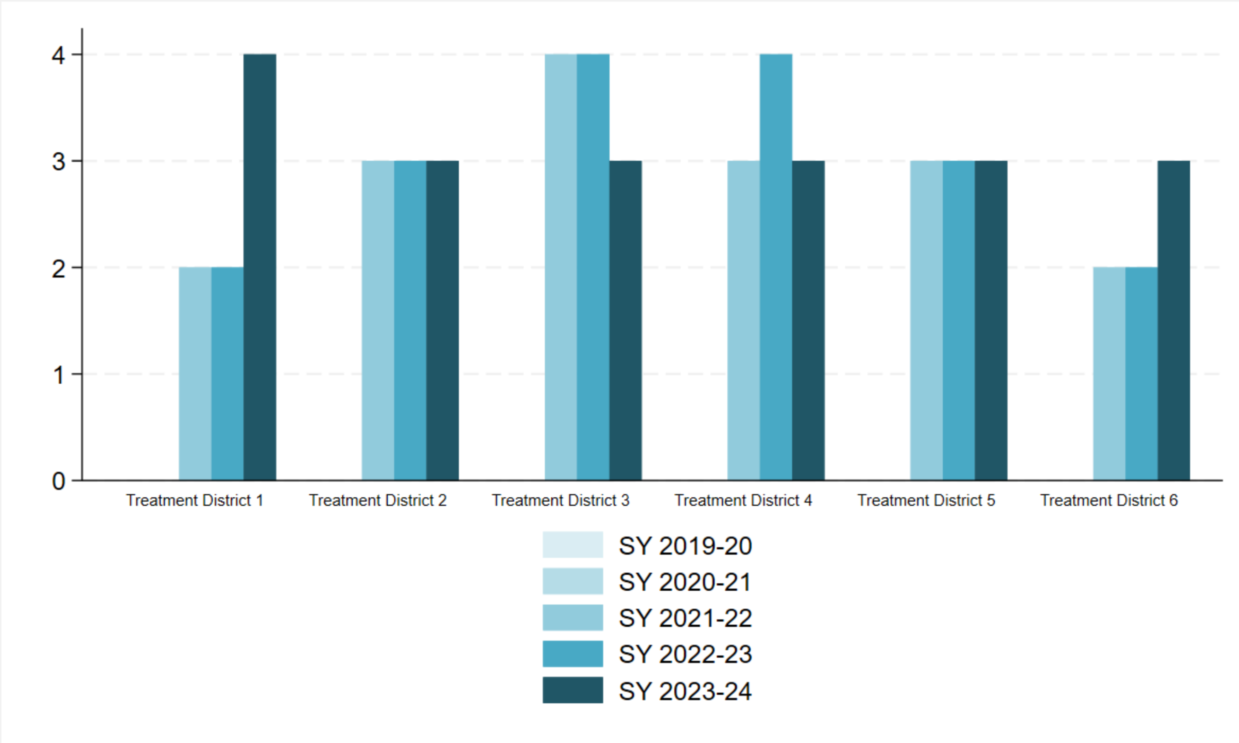
4 = To a great extent (Goals have been reached and strategies and well-established)
3 = Somewhat (Steps have been taken and are continuing)
2 = A little (Planning is underway but few or no actions have been taken)
1 = Not at all (Nothing is planned or underway)

Exhibit B.20: "Extent to which equity strategies are employed to support interest and persistence in CS among traditionally underrepresented student groups?"



Answers:
4 = To a great extent (Goals have been reached and strategies and well-established)
3 = Somewhat (Steps have been taken and are continuing)
2 = A little (Planning is underway but few or no actions have been taken)
1 = Not at all (Nothing is planned or underway)

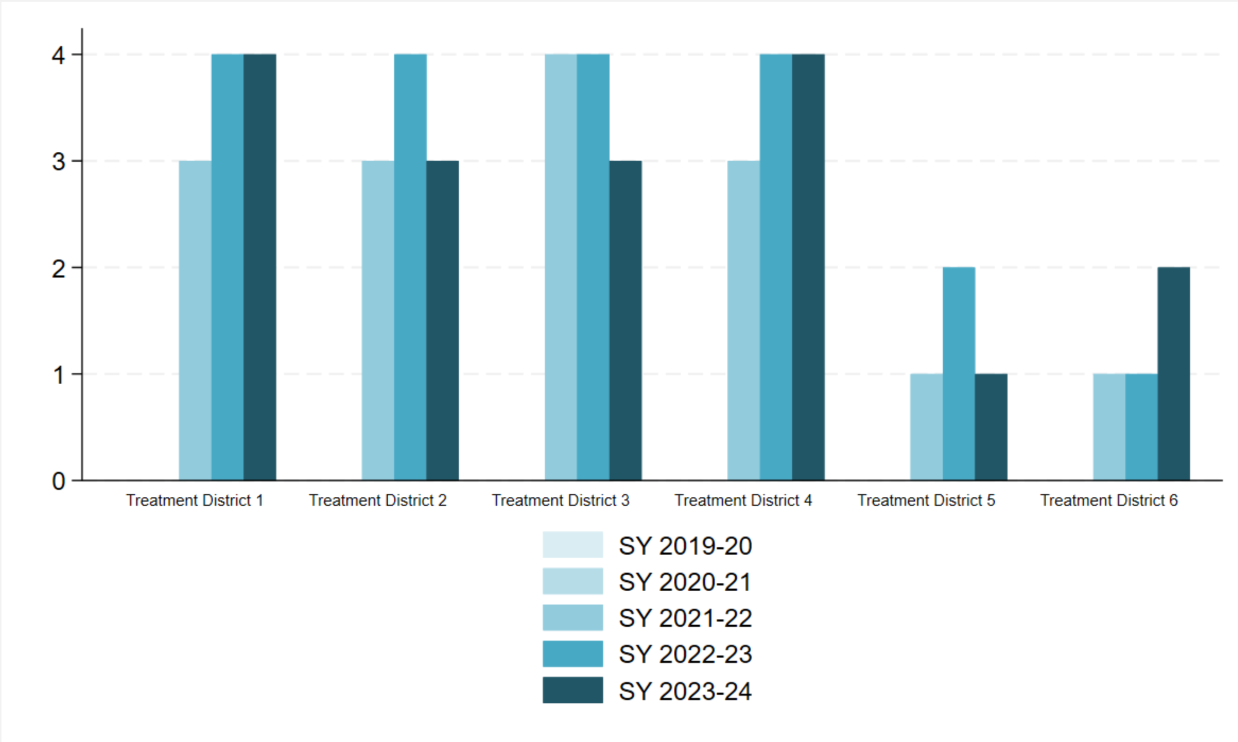
Exhibit B.21: "Extent to which implementation of inclusive CS pathway planning occurs?"



Answers:

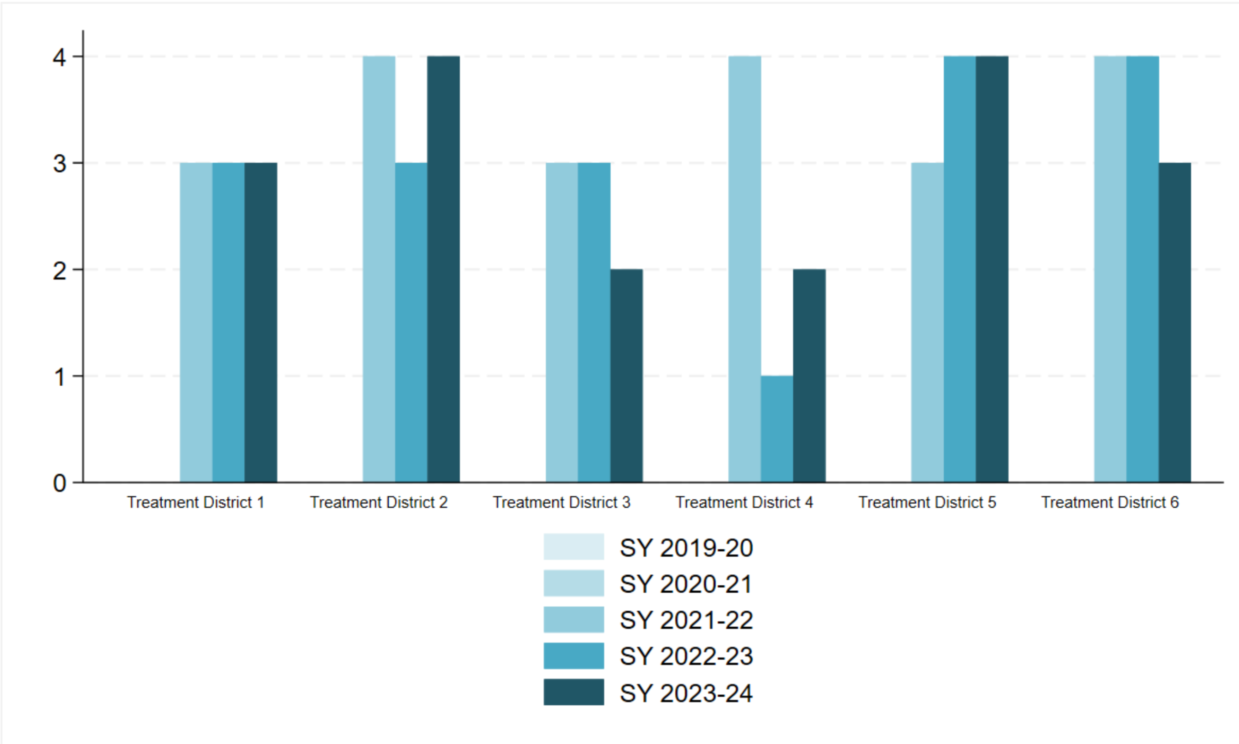
4 = To a great extent (Goals have been reached and strategies and well-established)
3 = Somewhat (Steps have been taken and are continuing)
2 = A little (Planning is underway but few or no actions have been taken)
1 = Not at all (Nothing is planned or underway)

Exhibit B.22: "Extent to which CS is provided in sequential middle-school years at a minimum of 75 instructional hours per year?"



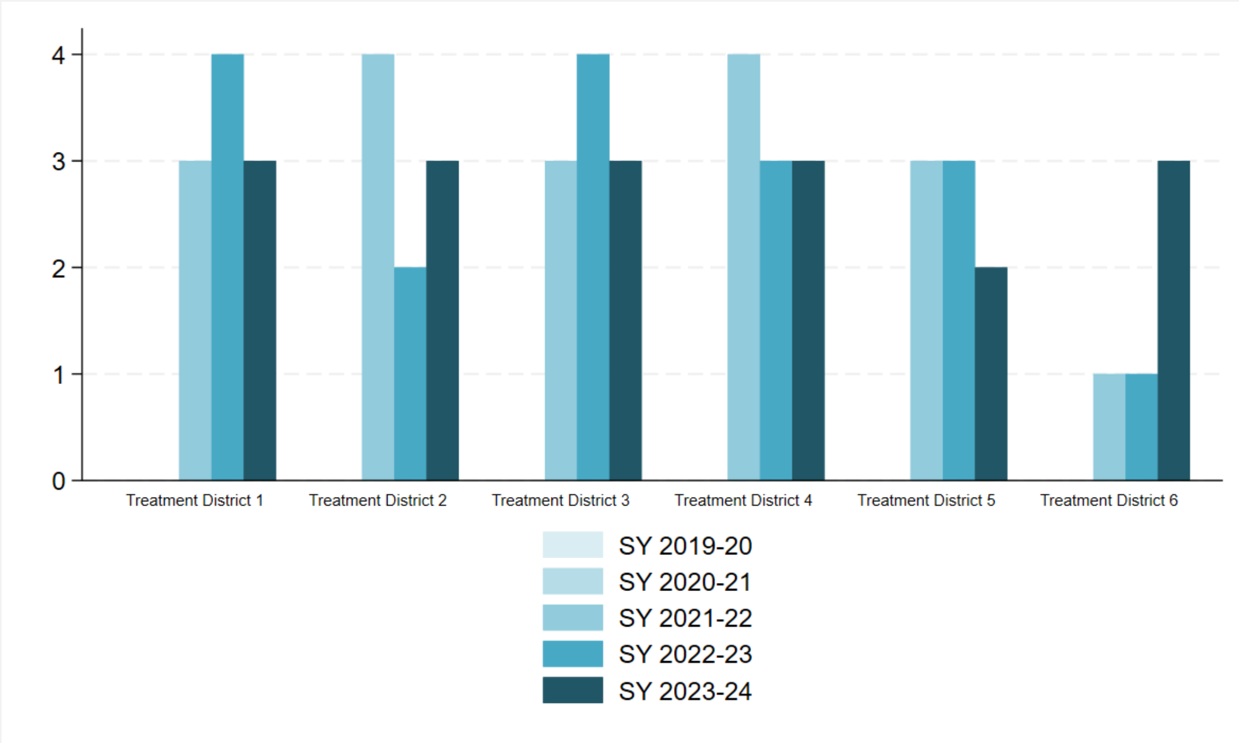
Answers:
4 = To a great extent (Goals have been reached and strategies and well-established)
3 = Somewhat (Steps have been taken and are continuing)
2 = A little (Planning is underway but few or no actions have been taken)
1 = Not at all (Nothing is planned or underway)

Exhibit B.23: "Extent to which there is a district-level CS taskforce that includes representation from major stakeholder groups?"



Answers:
4 = To a great extent (Goals have been reached and strategies and well-established)
3 = Somewhat (Steps have been taken and are continuing)
2 = A little (Planning is underway but few or no actions have been taken)
1 = Not at all (Nothing is planned or underway)

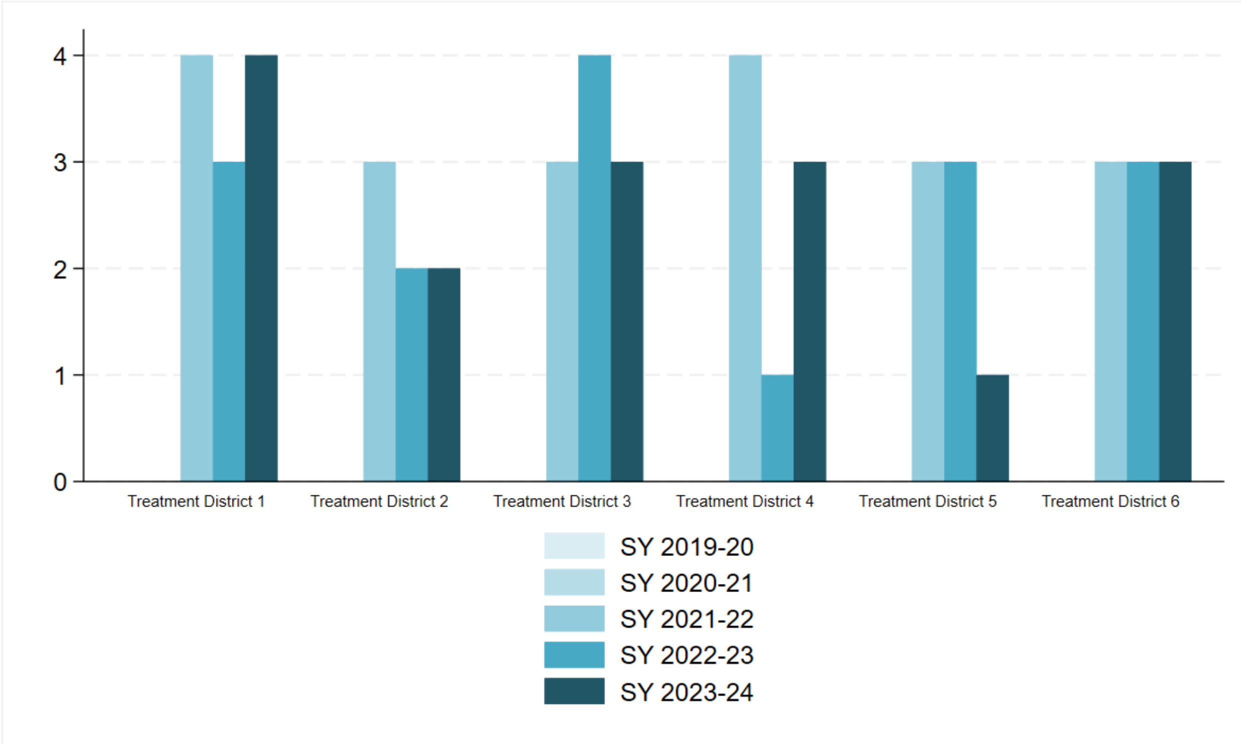
Exhibit B.24: "Extent to which CS pathways are integrated with district strategic plan?"



Answers:

4 = To a great extent (Goals have been reached and strategies and well-established)
3 = Somewhat (Steps have been taken and are continuing)
2 = A little (Planning is underway but few or no actions have been taken)
1 = Not at all (Nothing is planned or underway)

Exhibit B.25: "Extent to which information/technology specialists support CS teachers?"

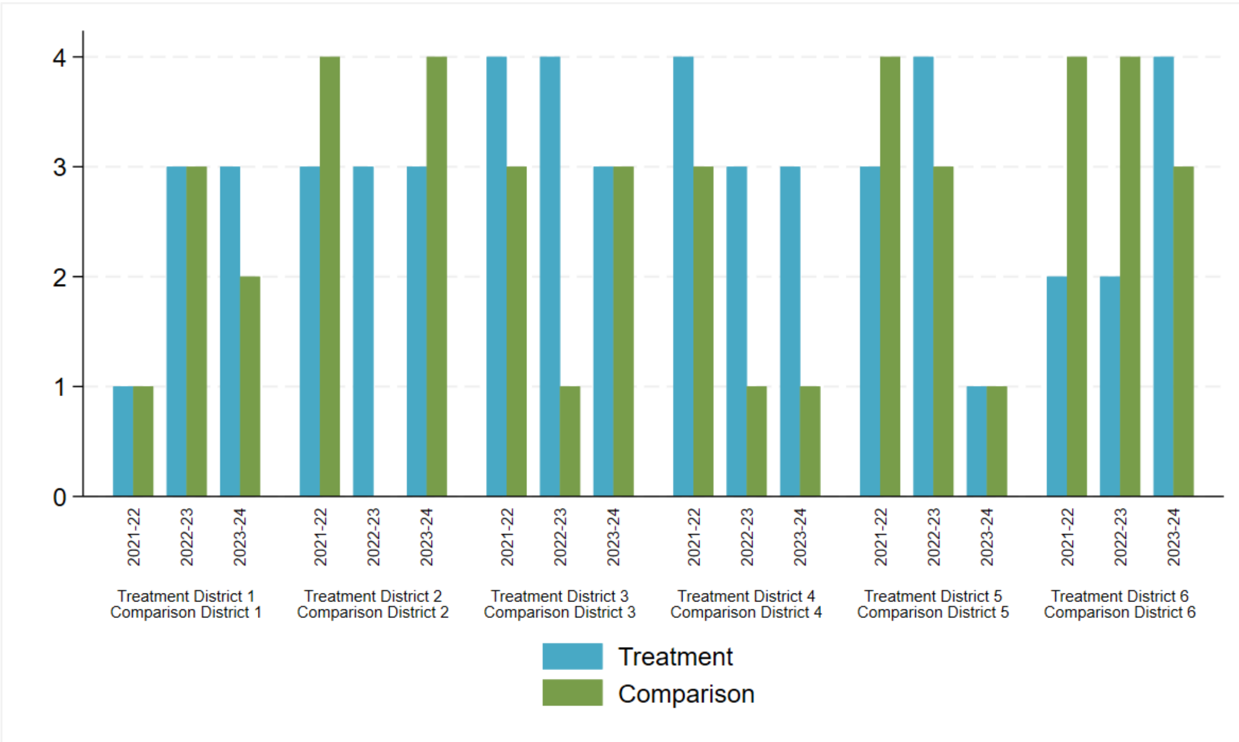


Answers:
4 = To a great extent (Goals have been reached and strategies and well-established)
3 = Somewhat (Steps have been taken and are continuing)
2 = A little (Planning is underway but few or no actions have been taken)
1 = Not at all (Nothing is planned or underway)

Appendix C: District Infrastructure Survey Findings – Treatment and Comparison Districts Over Time

This appendix presents findings from the District Infrastructure Survey for treatment and comparison districts. Districts completed the surveys in spring/summer of 2022, 2023, and 2024 and answered questions about the full academic year. Survey questions and response items in this appendix appear verbatim from the survey.

Exhibit C.1: "Does your district have a continuous improvement initiative in place?"



Answers:

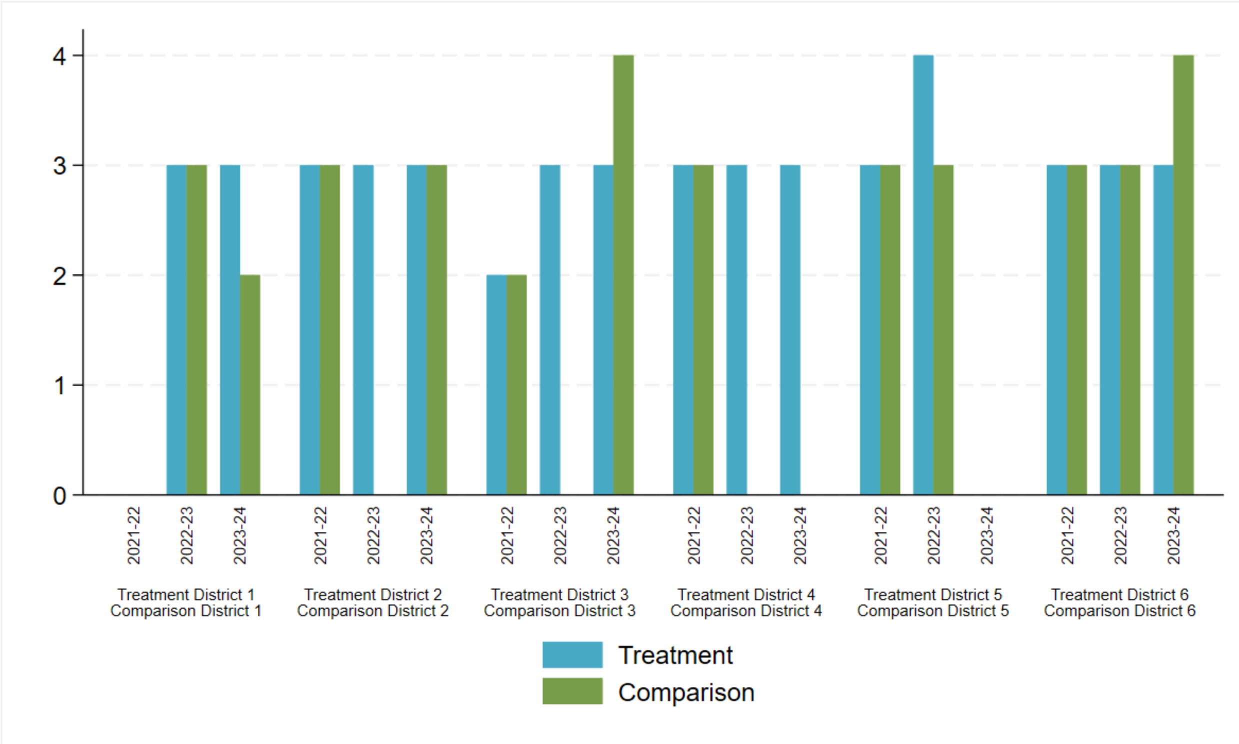
4 = Our district has a data-based continuous improvement initiative and the initiative itself is also subject to continuous improvement processes

3 = Our district has a data-based continuous improvement initiative

2 = Our district has a continuous improvement initiative, but does not use data to inform decisions

1 = No continuous improvement initiative

Exhibit C.2: "Does your district have systematic engagement in the continuous improvement initiative?"



Answers:

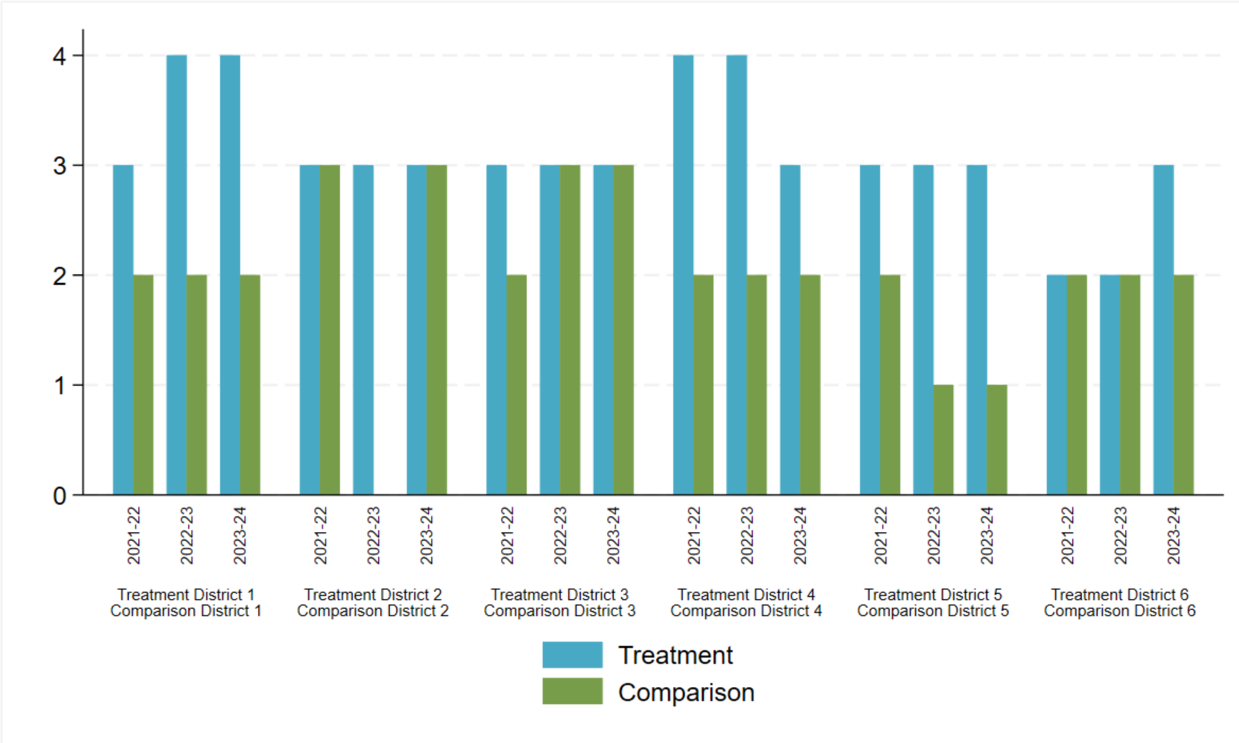
4 = Teachers and staff have access to continuous improvement planning documents and reports. Continuous improvement teams include individuals from all levels (support, classroom, building, central office) of the district. An organized professional learning community exists for continually improving CS education in the district.

3 = Our district has regular continuous improvement meetings. Continuous improvement practices are developed during in-service trainings.

2 = Our district has infrequent continuous improvement meetings. There is no coherent team addressing CI initiatives.

1 = No systematic engagement in the continuous improvement initiative

Exhibit C.3: "How well does your district select computer science curricula?"



Answers:

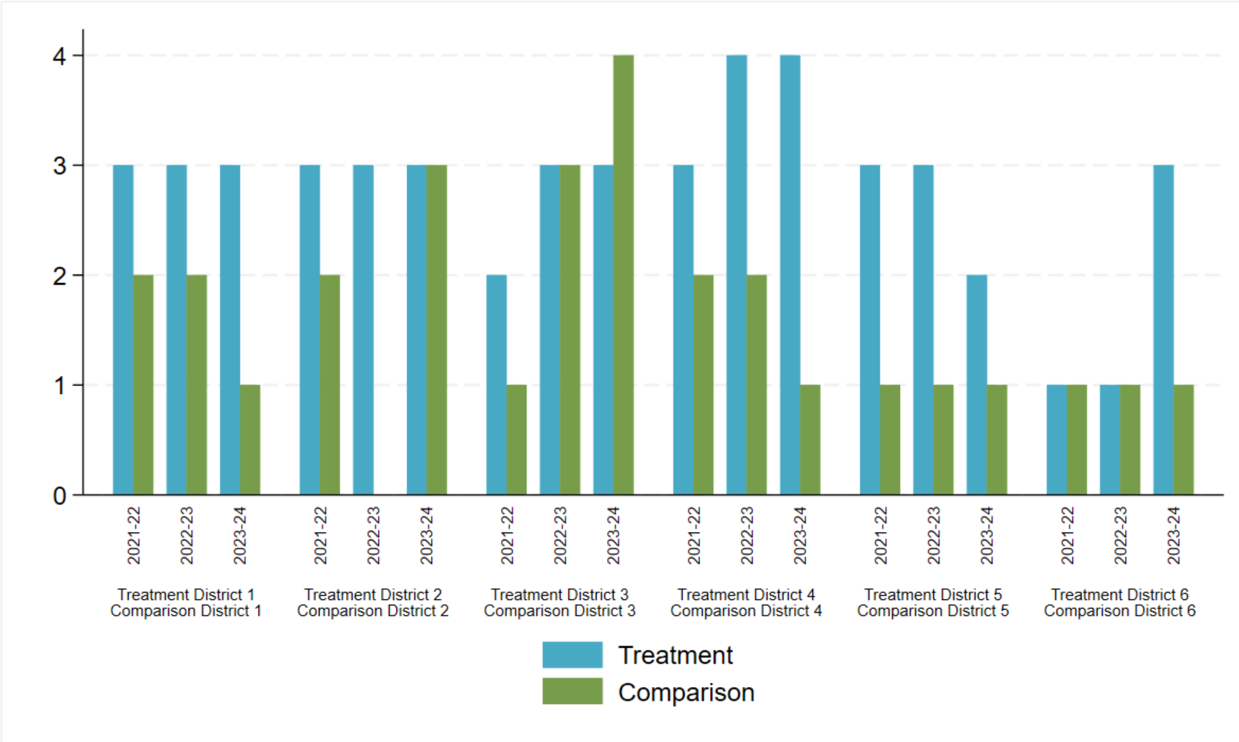
4 = The selected CS curricula is sequential and student learning builds each year in alignment with national standards and other district initiatives. There is a process for both grade level and multiple grade teams to meet and discuss or refine the curriculum based on individual needs of schools/students.

3 = One or more CS curricula is selected with communication between teachers and across grades. Selected CS curricula address a majority of relevant state or national CS Education standards or K-12 CS Framework concepts and practices.

2 = Some CS taught in schools and the CS curriculum is selected by individual teachers with no communication for pathway options.

1 = No CS curriculum selected for any grade levels.

Exhibit C.4: "How well are computer science classes sequenced and aligned in your district?"



Answers:

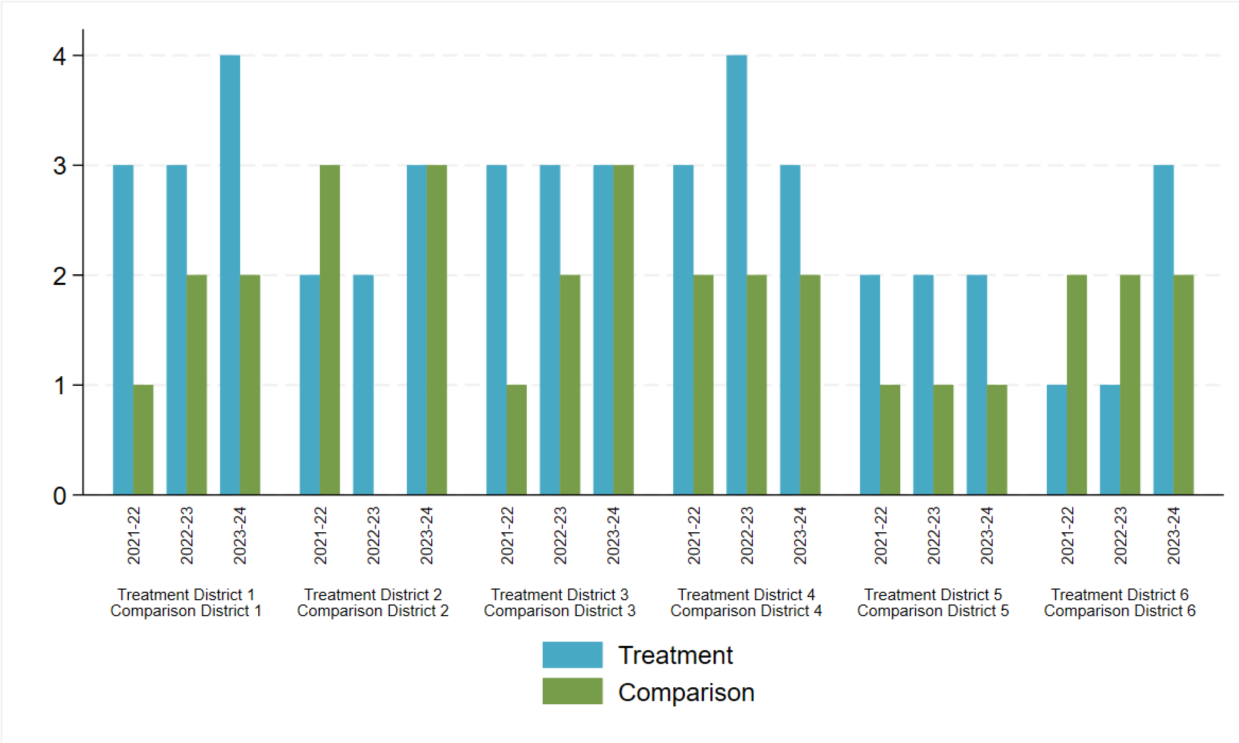
4 = The vision and 12th grade outcomes for students are clearly defined and all teachers of CS can describe how their curriculum fits in a multiyear sequence to arrive at those outcomes. Additionally, advanced pathways or electives exist for students who would like to pursue either more rigor (advanced placement or dual enrollment) or a specific flavor of CS (media arts or web design).

3 = Curricular activities are aligned to K-12 DLCS standards or the K12 CS framework. Activities are sequential and connected to the vision/outcomes for the school or district.

2 = CS curricular activities are developmentally appropriate for students but are disconnected and do not have a clear sequence to 12th grade for students.

1 = There is no alignment or progression to any CS activities that occur in the district. (Schools may engage in one-off activities like Hour of Code, but do not sequence the activities for student learning).

Exhibit C.5: "How well are diverse learners supported with CS materials in your district?"



Answers:

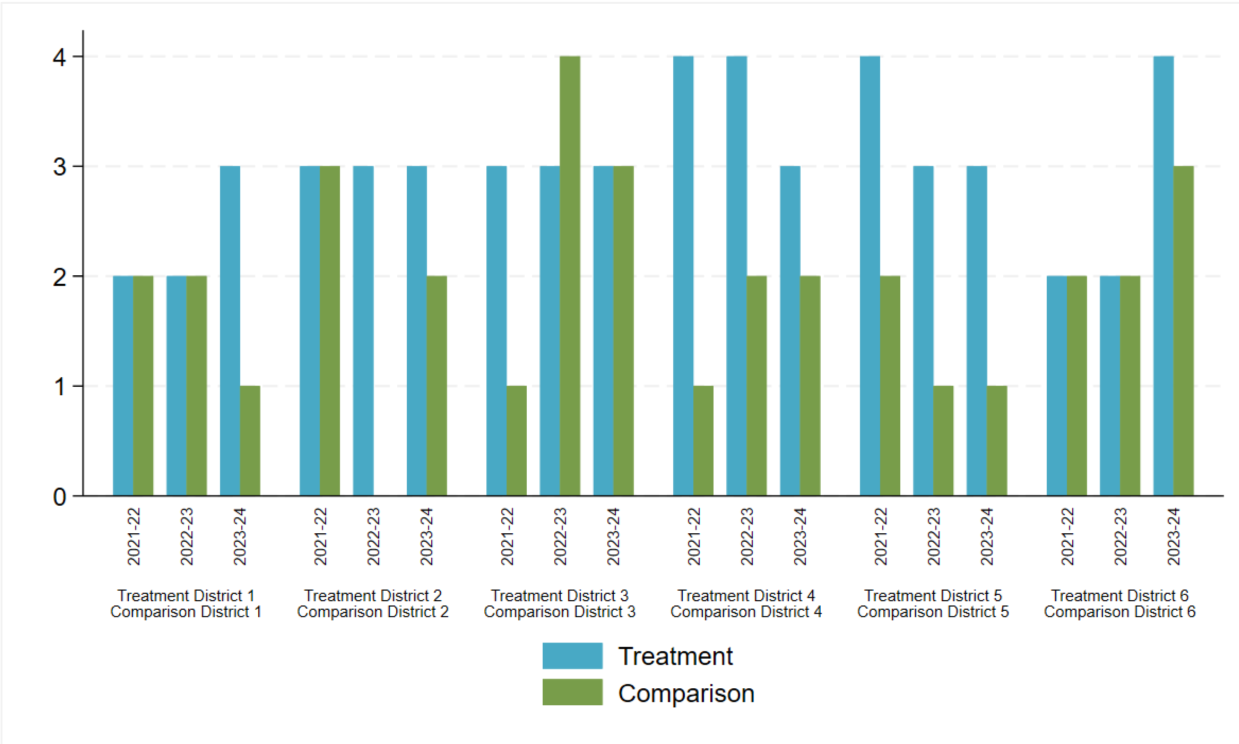
4 = Working groups of CS/content teachers and special education teachers proactively review curricula and materials for accessibility and potential bias. Together, the teams produce guidance documents for all teachers with best practices in the project-based computer science classroom. The teams apply Universal Design for Learning (UDL) principles used in other disciplines for potential areas of relevance.

3 = Teachers use Universal Design for Learning principles when creating CS materials for diverse learners. The teachers are connected to appropriate special educators and the teams have district support for necessary material development and refinement.

2 = Individual teachers create CS materials for diverse learners based upon a limited understanding of students in their class.

1 = There is no support for the creation or identification of CS materials for diverse learners.

Exhibit C.6: "What role does district-level leadership play in the planning and development of CS curriculum?"



Answers:

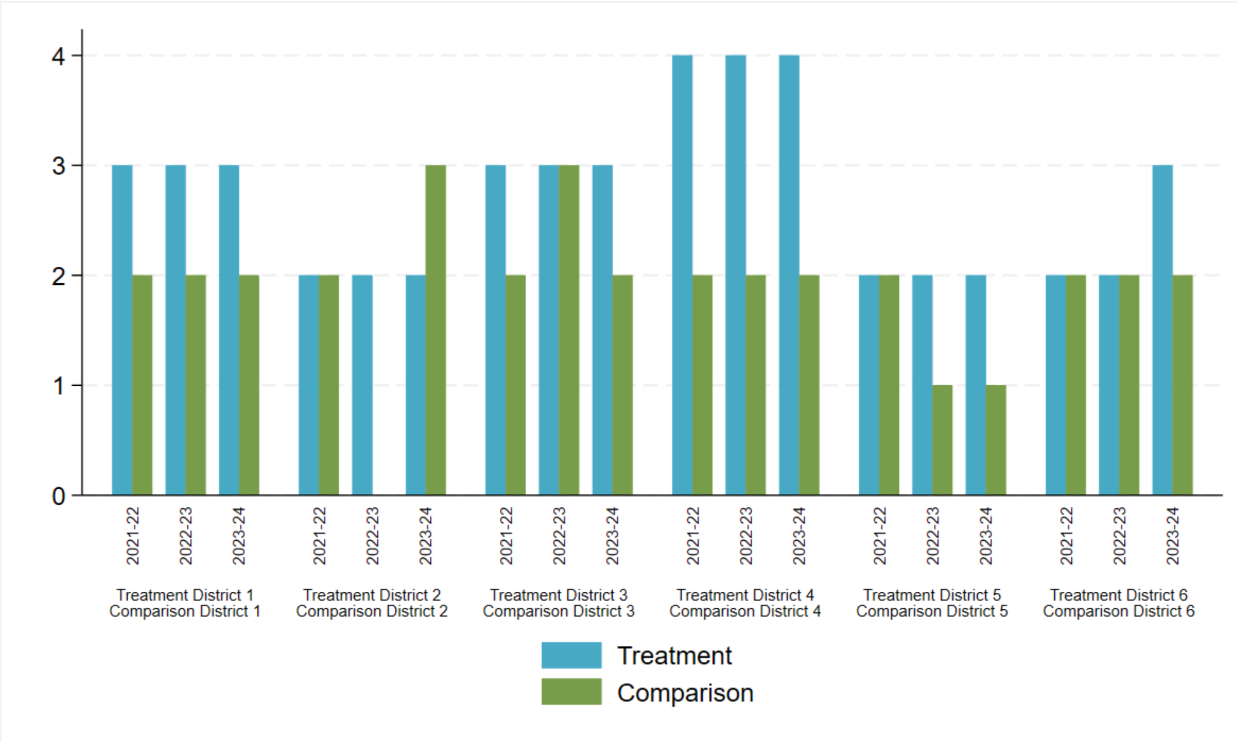
4 = District leadership proactively establishes a clear vision and plan that includes incentives for plan execution and engagement with CS education activities.

3 = District leadership actively participates in vision and goal setting activities for CS and coordinates across schools for coherent CS objectives.

2 = District leadership recognizes CS education efforts but is not engaged in coordination or shared planning processes (if they exist).

1 = District leadership does not play a role in CS education efforts in the schools.

Exhibit C.7: "What role does school-level leadership play in the planning and development of CS curriculum?"



Answers:

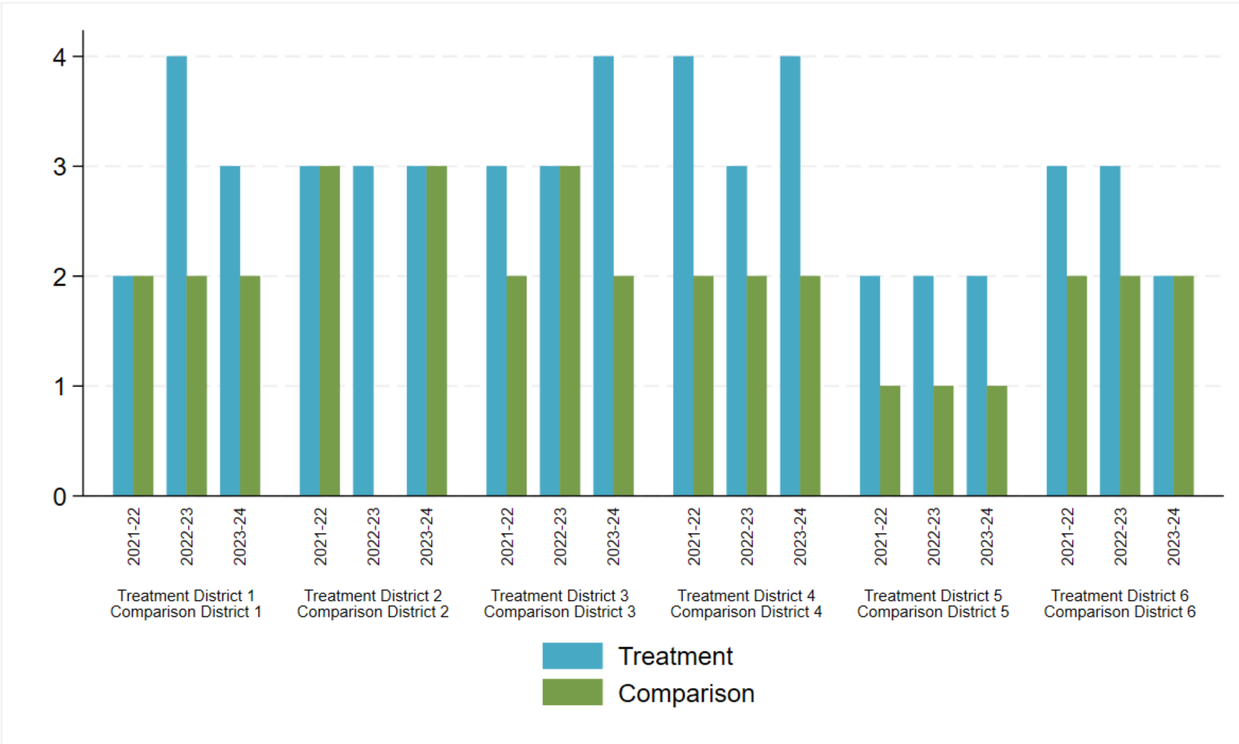
4 = Leadership teams make use of data about CS education enrollment and student performance to guide discussions of CS education. The leadership team actively encourages the participation of teacher leaders and collaborates with other schools for best practices and shared experiences. Schools feel connected to CS education outcomes and supported in the pursuit of those outcomes for specific needs of school populations.

3 = A representative sample of school leaders participate in vision and goal setting activities for CS, and all schools have leaders who are aware of district CS activities and given opportunities to provide feedback on initiative priorities based on individual school needs.

2 = School leadership recognizes CS education efforts but is not engaged in coordination or a shared planning process in their school.

1 = School leadership does not play a role in CS education efforts in their school.

Exhibit C.8: "What role does school personnel (support teachers and staff) play in the planning and development of CS curriculum?"



Answers:

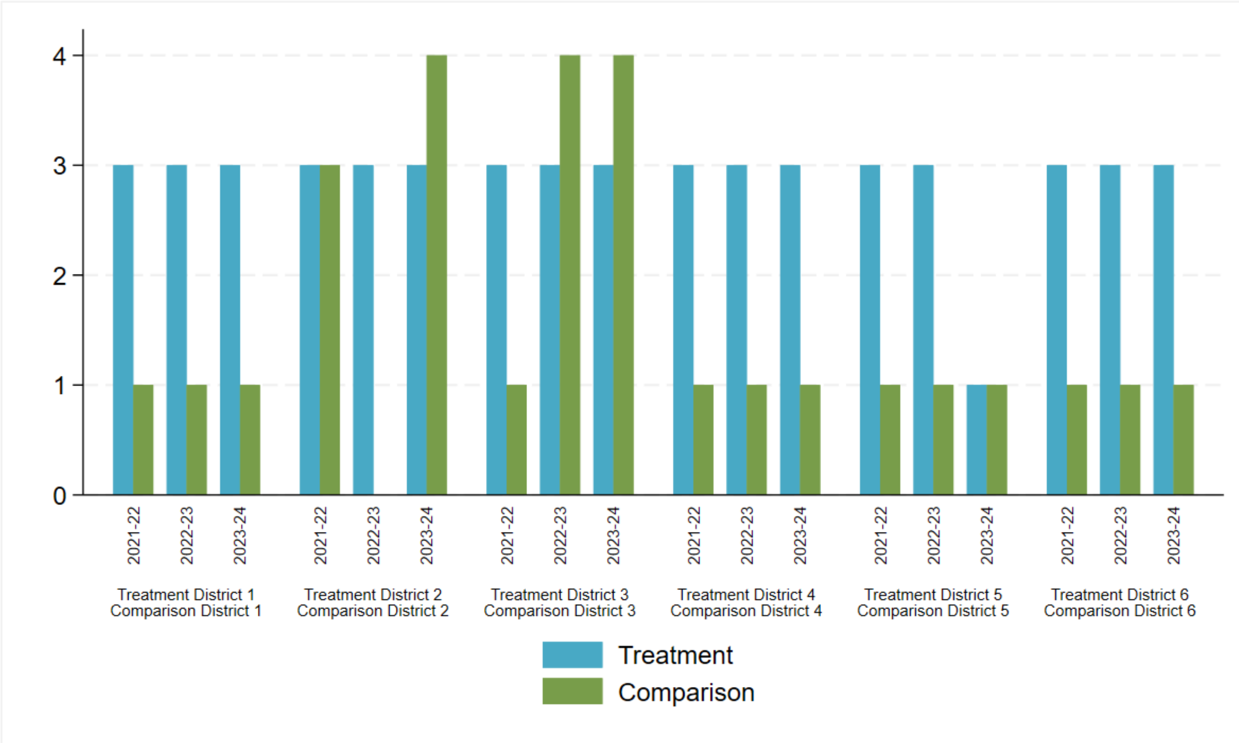
4 = Library media specialists, special educators, and guidance counselors are provided opportunities to engage in CS education PD as appropriate for their roles. They also regularly communicate with teachers and leadership teams about CS education plans and useful connections to their work.

3 = Library media specialists are aware of and participate in CS education activities in the school. Special educators are engaged in CS education planning, weighing in about curricular and tool choices and how they impact diverse learners. Guidance counselors are supported with information about pathways for students who are interested in CS, as well as the benefits of CS as a minor for students with other interests.

2 = School personnel are aware of CS education efforts but are not engaged in coordination or shared planning processes.

1 = School personnel do not play a role in CS education efforts in the schools.

Exhibit C.9: "Which of the following best describes your district's plan for computer science education?"



Answers:

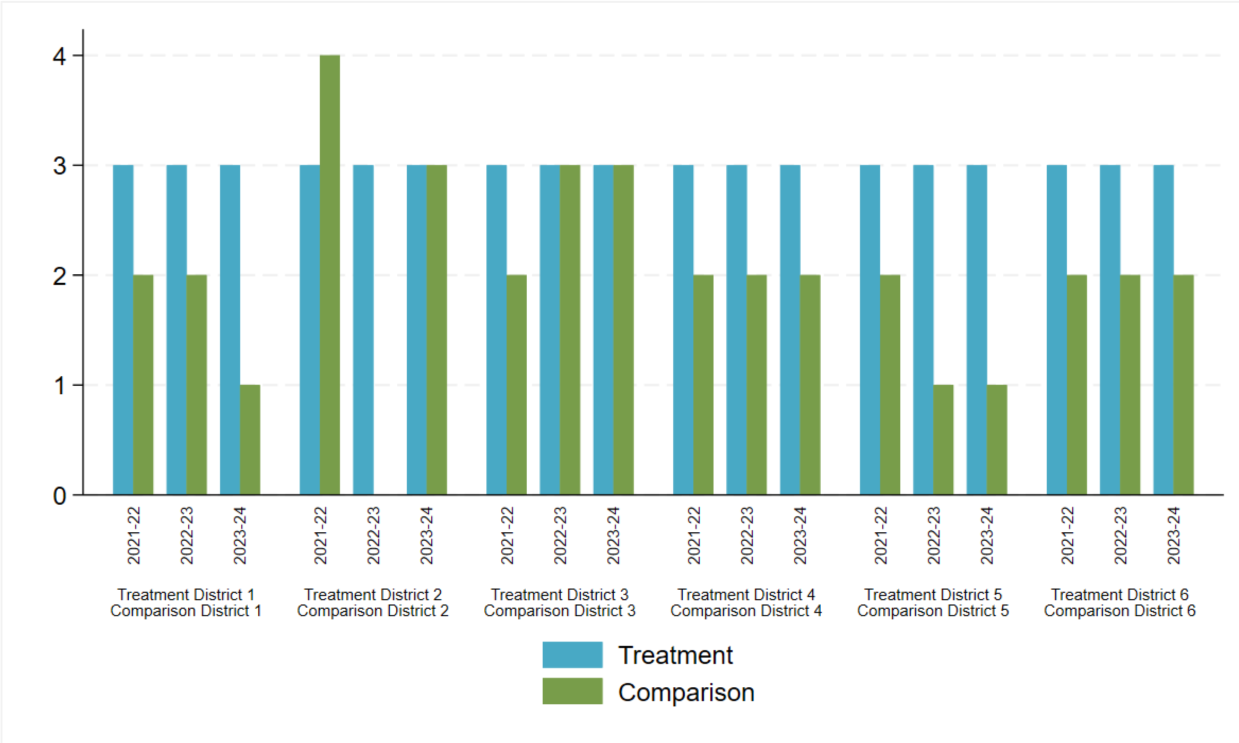
4 = A CS education plan exists that is updated regularly and has the ability for individual schools to use locally with different implementation. The plan was created with a shared process. The plan is actionable, flexible as necessary for multiple schools, and aligned with the district goals.

3 = A CS education plan exists that was created with a shared process. The plan is actionable, flexible as necessary for multiple schools, and aligned with the district goals.

2 = A CS education plan exists but does not use a shared process for its creation, and is not specific, actionable, or aligned with district vision for CS education.

1 = The school district does not have a documented plan for CS education efforts.

Exhibit C.10: "Which of the following best describes the way computer science education is implemented in your district?"



Answers:

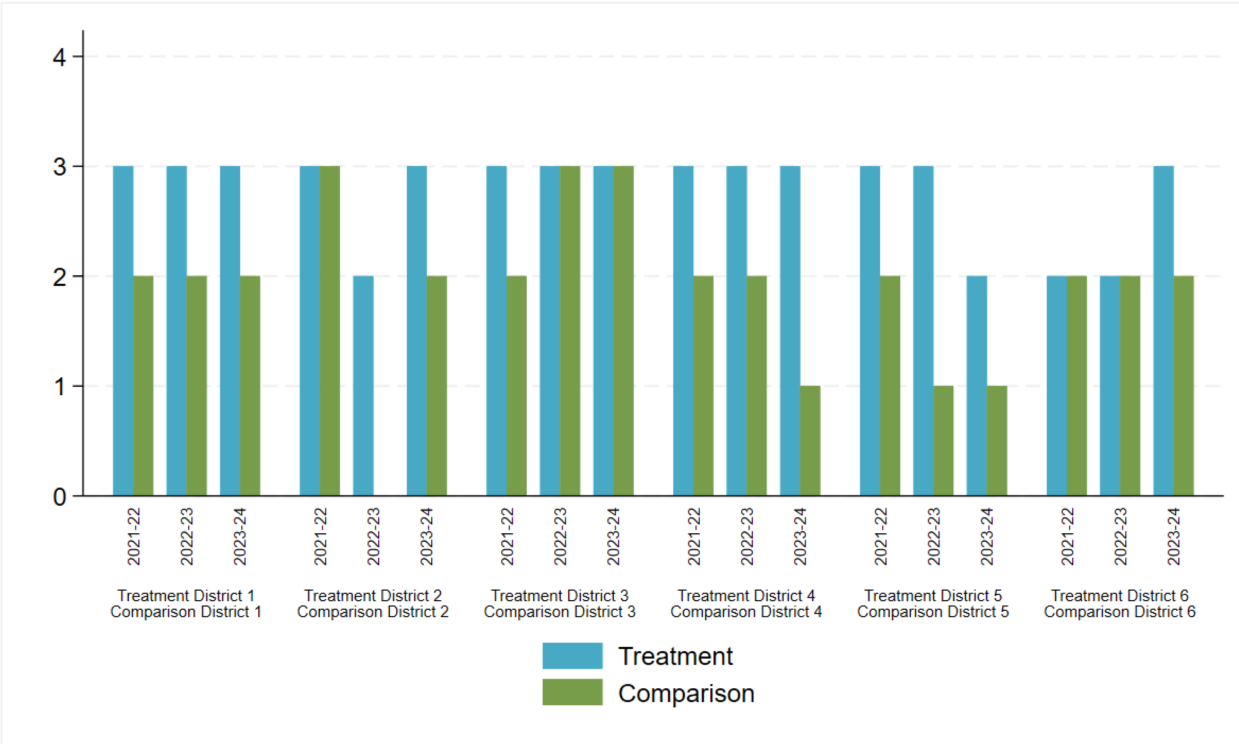
4 = Data is regularly collected and shared to help drive planning process and updated goals. The implementation of CS education in the district is goal- and vision-aligned. There is coordination of pathways and progressions for students across grades. All students are engaged in CS education efforts especially traditionally under-represented minority groups and at-risk populations.

3 = The implementation of CS education in the district is goal and vision aligned. There is coordination of pathways and progressions for students across grades. All students are engaged in CS education efforts especially traditionally under-represented minority groups and at-risk populations. However, there is no regularly collected data that is incorporated into the process.

2 = The implementation of CS education is teacher-led with little coordination for pathways or progressions. Electives may be offered at individual schools, but no connected sequence of courses exist.

1 = There is no implementation of CS education within the district.

Exhibit C.11: "Which of the following best describes the computer science outcomes that have been set by the district?"



Answers:

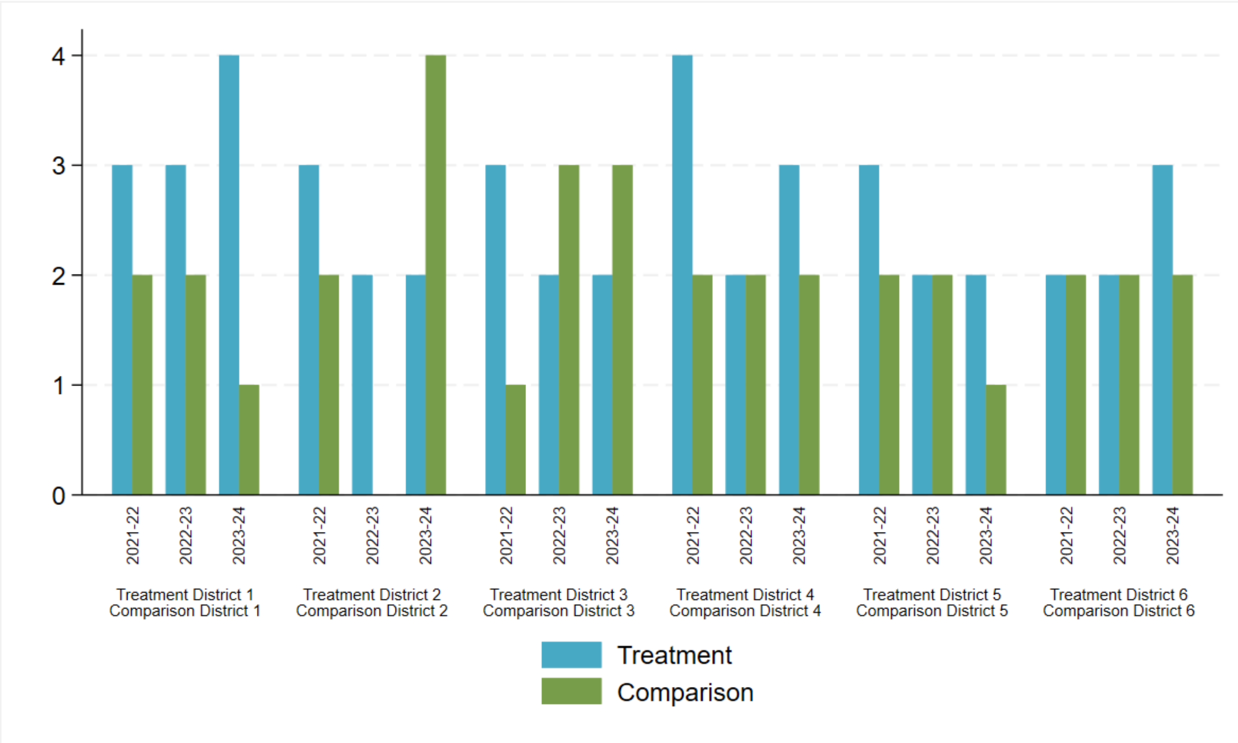
4 = Community level outcomes exist regarding parent education, community engagement, and informal learning opportunities for students. Student level outcomes exist aligned to state/national standards where appropriate. Teacher level outcomes exist related to Teacher development.

3 = Student level outcomes exist aligned to state/national standards where appropriate. Teacher level outcomes exist related to Teacher development. There are no community level outcomes.

2 = Course or program level outcomes exist. (e.g., offer a class, run an hour of code)

1 = There are no defined outcomes for CS education within the district.

Exhibit C.12: "Which of the following best describes the computer science teacher professional development in your district?"



Answers:

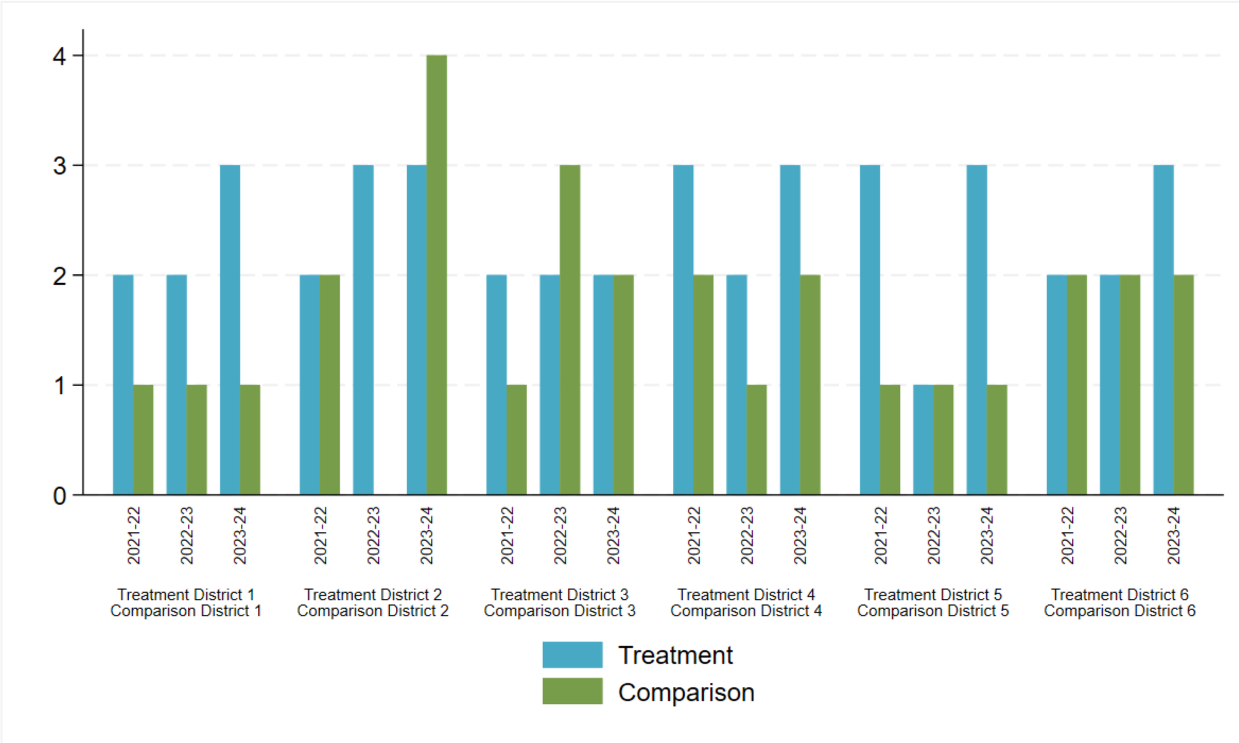
4 = Teacher CS professional development is chosen to align with district vision and goals, and teachers are supported in the selection and attendance of the PD.

3 = Teachers are supported in their selection of CS professional development opportunities and are connected to each other for coherent pathways and grade level consistency.

2 = Teachers independently identify CS professional development opportunities and participate in CS orientation PD at their own discretion.

1 = Teachers have not participated in CS education PD or have not had prior CS education experience.

Exhibit C.13: "Which of the following best describes the computer science teacher working groups in your district?"



Answers:

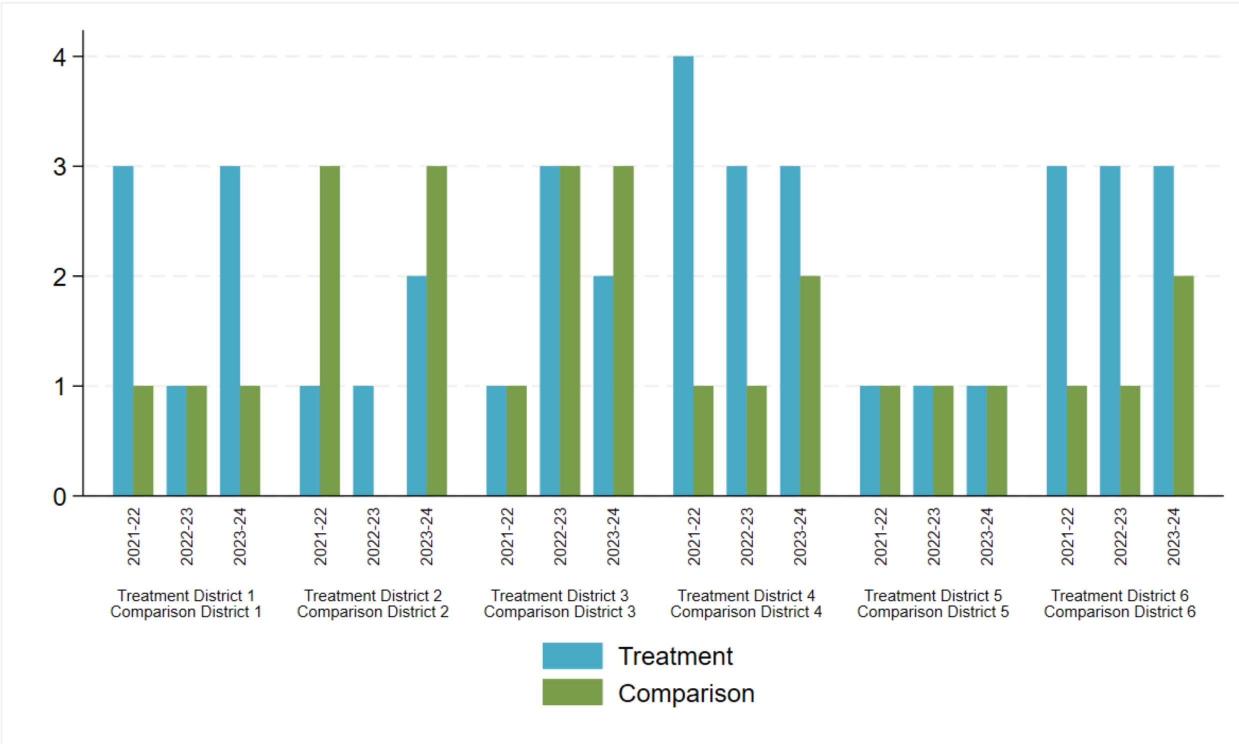
4 = There are K-12 working groups for sequential CS education planning in the district, and outcomes from these groups are shared in district communication. Teacher working groups use student data and artifacts to drive teacher development. Meetings are scheduled and participation is part of incentive structures for teacher performance rating and there is a consistently high attendance rate.

3 = Teachers participate in CS working groups both at a local and national level as a part of their professional learning network (PLN). Teachers are supported and recognized for this work with PD hours or other standard district incentives for professional learning.

2 = Participation in CS teacher working groups is entirely driven by individual teachers and mostly consists of participation in national communities such as CSTA or CS for ALL Teachers.

1 = There is no participation by teachers in working groups focused on CS education.

Exhibit C.14: "Which of the following best describes the district-level resources for the computer science teacher working groups in your district?"



Answers:

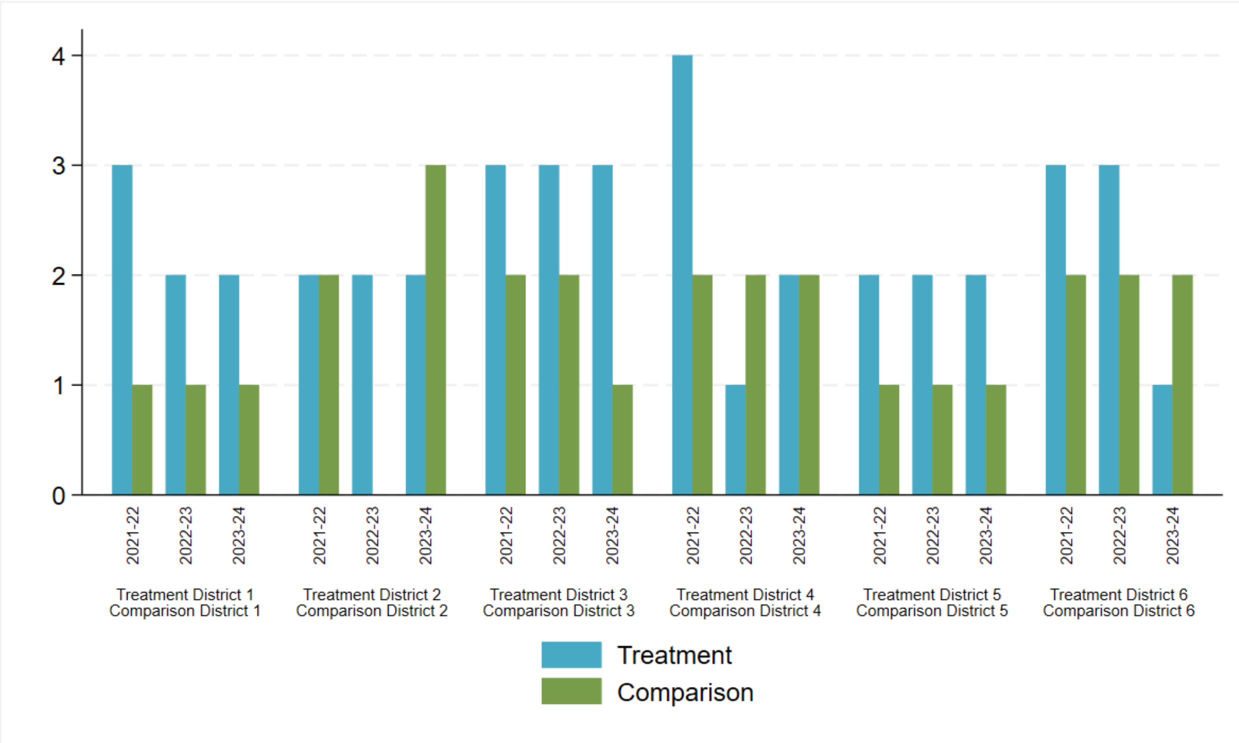
4 = The district supports working groups of administrators and teachers in order to create relevant feedback frameworks for CS education and provide training for their implementation. District-level resources for administrators connect to best practices research for CS education.

3 = Administrators work with teachers or district teams to understand the relevant goals and best practices in CS education for use in teacher observation and feedback.

2 = Teacher feedback is aligned to best practices in CS education by individual administrators.

1 = There is no support for administrators in the observation and teacher feedback and evaluation process for CS teachers or lessons containing CS content.

Exhibit C.15: "Which of the following best describes the local partners (including informal education) that engage with computer science education in your district?"



Answers:

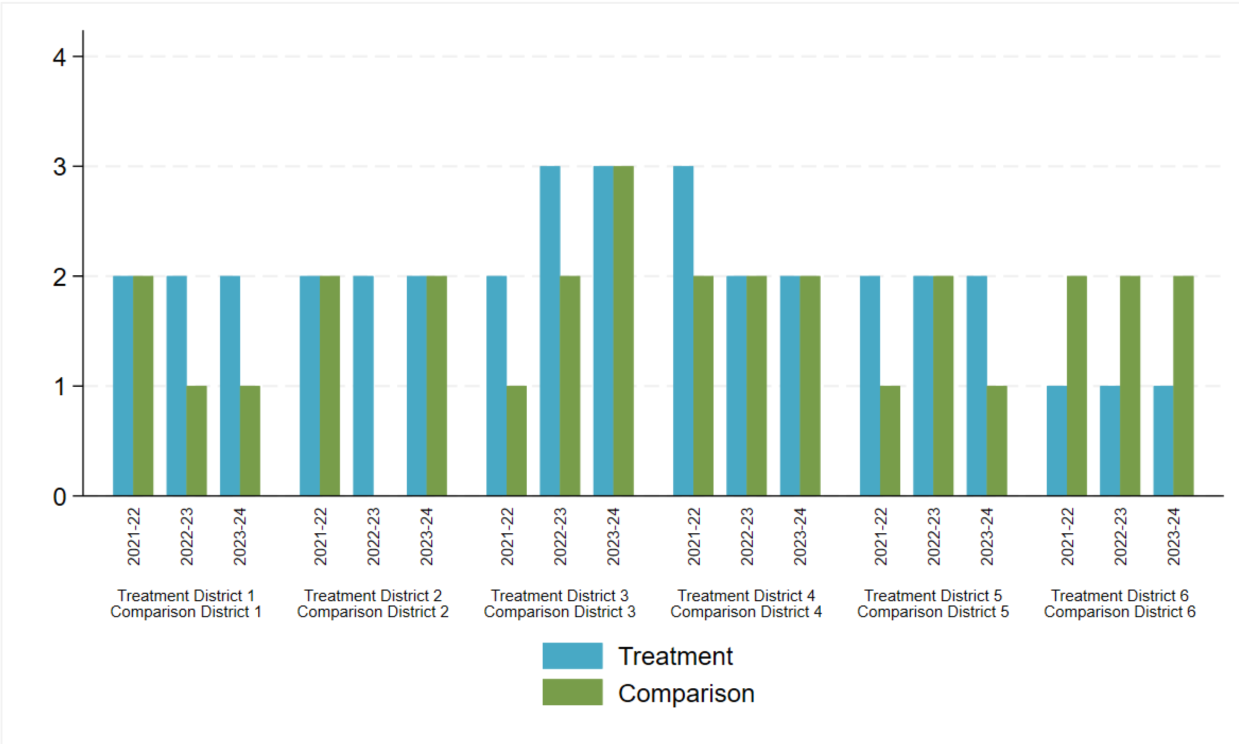
4 = Local partners are included in the district planning and revision processes. Informal enrichment opportunities are included as a part of student pathway options, and efforts are made to engage local partners in curricular efforts for students and learning opportunities for teachers. Local partners are connected with teachers for PD opportunities (teachers participating in informal activities) or for content specialists who can engage with teachers for knowledge and resource sharing.

3 = Local partners are engaged by the school district for awareness and integration into any CS education plans. Communications for students and parents include enrichment opportunities from local partners in addition to classroom-based opportunities.

2 = The district/teachers are aware of some local partners (e.g., Girl Scouts, community centers, etc.) who offer enrichment activities, and activities may be advertised in the school.

1 = Local partners are not engaged with CS education efforts.

Exhibit C.16: "Which of the following best describes the professional learning partners that engage with computer science education in your district?"



Answers:

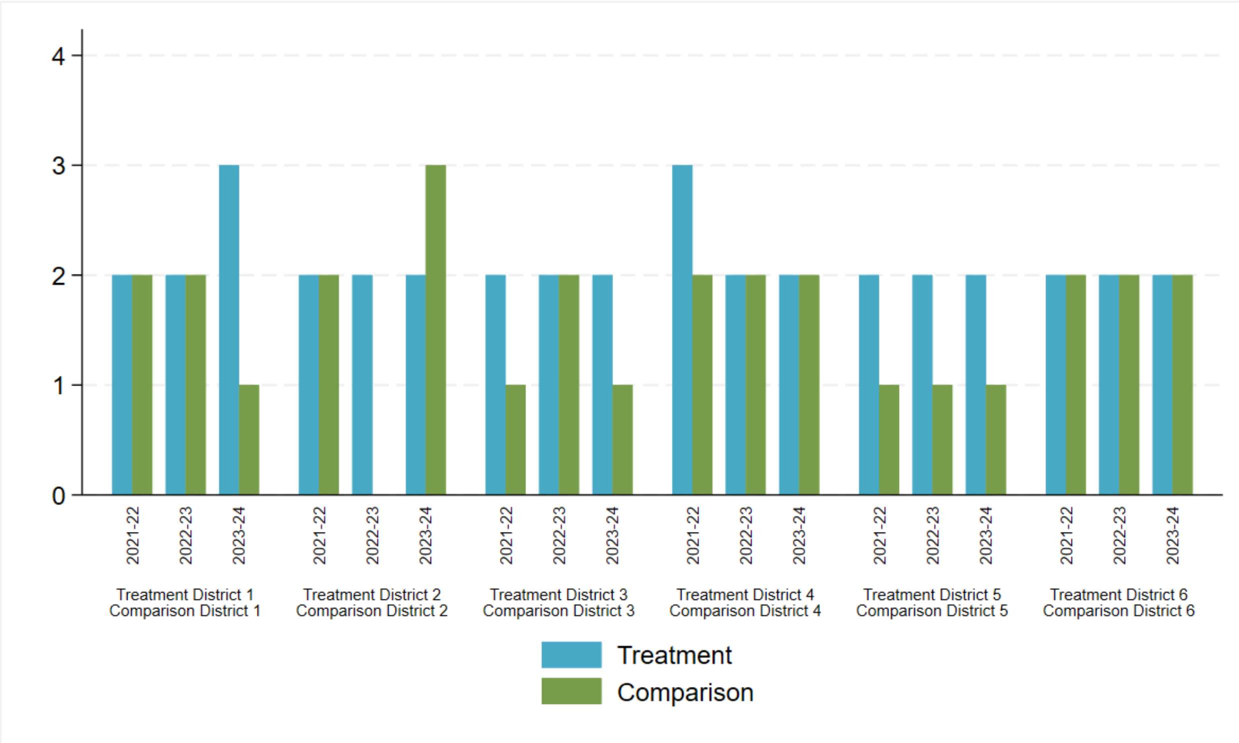
4 = Professional learning partners are used not only by individual teachers, but as a part of larger development plans. Information from partners is used in CS education plan development and revision, and district activities are shared in relevant networks as exemplars and for feedback.

3 = Engagement with professional learning partners is recognized by the district and CS education plan as a positive, and incentivized part of teacher development. Teachers new to computer science receive information about relevant partners in mentoring or advising sessions.

2 = Teachers in the district are aware of and make use of professional learning partners for continued development. Examples could include participating in teacher associations (CSTA) discussion boards (Code.org, CS for All Teachers) or social network communities (twitter chats, Facebook groups).

1 = The district or teachers have not identified any professional learning partners outside the district for support.

Exhibit C.17: "Which of the following best describes the ways families engage with computer science education in your district?"



Answers:

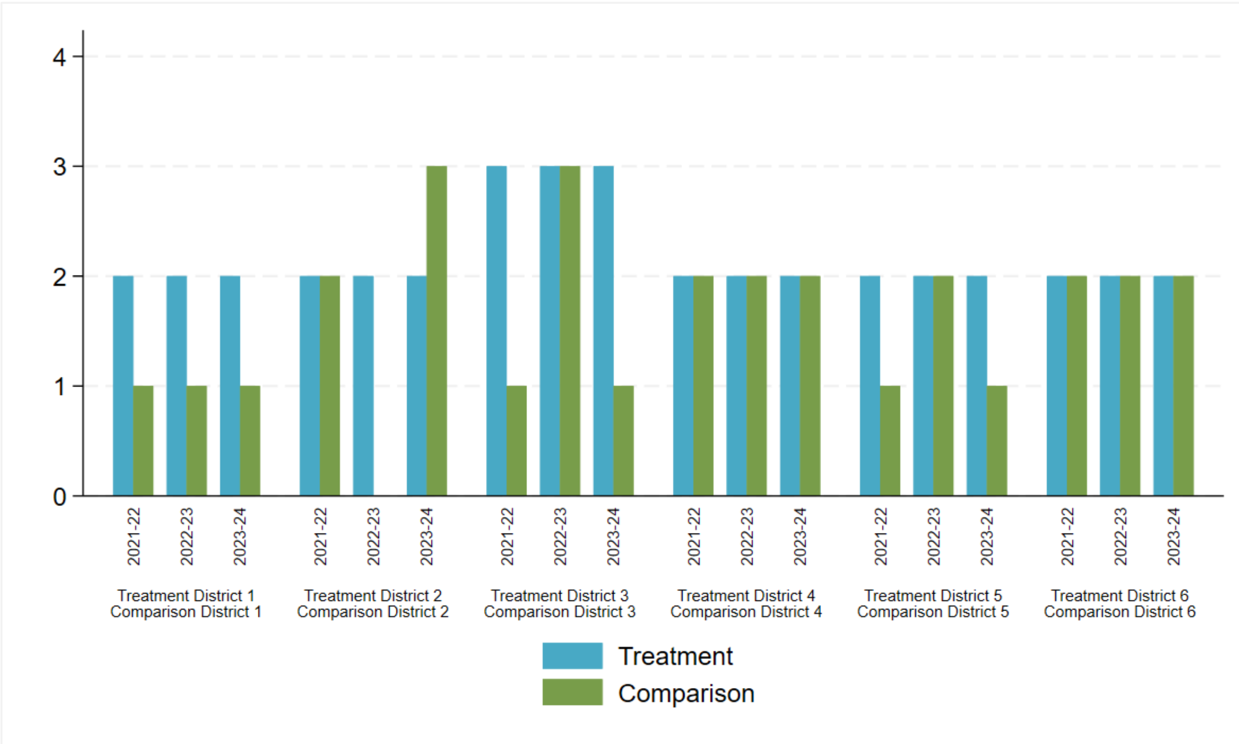
4 = Teachers and guidance counselors not only share the parent resource, but also regularly review it for updates. The resource may include a calendar for partners and community members to add items (such as hackathons, summer workshops, etc.). Evening and weekend events are planned to engage families in CS education opportunities.

3 = There is a developed resource for parents offering clarity around the CS education plan of the district, in-school pathways for students, extracurricular activities, and partner opportunities for enrichment.

2 = Individual teachers or guidance counselors discuss CS education options with parents or families during back-to-school nights, open houses, or parent teacher conferences. District communications including flyers and newsletters include information about CS education efforts.

1 = Families are not engaged or informed of CS offerings or student pathways.

Exhibit C.18: "Which of the following best describes the ways the local workforce engages with computer science education in your district?"



Answers:

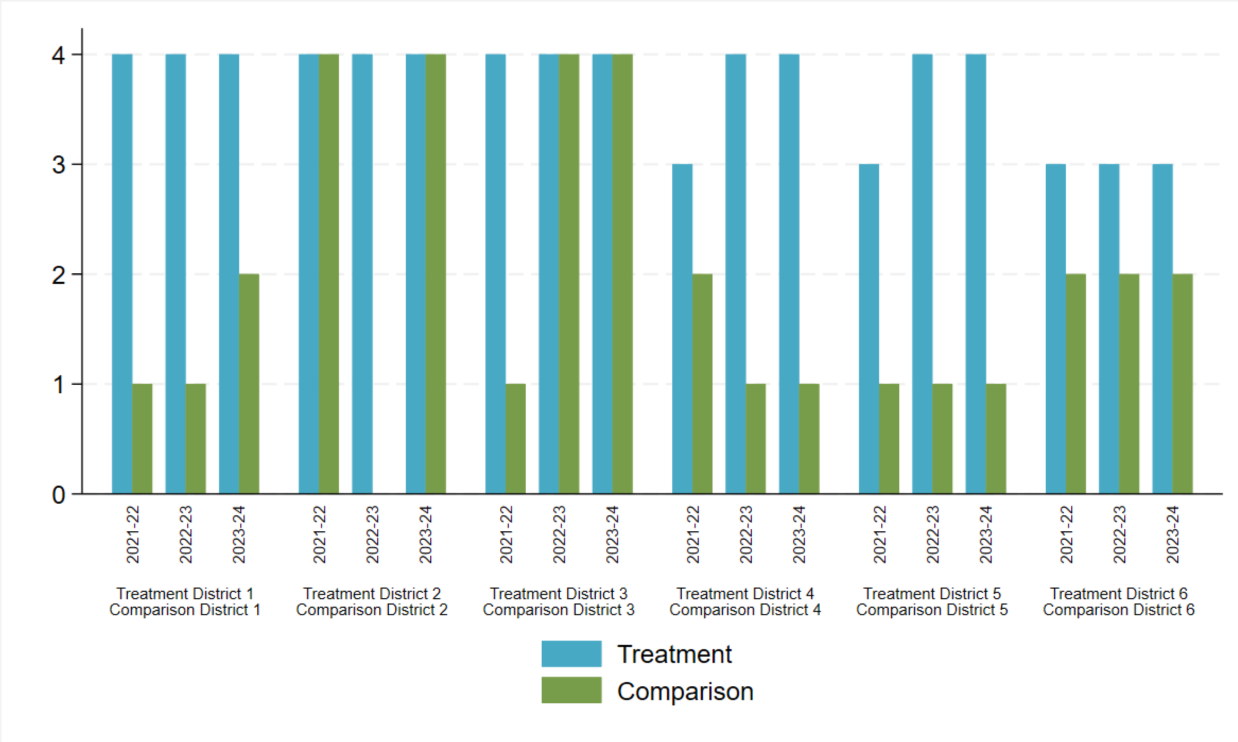
4 = Local workforce efforts engage with individual schools to provide materials for student pathways, and clarity for guidance counselors in recommending student experiences. The school community (teachers, students, parents, guidance, and administrators) understand the regional workforce efforts and leverage appropriate resources to supplement district resources.

3 = Local workforce efforts are connected or consulted by the district in the development of CS education plans. Curricular selection and enrichment activities are designed to not only prepare students for college but also for potential career readiness opportunities locally. Local industry is engaged in opportunities to support district efforts through employee volunteer programs, support for events or initiatives, and engagement in district plans.

2 = Individual teachers may connect to local workforce efforts, but there is little to no alignment between community workforce development and CS education programs. There may be connections to local industry for one-time events or gifts, but little connection between these interactions and the larger goals or plans of the district.

1 = Local workforce efforts are not engaged or connected to the CS education efforts of the district.

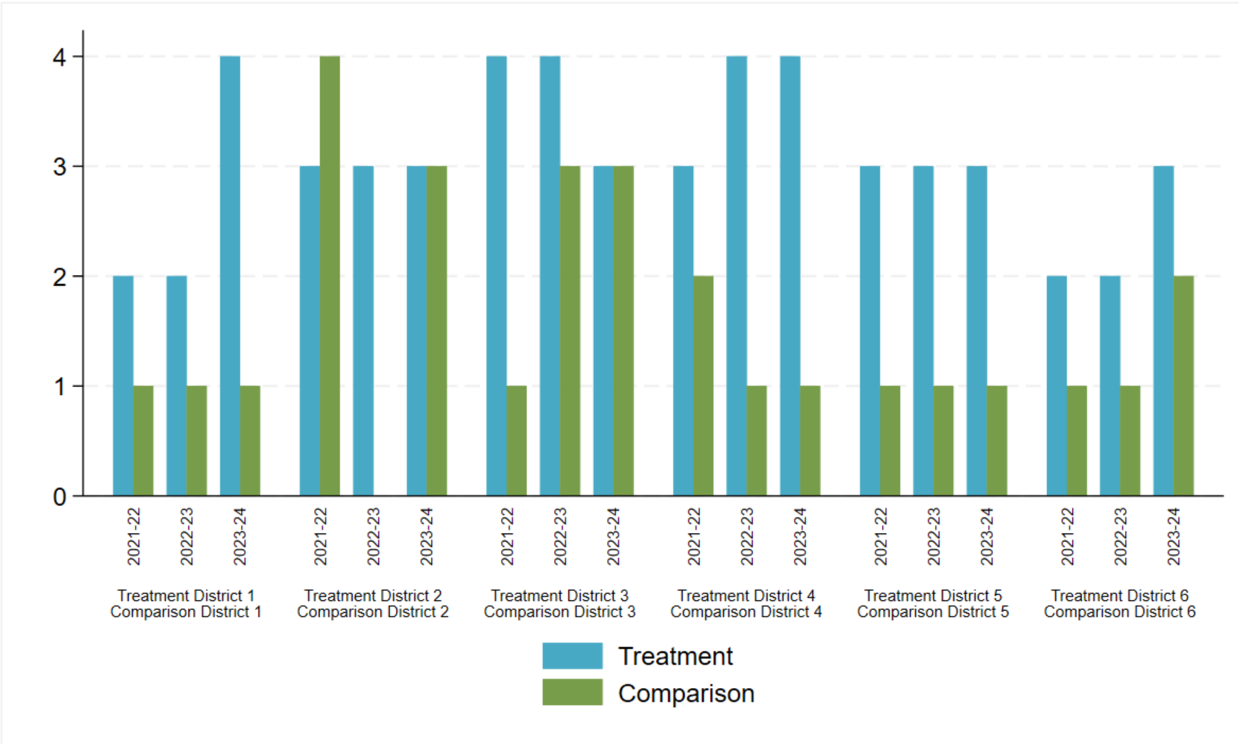
Exhibit C.19: "Extent to which all 7th and 8th grade students receive CS instruction?"



Answers:

4 = To a great extent (Goals have been reached and strategies and well-established)
3 = Somewhat (Steps have been taken and are continuing)
2 = A little (Planning is underway but few or no actions have been taken)
1 = Not at all (Nothing is planned or underway)

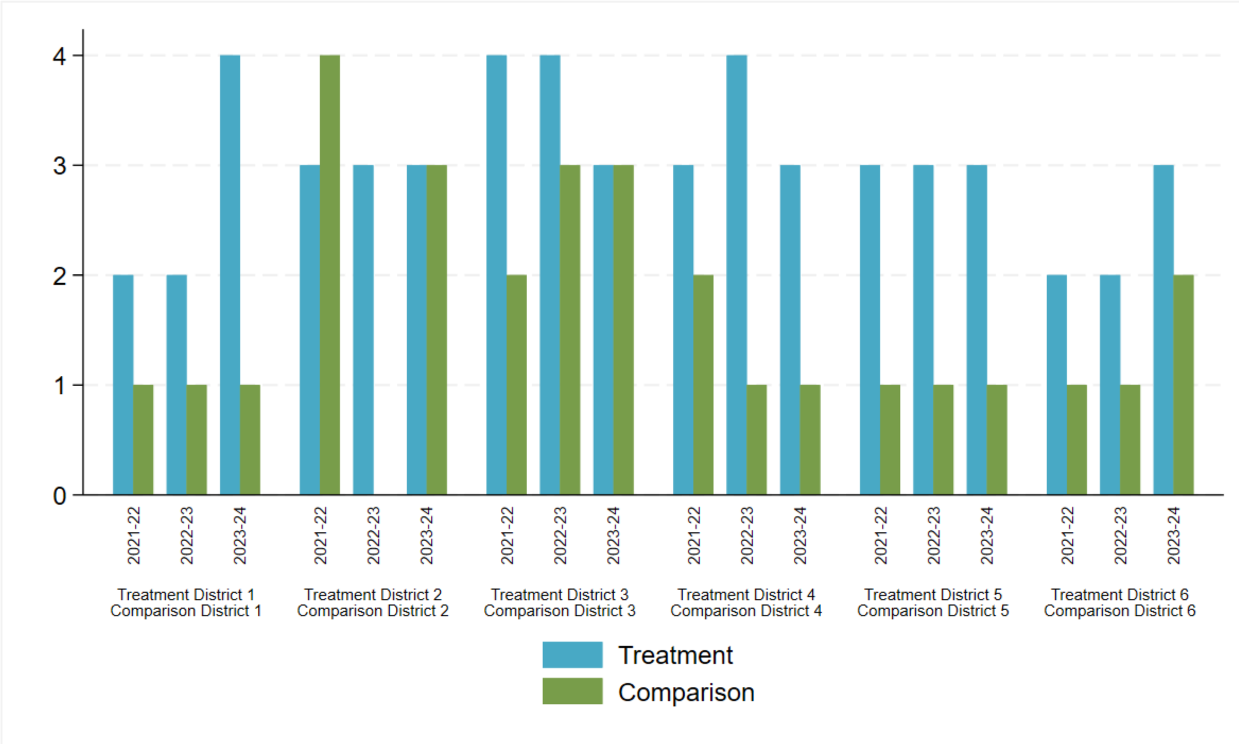
Exhibit C.20: "Extent to which equity strategies are employed to support interest and persistence in CS among traditionally underrepresented student groups?"



Answers:

4 = To a great extent (Goals have been reached and strategies and well-established)
3 = Somewhat (Steps have been taken and are continuing)
2 = A little (Planning is underway but few or no actions have been taken)
1 = Not at all (Nothing is planned or underway)

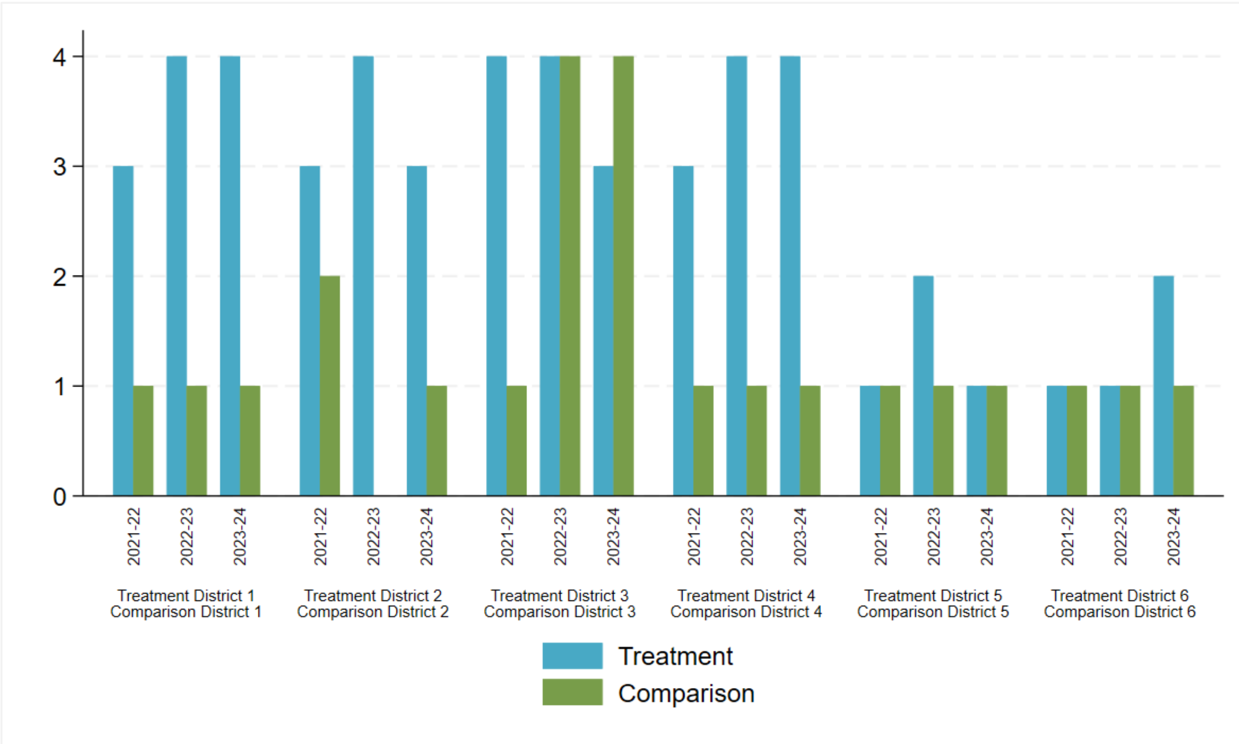
Exhibit C.21: "Extent to which implementation of inclusive CS pathway planning occurs?"



Answers:

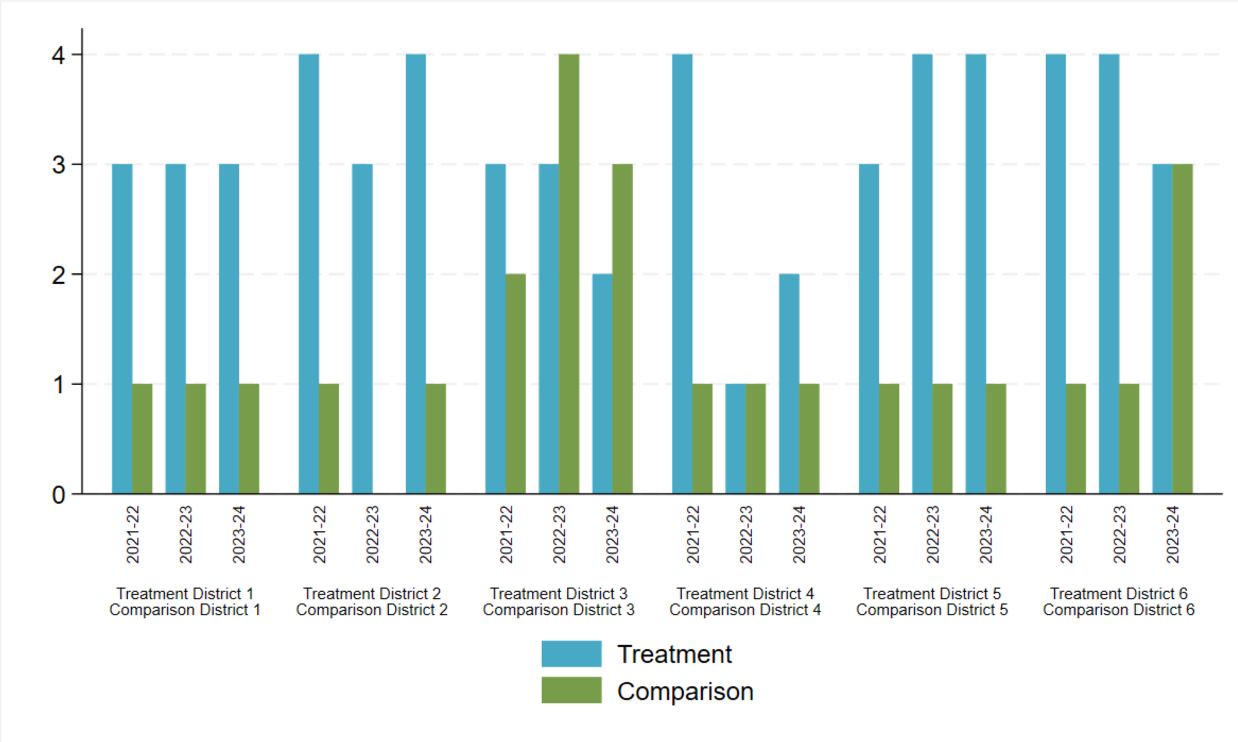
4 = To a great extent (Goals have been reached and strategies and well-established)
3 = Somewhat (Steps have been taken and are continuing)
2 = A little (Planning is underway but few or no actions have been taken)
1 = Not at all (Nothing is planned or underway)

Exhibit C.22: "Extent to which CS is provided in sequential middle-school years at a minimum of 75 instructional hours per year?"



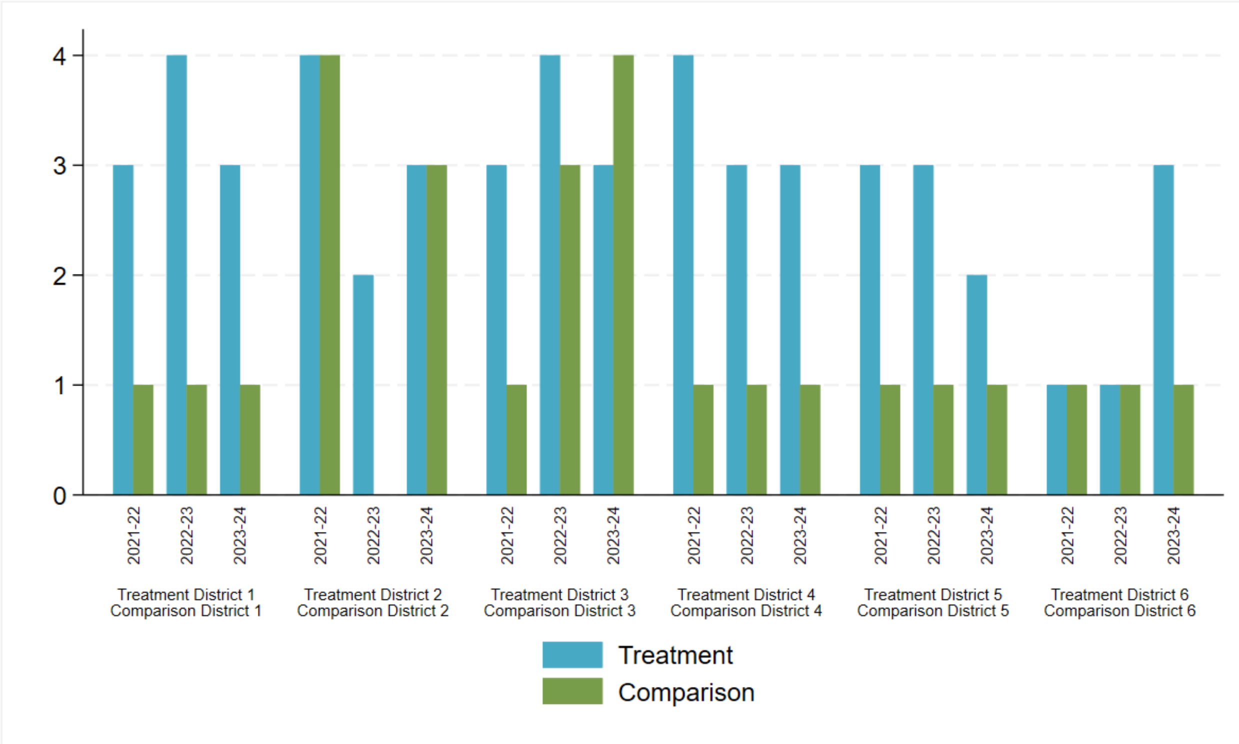
Answers:
4 = To a great extent (Goals have been reached and strategies and well-established)
3 = Somewhat (Steps have been taken and are continuing)
2 = A little (Planning is underway but few or no actions have been taken)
1 = Not at all (Nothing is planned or underway)

Exhibit C.23: "Extent to which there is a district-level CS taskforce that includes representation from major stakeholder groups?"



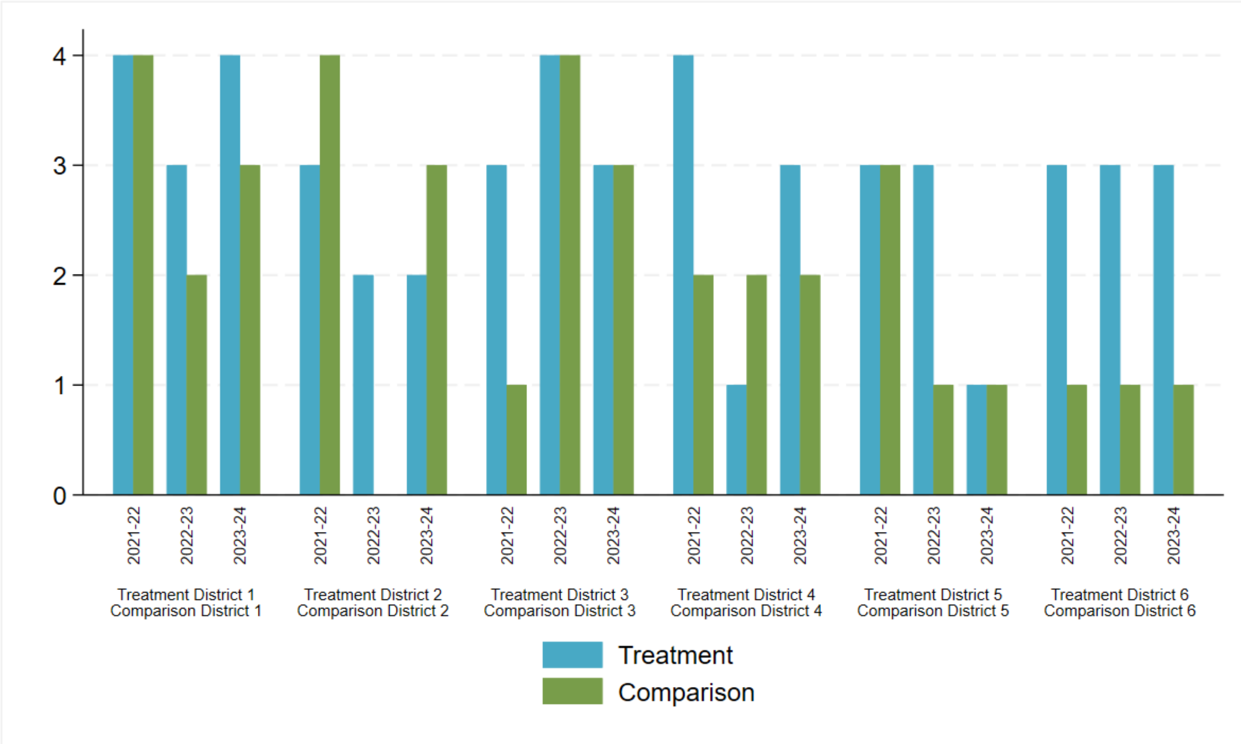
Answers:
4 = To a great extent (Goals have been reached and strategies and well-established)
3 = Somewhat (Steps have been taken and are continuing)
2 = A little (Planning is underway but few or no actions have been taken)
1 = Not at all (Nothing is planned or underway)

Exhibit C.24: "Extent to which CS pathways are integrated with district strategic plan?"



Answers:
- 4 = To a great extent (Goals have been reached and strategies and well-established)
- 3 = Somewhat (Steps have been taken and are continuing)
- 2 = A little (Planning is underway but few or no actions have been taken)
- 1 = Not at all (Nothing is planned or underway)

Exhibit C.25: "Extent to which information/technology specialists support CS teachers?"



Answers:
4 = To a great extent (Goals have been reached and strategies and well-established)
3 = Somewhat (Steps have been taken and are continuing)
2 = A little (Planning is underway but few or no actions have been taken)
1 = Not at all (Nothing is planned or underway)

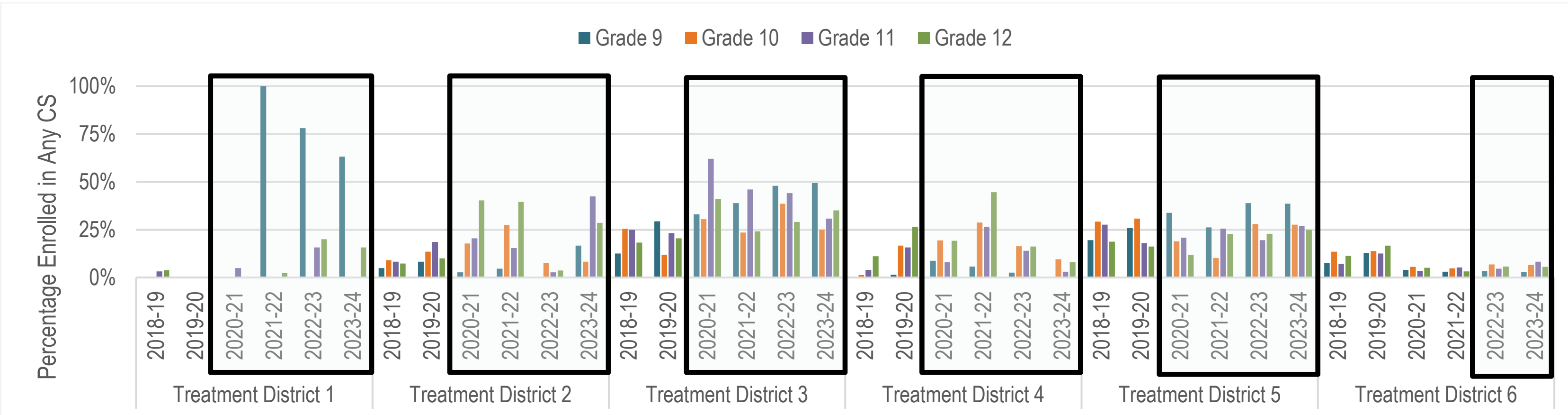
Appendix D. Course Enrollment in High School Grades

Among the district-level mediators in the PACE logic model is establishment of a CS course sequence in middle school "that has potential to lead into a high school CS pathway" (Exhibit 1.1). This appendix repeats the analysis of course enrollment that appears using middle school grades in Section 3.3, but instead focuses on high school grades. In doing so, it explores whether district-level changes in attitude towards CS instruction were apparent via high school enrollment in CS.

Although the high school students included in this analysis did not receive *CS Discoveries* in middle school, systematic changes to their enrollment rates would be additional evidence of district-level changes to CS instruction. As such, Exhibits D.1 and D.2 repeat the tabulations that appeared in Section 3.3 of the report, but for grades 9 through 12.

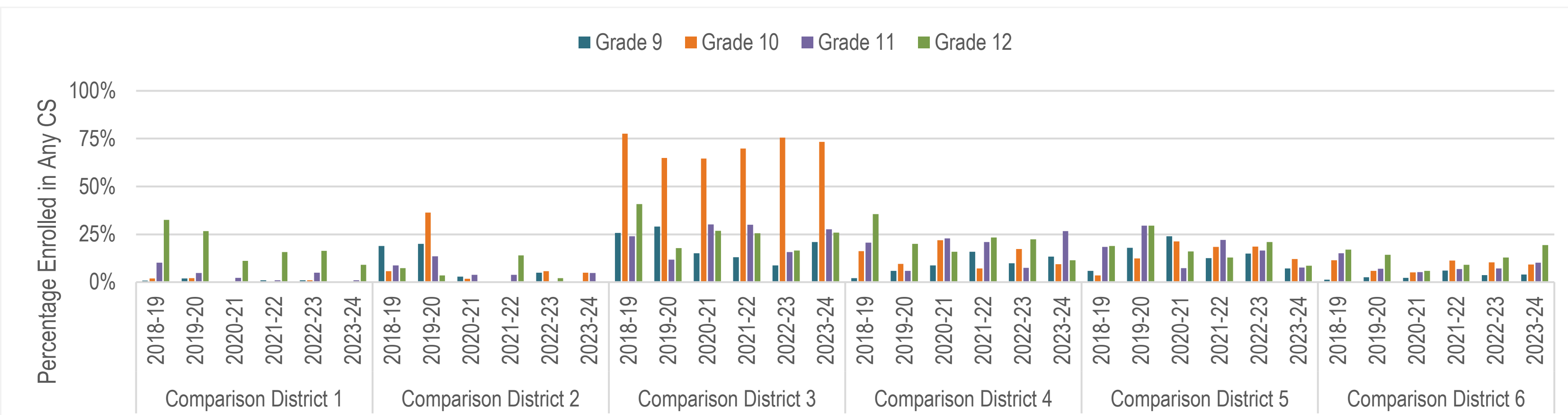
In general, the patterns in Exhibits D.1 and D.2 show varying degrees of CS enrollment in high school across districts. There do not appear to be systemic changes in CS enrollment in high school in either treatment or comparison districts. However, some of the treatment districts demonstrate a slight upward trend in CS enrollment in high school during the implementation period, though specific grades vary across districts. There do not appear to be any changes to CS enrollment in high school in comparison districts.

Exhibit D.1: Percentage enrollment in any "Computer and Information Science" course by grade in PACE districts (high school)



Notes: The exhibit shows the percentage of students enrolled in any course identified by DESE as "Computer and Information Sciences" separately for grades 9-12 across SYs 2018-19 – 2023-24. Black boxes indicate years of PACE implementation.

Exhibit D.2: Percentage enrollment in any "Computer & Information Science" course by grade in comparison districts (high school)



Notes: The exhibit shows the percentage of students enrolled in any course identified by DESE as "Computer and Information Sciences" separately for grades 9-12 across SYs 2018-19 – 2023-24. Comparison districts appear in Exhibit D.2 such that their position corresponds to their matched treatment district in Exhibit D.1.

Appendix E. Impact Study Design Supplemental Details

This appendix provides additional information about the impact study design, including the district matching process and statistical models for impact analyses and assessment of baseline equivalence.

Matching Process

From the pool of districts in Massachusetts not implementing PACE, the evaluation team identified a set of potential comparison districts for each treatment district. Using district-level data, each treatment district was matched to a comparison district with the **same** NCES urbanicity definition, the **same** middle school configuration, and **similar** baseline characteristics. The steps involved in this matching process were as follows:

1. **Model the likelihood of participating in the PACE evaluation for all potential comparison districts using student and district characteristics.** First, Abt estimated a logit model using the entire population of districts in Massachusetts, where the likelihood of participating in the PACE intervention was modeled as a function of the following baseline characteristics:

    - *Prior district MCAS aggregate math scores* – These data were used to match academic achievement in treatment and comparison districts. Baseline MCAS data for matching treatment districts to comparison districts came from district-level MCAS scores from Spring 2021 (for students that began receiving the PACE intervention in Fall 2021) and Spring 2022 (for students that began receiving the PACE intervention in Fall 2022).

    - *District size* – These data were used to match districts with similar resources. The measures of district size used in this model included the number of middle schools in the district and the total number of students in the initial implementation grade.

    - *Key student characteristics* – These data were used to match districts with similar student demographic and socioeconomic backgrounds. These characteristics include the total number of students in the district and the percentage of students in the following categories that are traditionally underrepresented in computer science fields: girls; students from underrepresented racial/ethnic groups; English learners; students with disabilities; and students defined as economically disadvantaged.[29]

2. **Use the prediction model to estimate a propensity score for all districts participating in PACE and all potential comparison districts.** Abt generated a predicted probability of participating in PACE (referred to as a "propensity score") from the logit model for each potential comparison district.

3. **Stratify potential comparison districts by urbanicity and middle school configuration**. To ensure that matched districts had the same urbanicity and middle school configuration, Abt stratified the population of comparison districts by the categories of these two variables. Urbanicity is defined based on a set of four categories established by the National Center for

[29] "Economically disadvantaged" is based on a student's participation in one or more of the following state-administered programs: Supplemental Nutrition Assistance Program (SNAP); Transitional Aid to Families with Dependent Children (TAFDC); Massachusetts Department of Children and Families' foster care program; and MassHealth, the state's Medicaid program (DESE, 2024b).

Education Statistics—city, suburban, town, and rural. Middle school configuration refers to the grades of students served by the school (e.g., grades 6–8).

4. **Within each stratum, generate a list of five potential comparison districts for each treatment district.** Abt selected five potential comparison districts for each treatment district. Comparison districts were *required* to have the same urbanicity and middle school configuration as the treatment district. Within those strata, the propensity score was used to generate a short list of matches, keeping only the comparison districts with a propensity score that was close in proximity to the propensity score for the treatment district. Within this filtered list, Abt selected five comparison districts, with a goal of choosing districts that were similar to the treatment district on three key baseline characteristics: MCAS math scaled score, proportion of students classified as economically disadvantaged, and total enrollment in grades 6–8.

Once a set of five potential comparison districts was identified for each participating treatment district, the lists were delivered to the PACE team, which managed recruitment for the study. The PACE team then reached out to comparison districts to inquire about their willingness to participate in the study, which involved completing an annual District Infrastructure Survey. A total of six comparison districts agreed to participate.

Statistical Models

This section discusses three separate types of statistical models that were estimated as part of the impact study: the impact analysis model, the baseline equivalence model, and the subgroup analysis model.

Impact Analysis

The regression model used for the main impact analysis is a two-level hierarchical linear model estimated at the cluster-level (level 2, districts). The left-hand side of the equation is any of the outcomes in this study. The right-hand side includes a set of baseline student-level covariates (standardized baseline MCAS math scaled score, sex, race/ethnicity, student disability, English learner status, and a measure of low income), an indicator for treatment-status (which takes on a value of 1 for treatment districts and a value of 0 for comparison districts), and indicators for each "block" of matched treatment and comparison districts.

The statistical model for the impact analysis is as follows:

Level-1: Student Level

$$Y_{ij} = \beta_{0j} + \beta_{1j}\left(Y_{ij}^{*}\right) + \sum_{k=1}^{K} \beta_{2.kj} X_{kij} + \epsilon_{ij}$$

Level-2: Cluster (District) Level

$$\beta_{0j} = \gamma_{00} + \sum_{p=1}^{P-1} \gamma_{01.p}\, MBlock_{pj} + \gamma_{02.p} T_j + \mu_{0j}$$

$$\beta_{1j} = \gamma_{10}$$

$$\beta_{2.kj} = \gamma_{2.k0}$$

where,

Y_{ij} = the outcome for student i in district j

β_{0j} = the intercept for district j

β_{1j} = the relationship between the baseline MCAS mathematics scaled score and the outcome for student i in district j

Y_{ij}^{*} = the baseline MCAS mathematics scaled score for student i in district j

$\beta_{2.kj}$ = the relationship between student covariate k and the outcome in district j

X_{kij} = the k^{th} covariate of K baseline covariates for student i in district j

ϵ_{ij} = the residual error term for student i in district j

γ_{00} = fixed intercept for district j

$\gamma_{01.p}$ = the difference between the mean of the omitted block and the mean of district block p

$MBlock_{pj}$ = 1 if district j is in district matching block p

$\gamma_{02.p}$ = the effect of treatment on the outcome

T_j = 1 if district j is a treatment district and 0 if district j is a comparison district

μ_{0j} = residual error term for district j

γ_{10} = mean relationship between the baseline MCAS mathematics scaled score and the outcome

$\gamma_{2.k0}$ = mean relationship between student covariate k and the outcome

This statistical model is slightly modified from the pre-registered analysis plan. The pre-registered analysis plan included three district-level covariates in the analytic model: district urbanicity, number of middle schools in the district, and total number of students enrolled in the district. Abt excluded these covariates from the analysis because of the small number of districts in the analytic sample.

Baseline Equivalence

The statistical model for assessing baseline equivalence uses a modified version of the statistical model for the impact analysis where the baseline MCAS math scaled score is moved to the left-hand side of the model and all other baseline covariates are omitted:

Level-1: Student Level

$$Z_{ij} = \beta_{0j} + \epsilon_{ij}$$

Level-2: Cluster (District) Level

$$\beta_{0j} = \gamma_{00} + \sum_{p=1}^{P-1} \gamma_{01.p}\, MBlock_{pj} + \gamma_{02.p} T_j + \mu_{0j}$$

where,

Z_i = standardized MCAS math score for student *i* in district *j*

and all other variables are defined in the same manner as for the impact model.

Subgroup Analysis

Appendix F includes the results from two subgroup analyses. The statistical model for subgroup analysis alters the overall impact analysis model by including an interaction between the indicator for treatment and the subgroup variable of interest, as follows:

Level-1: Student Level

$$Y_{ij} = \beta_{0j} + \beta_{1j}(Y_{ij}^{*}) + \sum_{q=1}^{Q} \beta_{2.qj} X_{qij} + \sum_{g=1}^{G-1} \beta_{4.gj}\left(T_{ij} \times 1\{S_{ij} = g\}\right) + \epsilon_{ij}$$

Level-2: Cluster (District) Level

$$\beta_{0j} = \gamma_{00} + \sum_{p=1}^{P-1} \gamma_{01.p}\, MBlock_{pj} + \gamma_{02.p} T_j + \mu_{0j}$$

$$\beta_{1j} = \gamma_{10}$$

$$\beta_{2.qj} = \gamma_{2.q0}$$

$$\beta_{4.gj} = \gamma_{4.g0}$$

where,

$\beta_{4.gj}$ = the treatment effect for individuals in group *g* as defined by subgroup variable S_{ij} (where subgroup variable S_{ij} has a total of *G* unique categories)

$1\{S_{ij} = g\}$ = 1 if subgroup variable S takes on a value of g for student *i* in district *j*

$\gamma_{4.g0}$ = mean treatment effect for subgroup *g*

and all other variables are defined in the same manner as for the impact model.

This statistical model is slightly modified from the pre-registered analysis plan. The pre-registered analysis plan included three district-level covariates in the analytic model: district urbanicity, number of middle schools in the district, and total number of students enrolled in the district. Abt excluded these covariates from the analysis because of the small number of districts in the analytic sample.

Effect Size Calculations for Baseline Equivalence and Impact Estimation

Appendix F reports effect sizes as part of both the assessment of baseline equivalence and the magnitude of the impact estimate. Reported effect sizes were calculated as Hedges' g for the difference between treatment and comparison districts using the following formula (What Works Clearinghouse, 2022, pp. 170–171):

$$g = \frac{\omega b}{SD_p}\sqrt{\gamma}$$

The components of this calculation are defined as follows:

- ω is the small-sample correction, defined as $\omega = 1 - \dfrac{3}{4df - 1}$

and

$$df = \frac{\left[(N-2) - 2\left(\frac{N}{M} - 1\right)\rho_{ICC}\right]^2}{(N-2)(1-\rho_{ICC})^2 + \frac{N}{M}\left(N - 2\frac{N}{M}\right)\rho_{ICC}^2 + 2\left(N - 2\frac{N}{M}\right)\rho_{ICC}(1 - \rho_{ICC})}$$

where,

- ρ_{ICC} is the intra-cluster correlation, calculated using the restricted maximum likelihood estimation method with degrees of freedom adjusted using the Kenward-Rogers adjustment (McNeish, 2017).
- N is the total analytic sample size
- M is the total number of districts
- b is the unstandardized mean difference in outcomes between the treatment and comparison districts
- SD_p is the pooled standard deviation, defined as:

$$SD_p = \sqrt{\frac{(n_i - 1)SD_i^2 + (n_c - 1)SD_c^2}{n_i + n_c - 2}}$$

- $\sqrt{\gamma}$ is the small number of districts correction, defined as

$$\sqrt{\gamma} = \sqrt{1 - \frac{2\left(\frac{N}{M} - 1\right)\rho_{ICC}}{N-2}}$$

Appendix F. Impact Study Supplemental Tables

This appendix presents impact tables for the results of the impact study, including the assessment of baseline equivalence, and the impact of the PACE intervention on confirmatory and exploratory outcomes.

How to Read Impact Tables

This appendix consists of tables that follow the format shown below. For each outcome measure, its table reports sample sizes, means, and unadjusted standard deviations (SDs) for the treatment and comparison groups.

The four right-most columns in the table provide the evidence the evaluation team used to assess (1) whether PACE was effective and (2) the magnitude of that effectiveness. The "**Impact**" column reports the estimate of the mean difference in outcome measure between the treatment and comparison groups, as estimated via the impact analysis model, along with stars indicating its statistical significance. The "**Standard Error**" column reports the estimated error of the impact estimate, which is used to calculate statistical significance. When the impact is denoted as statistically significant, the difference between treatment and comparison means can be confidently attributed to implementation of the PACE intervention. The "**Effect Size**" column reports Hedges' *g* (Hedges, 2007) using the pooled unadjusted standard deviation of each outcome. The last column in the table reports the ***p*-value** associated with the coefficient from the impact analysis model.

Mock Exhibit. Impact analysis

Outcome Measure	Comparison Group				Treatment Group				Impact	Standard Error	Effect Size[3]	p-Value
	Sample Size		Mean[1]	SD[1]	Sample Size		Model-Adjusted Mean[2]	SD[2]				
	# Clusters	# Students			# Clusters	# Students						
Geometry	6	755	6.72	4.13	6	820	7.25	3.78	0.54	0.89	0.13	.57

[1] Reported comparison group mean and standard deviation (SD) are unadjusted.
[2] Reported treatment group mean is calculated as unadjusted comparison group mean + (treatment − comparison difference), which comes from analytic model. Reported treatment group standard deviation is unadjusted.
[3] Effect size is an estimate of Hedges' *g* using the pooled unadjusted standard deviation of each outcome.
Note: Statistical significance indicated with asterisks as follows: * denotes $p<.05$; ** denotes $p<.01$.

Baseline Equivalence

Exhibit F.1 reports the results of the baseline equivalence assessment. The exhibit assesses baseline equivalence using the baseline MCAS math score, which has been standardized using grade-level means and standard deviations. This standardization is necessary because the baseline is measured at different grades for students in different districts.

Exhibit F.1. Baseline equivalence assessment

Baseline Measure	Comparison Group				Treatment Group				Impact	Standard Error	Effect Size[3]	p-Value
	Sample Size		Mean[1]	SD[1]	Sample Size		Model-Adjusted Mean[2]	SD[2]				
	# Clusters	# Students			# Clusters	# Students						
MCAS Math scaled score, z-scored	6	755	−0.02	1.08	6	820	−0.05	0.98	−0.03	0.09	−0.02	.79

[1] Reported comparison group mean and standard deviation (SD) are unadjusted.

[2] Reported treatment group mean is calculated as unadjusted comparison group mean + (treatment − comparison difference), which comes from analytic model. Reported treatment group standard deviation is unadjusted.

[3] Effect size is an estimate of Hedges' *g* using the pooled unadjusted standard deviation of each outcome.

Note: Statistical significance indicated with asterisks as follows: * denotes *p*<.05; ** denotes *p*<.01.

PACE Impacts

This section reports additional findings for confirmatory, exploratory, and subgroup analyses. Of note, the analytic model in the pre-registered analysis plan included three district-level covariates: an indicator for urbanicity, the total number of middle schools in the district, and the total number of students enrolled in the district. Given the small number of districts in the analytic sample (12), Abt did not include these district-level covariates in the analysis.

Confirmatory Outcomes

Exhibit F.2. Impact analysis for confirmatory student achievement outcomes

Outcome Measure	Comparison Group				Treatment Group				Impact	Standard Error	Effect Size[3]	p-Value
	Sample Size		Mean[1]	SD[1]	Sample Size		Model-Adjusted Mean[2]	SD[2]				
	# Clusters	# Students			# Clusters	# Students						
Geometry	6	755	6.72	4.13	6	820	7.25	3.78	0.54	0.89	0.13	.57
Life Sciences	6	755	7.46	3.04	6	820	7.51	2.97	0.05	0.43	0.02	.92

[1] Reported comparison group mean and standard deviation (SD) are unadjusted.

[2] Reported treatment group mean is calculated as unadjusted comparison group mean + (treatment − comparison difference), which comes from analytic model. Reported treatment group standard deviation is unadjusted.

[3] Effect size is an estimate of Hedges' *g* using the pooled unadjusted standard deviation of each outcome.

Note: Statistical significance indicated with asterisks as follows: * denotes *p*<.05; ** denotes *p*<.01.

Exploratory Outcomes

Exhibit F.3. Impact analysis for exploratory student achievement outcomes

Outcome Measure	Comparison Group				Treatment Group				Impact	Standard Error	Effect Size[3]	p-Value
	Sample Size		Mean[1]	SD[1]	Sample Size		Model-Adjusted Mean[2]	SD[2]				
	# Clusters	# Students			# Clusters	# Students						
Number system and expressions/ equations	6	755	9.16	5.04	6	820	9.32	5.03	0.16	0.73	0.03	.83
Fractions	6	755	5.01	2.86	6	820	5.32	2.76	0.31	0.39	0.11	.47
Statistics and probability	6	755	4.82	2.04	6	820	5.02	2.08	0.20	0.33	0.09	.58
Earth/space sciences	6	755	6.58	3.01	6	820	6.83	2.92	0.25	0.27	0.08	.40
Physical sciences	6	755	6.74	3.04	6	820	6.80	2.92	0.06	0.46	0.02	.90
Technology and engineering	6	755	7.38	2.91	6	820	7.38	2.81	0.00	0.24	0.00	.99
Scaled Score: Math	6	755	490.42	22.91	6	819	492.68	21.95	2.26	3.87	0.10	.58
Scaled Score: Science	6	755	493.91	23.19	6	813	494.92	21.99	1.01	2.73	0.04	.73

[1] Reported comparison group mean and standard deviation (SD) are unadjusted.
[2] Reported treatment group mean is calculated as unadjusted comparison group mean + (treatment − comparison difference), which comes from analytic model. Reported treatment group standard deviation is unadjusted.
[3] Effect size is an estimate of Hedges' *g* using the pooled unadjusted standard deviation of each outcome.
Note: Statistical significance indicated with asterisks as follows: * denotes $p<.05$; ** denotes $p<.01$.

Subgroup Analysis

Exhibits F.4 and F.5 report the results of two separate subgroup analyses. The first, reported in Exhibit F.4, explores whether the impact of the PACE intervention varied by student sex. The second, reported in Exhibit F.5, explores whether the impact of the PACE intervention varied by district cohort, differentiating three cohorts:

- Cohort 1a began implementing the PACE intervention in SY 2020-21 and began *CS Discoveries* in grade 7.
- Cohort 1b began implementing the PACE intervention in SY 2020-21 and began *CS Discoveries* in grade 6.
- Cohort 2 began implementing the PACE intervention in SY 2022-23.

The study found that both boys and girls experienced impacts of a similar magnitude in both geometry and life sciences, with no evidence of a difference between the groups. As with student sex, the study found no evidence that the impact of the PACE intervention varied by district cohort.

Exhibit F.4. Subgroup analysis by sex for confirmatory student achievement outcomes

Subgroup	Comparison Group		Treatment Group		Impact	*p*-Value
	# Students	Mean	# Students	Mean		
Geometry						
Male	421	6.54	454	7.05	0.50	
Female	331	6.94	365	7.61	0.68	
Statistical test for difference in impacts between subgroups					0.17	.33
Life Sciences						
Male	421	7.43	454	7.36	−0.06	
Female	331	7.50	365	7.56	0.06	
Statistical test for difference in impacts between subgroups					0.12	.45

Notes: Reported comparison group mean is unadjusted; reported treatment group mean is calculated as unadjusted comparison group mean + impact (from analytic model).
Statistical significance on test for difference in impacts between subgroups indicated with asterisks as follows: * denotes p<.05; ** denotes p<.01.

Exhibit F.5. Subgroup analysis by cohort for confirmatory student achievement outcomes

Subgroup	Control Group		Treatment Group		Impact	*p*-Value
	# Students	Mean	# Students	Mean		
Geometry						
Cohort 1a	265	7.46	167	6.85	−0.62	
Cohort 1b	194	5.68	259	5.40	−0.28	
Cohort 2	296	6.73	394	5.88	−0.84	
Statistical test for difference in impacts between Cohort 1a and Cohort 1b					0.33	.83
Statistical test for difference in impacts between Cohort 1b and Cohort 2					0.56	.75
Statistical test for difference in impacts between Cohort 1a and Cohort 2					0.23	.89
Life Sciences						
Cohort 1a	265	7.22	167	7.45	0.23	
Cohort 1b	194	7.51	259	7.81	0.30	
Cohort 2	296	7.64	394	7.43	−0.21	
Statistical test for difference in impacts between Cohort 1a and Cohort 1b					0.07	.94
Statistical test for difference in impacts between Cohort 1b and Cohort 2					0.51	.61
Statistical test for difference in impacts between Cohort 1a and Cohort 2					0.44	.66

Notes: Reported comparison group mean is unadjusted; reported treatment group mean is calculated as unadjusted comparison group mean + impact (from analytic model).
Statistical significance on test for difference in impacts between subgroups indicated with asterisks as follows: * denotes p<.05; ** denotes p<.01.

References

Bort, H., Guha, S., & Brylow, D. (2018). The Impact of Exploring Computer Science in Wisconsin: Where Disadvantage is an Advantage. In *Proceedings of the 23rd Annual ACM Conference on Innovation and Technology in Computer Science Education* (pp. 57–62). New York: Association for Computing Machinery. https://doi.org/10.1145/3197091.3197140

DESE [Massachusetts Department of Elementary and Secondary Education]. (2016). *Digital Literacy and Computer Science: Grades Kindergarten to 12.* Available at: https://www.doe.mass.edu/frameworks/dlcs.pdf.

DESE [Massachusetts Department of Elementary and Secondary Education]. (2022). *2021 Next-Generation MCAS and MCAS-Alt Technical Report.* https://www.doe.mass.edu/mcas/tech/2021-nextgen-tech-report.pdf.

DESE [Massachusetts Department of Elementary and Secondary Education]. (2023). *2022 Next-Generation MCAS and MCAS-Alt Technical Report.* https://www.doe.mass.edu/mcas/tech/2022-nextgen-tech-report.pdf.

DESE [Massachusetts Department of Elementary and Secondary Education]. (2024a). *Release of Spring 2024 MCAS Test Information from the Grade 8 Mathematics Test.* https://www.doe.mass.edu/mcas/2024/release/g8-math.pdf

DESE [Massachusetts Department of Elementary and Secondary Education]. (2024b). *Researcher's Guide to Massachusetts State Education Data*. Available at: https://www.doe.mass.edu/research/researchers.html.

DESE [Massachusetts Department of Elementary and Secondary Education]. (2024c). *Student Course Schedule (SCS) Data Handbook – Version 9.3.* Available at: https://www.doe.mass.edu/infoservices/data/scs/.

DESE [Massachusetts Department of Elementary and Secondary Education]. (2024d). *2023 Next-Generation MCAS and MCAS-Alt Technical Report.* https://www.doe.mass.edu/mcas/tech/2023-nextgen-tech-report.pdf.

Hedges, L. V. (2007). Effect sizes in cluster-randomized designs. *Journal of Educational and Behavioral Statistics*, *32*(4), 341-370. https://doi.org/10.3102/1076998606298043

McGee, S., Greenberg, R. I., McGee-Tekula, R., Duck, J., Rasmussen, A. M., Dettori, L., & Reed, D. F. (2019). An Examination of the Correlation of Exploring Computer Science Course Performance and the Development of Programming Expertise. In Proceedings of the 50th ACM Technical Symposium on Computer Science Education (pp. 1067–1073). New York: Association for Computing Machinery. https://doi.org/10.1145/3287324.3287415

McGee, S., McGee-Tekula, R., Duck, J., McGee, C., Dettori, L., Greenberg, R. I., … & Brylow, D. (2018). Equal Outcomes 4 All: A Study of Student Learning in ECS. In *Proceedings of the 49th ACM Technical Symposium on Computer Science Education* (pp. 50–55). New York: Association for Computing Machinery. https://doi.org/10.1145/3159450.3159529

What Works Clearinghouse. (2022). *What Works Clearinghouse Procedures and Standards Handbook, Version 5.0.* Washington, DC: Institute of Education Sciences, National Center for Education Evaluation and Regional Assistance, U.S. Department of Education. https://ies.ed.gov/ncee/wwc/Handbooks

What Works Clearinghouse. (2024). *What Works Clearinghouse Study Review Protocol and Supplement to the* What Works Clearinghouse Procedures and Standards Handbook, Version 5.0*, Version 5.1.* Washington, DC: Institute of Education Sciences, National Center for Education Evaluation and Regional Assistance, U.S. Department of Education. https://ies.ed.gov/ncee/wwc/Document/1297#/Protocol_CurrentProtocol