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2020-2025 RESEARCH and EVALUATION REPORT

Pathways for Alabama Computer Science

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Haynie Research and Evaluation

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We would like to offer a special thank you to the PACS Team,
Leaders, Facilitators, Teachers, Counselors, Coaches, and Students
For being part of this excellent program in these past six years

Table of Contents

0. Executive Summary

The Pathways for Alabama Computer Science (PACS) initiative has transformed access to high-quality computer science education in Alabama's rural and high-need high schools. Established in 2020 through a partnership between the Alabama State Department of Education, The University of Alabama, Tuskegee University, and the Alabama Math, Science, and Technology Initiative (AMSTI), PACS set out to expand rigorous CS pathways and engage students from historically underrepresented backgrounds in STEM. Through a combination of professional development for teachers and counselors, annual statewide CSPdWeek gatherings, and year-round support from regional in-service centers, PACS built sustainable capacity for schools to implement a three-course computer science sequence—Exploring Computer Science, Bootstrap Algebra, and AP Computer Science Principles. Over five years, PACS reached more than 400 teachers and counselors, creating a durable professional community and providing rural students with new opportunities to build computational thinking skills, strengthen mathematics learning, and explore computing careers.

Two complementary impact studies provided rigorous evidence of PACS's effectiveness in rural Alabama schools. A Comparative Interrupted Time Series (CITS) study used statewide ACT data to compare math and science outcomes for students in 29 PACS schools against 60 similar schools, showing how integrated CS pathways can influence academic achievement. A second Quasi-Experimental Design (QED) study followed a cohort of over 1,700 students across three years, examining computational thinking, algebra skills, CS attitudes, career interest, and AP CSP exam performance. Together, these studies demonstrated that PACS not only strengthened math and science achievement but also improved student engagement, confidence, and interest in CS-STEM pathways, underscoring its potential to reduce opportunity gaps in Alabama's rural communities. Professional development for teachers and counselors, supported by school-level communities of practice, is linked to expanded CS pathways in rural Alabama high schools. As a result, students impacts include computational thinking and algebraic problem-solving skills, stronger math achievement, and increased interest in CS-STEM courses, careers, and higher education.

0.1. Impact Evaluation

The PACS initiative employed two complementary studies to evaluate its impact in rural Alabama high schools: a Comparative Interrupted Time Series (CITS) analysis of school-level ACT scores and a Quasi-Experimental Design (QED) tracking student-level outcomes across three years following a single student cohort drawn from 29 PACS "Pathway" schools. Together, these studies offer a rigorous, multi-angle view of how a schoolwide CS pathway can build both build computational thinking and increase students' interest and confidence in rural settings.

Comparative Interrupted Time Series Impact Study 1 School-level Results.

PACS's first impact study examined ACT Math and Science trends across five years (2019–2024) in 29 PACS Pathway schools and 82 matched comparison schools. Despite implementation of ECS (Grade 9), Bootstrap Algebra (Grade 10), and AP CSP (Grade 11), no measurable gains were detected in Math ACT scores (Research Question 4 = RQ4) or Science ACT scores (Exploratory Question 10 = EQ10). In fact, comparison schools showed modest post-pandemic recovery while PACS schools remained flat or declined slightly. However, these results should be interpreted with caution. The ACT Math test is not fully aligned to the computational thinking skills emphasized by PACS; the ACT Science test, though requiring analytical is not directly aligned with the computational thinking skills emphasized by PACS. While the findings do not suggest academic transfer effects for ACT Math or Science tests, they also do not preclude gains in problem-solving or computational thinking not captured by this standardized test.

Quasi-Experimental Design Impact Study 2 Student-level Results.

The second study followed a single cohort of students (N=~1,300) from 9th to 11th grade in 38 schools, comparing outcomes between PACS and non-PACS sites. Key findings for students' computational thinking and problem-solving included:

- **RQ1**: *Computational Thinking in Grade 9*: After one year, students in PACS schools significantly outperformed peers (Hedges' g = .27)
- **RQ3**: *Algebra Proficiency in Grade 10*: Students in PACS schools significantly outperformed peers, suggesting early academic benefits (Hedges' g = 0.27)
- **RQ2**: *Computational Thinking in Grade 11*: After three years, students in PACS schools significantly outperformed peers (Hedges' g = 0.23), supporting the theory that cumulative exposure builds stronger skills.
- **EQ9**: *AP CSP Exam Participation*: PACS students were more likely to take the AP CSP exam than peers (66% vs. 44%), though qualifying rates were similar.

Attitude and Career Outcomes.

- **EQ5–EQ6**: Student attitudes toward CS (belonging, encouragement, interest, confidence) remained relatively stable. PACS students reported higher scores overall, but changes over time were generally comparable across groups.

- **EQ7–EQ8**: Students' interest in computing careers remained moderately positive but did not significantly increase in PACS schools. Both short-term (9th grade) and long-term (11th grade) analyses found similar patterns in treatment and control groups.

PACS Students Show Consistent Gains in Computational Thinking, Algebra, and AP Exam Participation—While Career Outcomes Remain Unchanged

Across a set of rigorous experimental and quasi-experimental studies, the Pathways for Alabama Computer Science initiative demonstrated meaningful impacts on student learning—especially in the program's core domain of computational thinking. Of the six research questions addressed in this multi-year evaluation, five were tested using experimental designs, underscoring the robustness of findings. Since its inception, the primary goal of PACS has been to expand and deepen students' computational thinking skills, and the evidence confirms success on that front. Students in PACS-trained schools (i.e., Pathway schools) significantly outperformed peers in computational thinking at both the 9th grade (Hedges' $g = 0.27$) and 11th grade ($g = 0.23$), with gains persisting and compounding over time. In 10th grade, students also showed significantly higher algebra proficiency ($g = 0.27$), reinforcing the academic value of PACS's math-integrated approaches.

Students' growing sense of competence and readiness appears to have translated into action: PACS students were substantially more likely to take the AP Computer Science Principles exam than their peers in non-PACS schools (66% vs. 44%). This difference—while not tied to higher qualification rates—reflects an important behavioral marker of confidence and academic self-efficacy. In other words, PACS students were more likely to "go for it," signaling a shift from passive exposure to active engagement in advanced computing opportunities.

However, attitudinal outcomes—including belonging, encouragement, interest, confidence, and career aspirations—did not show significant shifts relative to business-as-usual schools, despite generally higher starting points for PACS students. This pattern likely reflects the nature of implementation: early years emphasized schoolwide exposure over direct ECS enrollment. The ACT-based Math and Science measures, used with 11th graders, were not tightly aligned with computational thinking constructs, and showed no differential effect for PACS schools.

Taken together, these impact study findings suggest that PACS has moved the needle on computational thinking, algebra proficiency, and AP exam-taking—especially when students engage across multiple years in their school's CS Pathway. However, changes in broader academic outcomes and career interest remain elusive, highlighting the need for deeper, more personalized engagement strategies. As implementation deepens and more students progress through the full PACS sequence, continued monitoring will be essential to capture delayed or cumulative impacts.

0.2. Evaluation of Implementation Fidelity, 2020-2025

Over the past six years, the Pathways for Alabama Computer Science initiative has fundamentally expanded computer science education in rural Alabama. Launched in 2020 amidst the COVID-19 pandemic, PACS introduced five professional development strands: Exploring Computer Science (2020-2025), Bootstrap Algebra (2020-2024), Bootstrap Data Science (2025), AP Computer Science Principles (2020-2024), and Counselors for Computing (2020-2025). These programs emphasized equity, inquiry-based instruction, and sustained educator support.

More than 400 Alabama educators and counselors have participated in PACS PD, reaching thousands of students across the state. Below is a summary of key accomplishments by strand, highlighting the recent accomplishments from Summer 2025.

Exploring Computer Science (ECS).

Since 2020, ECS has trained over 140 high school teachers, building a statewide professional learning community grounded in inquiry and equity. Initial virtual sessions expanding into robust, in-person sessions during each CS PD Week.

The 2025 workshop at Tuskegee University engaged 60 teachers. Among them, seven PACS-funded second-year participants- averaging 17 years of teaching experience - brought deep classroom expertise into the sessions. Participants rated the sessions between 4.57 and 4.86 (out of 5), with top marks for efficient pacing and facilitator expertise. The "teacher-as-learner" model was enacted with vibrancy, with educators rotating roles, journaling reflections, and engaging in structured debriefs such as the Teacher–Learner–Observer cycle. Topics spanned sustainability, data privacy, culturally situated design tools, and AI/media literacy. Collaboration, peer modeling, and concrete classroom resources were consistently cited as program strengths. All attendees planned to teach ECS in 2025–2026, underscoring both satisfaction and impact.

Bootstrap Algebra and Data Science.

Bootstrap Algebra trained over 70 teachers and AMSTI specialists between 2020 and 2024, transitioning from virtual to high -quality in-person sessions. By 2024, the strand achieved 100% attendance and 91%. Teachers left with actionable plans to integrate algebra and coding through video game design, a hallmark of the Bootstrap approach.

In Summer 2025, PACS launched Bootstrap Data Science in Montgomery, with 17 attendees, mostly Algebra I/II teachers. It became one of PACS's highest-rated trainings, earning a 9.5 out of 10 likelihood-to-recommend score. Facilitators received praise for expertise and learning environment quality: 94% strongly agreed they were knowledgeable and created a positive learning environment. Participants reported high confidence in teaching data science (95%), implementing equity practices (90%), and using the module effectively (85). Most planned to adopt at least half the curriculum. Together, the Bootstrap strands gave Alabama teachers practical, equity-oriented tools for infusing coding and data science into core math instruction.

AP Computer Science Principles (AP CSP).

Over five years, more than 50 teachers received AP CSP training. Initially virtual in 2020, the program shifted to in-person by 2022, maintaining over 90% attendance and assignment completion. Teacher self-reported readiness increased from 1.3 to 2.5 points on 4-point scales, indicating growth in both content knowledge and confidence.

Teachers highlighted tools like Codio, Scratch, and AP Classroom as valuable resources. Preparation for the AP exam and sustained peer support were frequently cited as strengths and critical to sustaining their work. Satisfaction remained high across years (80%-100%), showing that the PD consistently delivered both technical and practical value.

Counselors for Computing (C4C).

From 2020 through 2025, over 130 school counselors participated in C4C PD. Sessions evolved from virtual pilots to engaging in-person workshops, offering counselors tools to promote CS enrollment, revise schedules, and integrate CS into their STEM advising. The 2025 C4C workshop engaged 17 counselors. Speakers were rated 4.76/5, and content rated 3.82/5. Participants left with concrete commitments to promote CS opportunities at their schools, eliminate scheduling barriers, and support initiatives like Girls' STEM Camps and Aspirations in Computing. C4C positioned counselors as key drivers for students across Alabama to pursue computing pathways.

School-level Communities of Practice.

The final key component PACS initiative was the emphasis on building school-level communities of practice (SCoPs) as a sustainable foundation for expanding CS access. PACS tracked four key indicators of schoolwide capacity: multi-educator participation per school, PACS-provided planning structures for school-based teams, coaching and resource use, and communities of practice. PACS prioritized school-based multi-role educator teams, comprising teachers, counselors, and administrators, who could collectively champion CS pathways.

From 2020–2024, 190 schools participated in PACS training; half sent two or more educators. Among the 29 Pathway schools, 86% had teams of three or more by Year 3—an indicator of strong capacity-building. PACS supported school-based teams with planning templates, guided prompts, and equity tools. Early support in Year 1 enabled teams to articulate CS visions, while Years 2–3 saw deeper collaboration and multi-year action plans. By 2023, 72% of AP CSP teachers used PACS coaching, and all engaged in CoPs. The clearest successes came when teams had both the time and support to collaborate across roles. Though implementation faced structural challenges, especially in under-resourced schools, the PACS model clearly seeded long-term, school-level capacity for CS education. These successes offer a compelling and replicable blueprint for building inclusive, durable systems beyond individual PD efforts.

Impact of PACS PD.

Over the past six years, the PACS PD initiative has transformed computer science education in Alabama's rural schools—communities that have long faced limited access to high-quality STEM opportunities. By equipping more than 400 educators and counselors with the skills, confidence, and resources to deliver rigorous, inquiry-driven CS instruction, PACS catalyzed a ripple effect that has reached thousands of rural students who might otherwise have been left behind.

The initiative consistently emphasized inclusive, inquiry-based pedagogy that positioned computer science as accessible to all students. It demonstrated adaptability by transitioning from virtual to in-person delivery while sustaining high fidelity and participant satisfaction. Teachers reported substantial gains in both content confidence and readiness to implement CS curricula, while counselors became equity-minded advocates, integrating CS into advising and promoting access in even the most resource-constrained settings.

Crucially, PACS did more than deliver training—it built durable professional and school-level communities that continue to support and sustain implementation. Integration with AMSTI, Alabama-based facilitation, and repeat participation fostered a statewide network of CS advocates committed to equity and inclusion. Achieving this level of impact in rural contexts—where infrastructure, staffing, and resources are often constrained—marks a significant accomplishment. PACS has made computer science a meaningful and accessible pathway for Alabama's rural students, preparing a diverse new generation to thrive in a digital world.

0.3. Program Measures for Years 4 and Summer 2025

Although program measures are reported directly to the funder, highlights for Year 4 and Summer 2025 are summarized here, with full details reported in section 5.

Strong Progress on Program Performance Indicators, with Targets Met or Exceeded for Key Goals.

The PACS initiative continued to demonstrate strong implementation progress through Year 4, as measured by 17 program performance indicators originally established with the funder. Across the life of the project, key milestones were met or exceeded in areas such as school participation, teacher leadership development, professional development delivery, and counselor preparedness. For example, PACS exceeded its cumulative PD delivery goal by 24%, offering more than 850 hours of training across ECS, Bootstrap Algebra, AP CSP, and C4C modules. Similarly, PACS met or surpassed goals for training teacher-leaders, producing more ECS and AP CSP facilitators than originally planned by the end of Year 3.

Capacity Building: PD, Coaching, and Teacher Leadership.

High-quality PD remains a cornerstone of the initiative's success. Teachers consistently reported increased confidence, CS teaching efficacy, and preparedness—particularly those engaged in multi-year pathways or who taught multiple PACS courses. However, while PD delivery remained strong, coaching services declined in the final year, especially for new Bootstrap teachers, where no AMSTI coaching was offered in 2024–25. Despite early-year gains, this shift contributed to mixed fidelity of implementation, particularly in Bootstrap.

Additionally, teacher retention in PACS target courses fell short of expectations. By Year 3, only 48% of teachers were still teaching the course they had been trained for, far below the 75% retention benchmark.

Instructional Quality and Curriculum Fidelity.

Instructional fidelity and standards alignment remained strong in ECS and AP CSP, with most teachers reporting implementation of major units and adherence to pacing guidelines. In contrast, Bootstrap implementation dropped significantly in Year 3 (just 19% full implementation), and no implementation data were available in Year 4. Classroom observations were not conducted in the final year, but earlier data showed strong quality ratings for ECS and Bootstrap, with 83–86% of observed sessions meeting standards, compared to 59% in AP CSP, which fell short of its 80% goal. Across the three courses, access to complete and aligned curriculum remained intact. However, equity in enacted curriculum, coaching support, and classroom quality monitoring varied substantially by course and year.

Student Engagement and AP CSP Outcomes.

The initiative made visible progress in student AP CSP participation: 66% of students in PACS schools took the AP exam, a notable rate compared to national trends, although still below the original 80% target. Only 31% passed with qualifying scores—substantially under the 60% goal. Yet there is promising evidence that targeted supports matter: among students who attended the summer AP CSP institute, 64% passed—meeting the goal for this subgroup and suggesting benefits of early preparation. Other student-facing programming also continued, including virtual academic-year sessions and summer AP CSP workshops. However, attendance was not tracked in Year 4, limiting ability to assess participation or outcomes.

Counselor Engagement and Career Awareness.

The initiative continued to build counselor capacity, with 98% reporting increased understanding of CS pathways and 97% reporting increased confidence in supporting students. This indicator reached and sustained success across all years. However, documentation of follow-through—such as offering advising on internships or cooperative opportunities—was limited, and remains an area for growth. Student exposure to career-connected learning also appeared strong in prior years. In Year 3, 87% of 11th graders had at least one CS-related career exposure experience, exceeding the 80% benchmark. No data were collected in Year 4.

Student Attitudes and Gains.

PACS set an ambitious goal for 75% of students to improve in all five measured areas of CS attitudes (belonging, encouragement, interest, confidence, and career interest). However, across multiple years and student groups, gains were generally modest and uneven. For example, belonging scores remained flat across timepoints, with just 45% of students improving in Year 1 and Year 3. Career interest dipped slightly. Still, some positive movement was evident in encouragement and confidence, especially among students with multi-year exposure.

Additionally, PACS exceeded its target for growth in computational thinking: 65% of students improved on the CTA-HS assessment between Year 1 and Year 3, surpassing the 60% goal. This suggests that instructional efforts had a measurable impact on core student competencies, even if broader attitudes shifted more slowly.

0.4. Impact and Recommendations for Scale-Up

Over five years, the Pathways for Alabama Computer Science initiative has made measurable, lasting contributions to rural education in Alabama. Rigorous evaluation confirms that PACS improved students' computational thinking, algebra proficiency, and participation in advanced computing coursework, including a substantial increase in AP Computer Science Principles exam-taking rates. These findings are particularly meaningful given the initiative's focus on rural and high-need schools, where such opportunities were previously scarce.

At the systems level, PACS built durable school-based teams, regional professional learning networks, and an integrated infrastructure for equity-driven computer science education. Teachers demonstrated significant growth in confidence, preparedness, and CS teaching efficacy, while counselors became active advocates for student access and advising. Collectively, these outcomes signal that PACS did more than expand course offerings—it created sustainable capacity and a culture of inclusion around computer science learning.

PACS's success unfolded amid Alabama's rapidly changing policy context. The 2019 Computer Science Act (2019-389)**,** mandated that every high school offer at least one CS course, accelerating statewide adoption through A+ College Ready. In this environment, PACS schools were no longer compared to "business as usual" but to peers also scaling up computing—yet PACS schools remained competitive and, in many cases, developed strong leadership. This achievement underscores the initiative's quality and credibility while also revealing the challenge of institutionalizing PACS within a maturing statewide system.

Looking ahead, PACS's next phase lies not in vertical institutionalization within Alabama, but in horizontal scale-up and diversification. The model—anchored in multi-role educator teams, sequenced PD, and cross-disciplinary integration—has strong potential for replication in other rural and high-need regions. States such as Mississippi, South Carolina, Arkansas, and Kentucky, could benefit from adopting PACS as a scalable framework for equitable CS pathways.

To advance this work, PACS should:

- Pursue mid-phase EIR funding to test and expand the model regionally.
- Develop a transferable implementation toolkit including PD materials, coaching models, and counselor engagement strategies.
- Convene a leadership summit with current and prospective partners to align on a coherent multi-state scale-up plan.

PACS has proven that equitable, high-quality computer science education, leading to advances in students' computational thinking, can thrive in rural contexts. The initiative now stands ready to expand that promise beyond Alabama—offering a replicable, evidence-based pathway for rural systems transformation nationwide.

1. Evaluator Information

1.1. *Contact Information*

Kathleen Haynie Consulting, d/b/a/ Haynie Research and Evaluation is the independent evaluation organization. Primary contact is Dr. Kathleen Haynie, Director of Haynie Research and Evaluation, Skillman, NJ, kchaynie@stanfordalumni.org.

1.2. *Confidentiality Protection*

The research study has been reviewed by the Institutional Review Board (IRB) office at the University of Alabama and approval was given on May 18, 2020. Procedures to maintain confidentiality include the following. Federal regulations require that study data and consent documents be kept for a minimum of three (3) years, and HIPAA documents be kept for a minimum of six (6) years after the completion of the study by the PI. Electronic Data are secured via password access, coded with a master list kept as a hardcopy or on a secure network (confidential), data kept on a secure network (e.g., firewall), and data are de-identified by PI or research team. Participants are asked to utilize their state-level IDs. All survey data use state-level IDs as the only identifiers. Transcribed observations are not associated with participant names. After transcription, audio files are backed up, stored as encrypted files, and preserved for five years until the end of the PACS study.

Survey data are collected through Qualtrics and all safeguards for data offered by Qualtrics are applied to this study. Only the PIs and lead researchers access raw data. Participants who agree to participate in follow-up surveys are directed to a separate Qualtrics survey that asks for their contact information (i.e., email, address, and telephone number). Thus, a list of participants' names and contact information are maintained for future contact, but not associated with their survey responses. All electronic files are kept in password-protected computers. Cloud storage for file sharing among project personnel uses Google Drive. Any potentially identifying information is stored as encrypted files. Classroom observations are audio-recorded. These audio files are necessary to preserve participant responses, and they are transcribed and identified with Subject IDs. After transcription, audio files are backed up and stored as encrypted files. Archived audio files are preserved for five years until the end of the PACS study.

1.3. *Independence of Evaluation*

Haynie Research and Evaluation is independent of and external to the applicant entity and any partners. This evaluation will be conducted according to the guidance offered in the document "Independent Evaluation Guidance" (see Appendix A). In particular: (a) findings reported are subject to the approval of the project director or staff conceptualizing/implementing the intervention; (b) the evaluator independently conducts all key aspects of the evaluation, including random assignment, collection of key outcomes data (other than from administrative records), analyses, and reporting of study findings.

2. Summary of Intervention

The Pathways for Alabama Computer Science (PACS) established a statewide high school pathway of computer science courses, primarily for high-need, Title 1 schools in rural areas of the state. This innovative initiative was built through a partnership between the Alabama State Department of Education, The University of Alabama, Tuskegee University, and Alabama Math, Science, and Technology Initiative (AMSTI). The objectives of the intervention were to expand access to rigorous CS pathways in Alabama's rural high schools and to engaged students with diverse backgrounds, particularly those historically underrepresented in STEM fields.

The core activities and services of PACS included the implementation of multiple professional development strands designed for first-time rural educators in computer science, as well as counselors from rural schools. A central feature each year was Alabama CSPdWeek, which convened hundreds of teachers and counselors in shared professional learning. Treatment schools implemented three-course pathways, including Exploring Computer Science (primarily 9th grade), Bootstrap Algebra (10th grade), and AP CSP Principles (primarily 11th and 12th grades). Teachers were trained to deliver these courses using best practices over multiple summers, starting in summer 2020. In addition, school counselors were trained through Counselors for Computing (C4C) which equipped them with strategies to encourage broader student participation in CS pathways and to guide students toward computing-related careers.

Teacher trainings evolved over time. In summer 2020, PD was piloted online during the height of the pandemic. In summer 2021, Alabama CSPdWeek was delivered in hybrid format, combining Zoom-based session with face-to-face training held at a conference center in Prattville, AL. Beginning in Summer 2022 and continuing through 2024, educators participated in fully in-person sessions on the campus of The University of Alabama, with additional workshops held at Tuskegee University (2025 ECS) and Montgomery (2025 Bootstrap Data Science). Ten regional in-service centers, many located near the state's most rural areas, supported year-round teacher engagement through professional learning communities and classroom coaching. Each academic year from 2020-2025, schools had the opportunity to build their CS pathways, introducing new courses or strengthening existing ones through repeated participation. Beyond the three-course pathway, PACS added new strands during the grant period - the introduction of Bootstrap Data Science in 2025. Across five years, AP CSP PD reached more than 50 teachers, while ECS engaged more than 140. In total, more than 400 teachers and counselors statewide participated in PACS PD, creating a durable professional community grounded in equity, inquiry, and teacher empowerment.

Impact Study 2 was launched in spring 2021. This study involved 29 treatment schools participating in CSPdWeek, and 9 control schools that were not eligible to receive PACS training until the summer of 2023. The study followed a stable sample of 9th graders beginning in 2021-2022 through 11th grade in 2023-2024. Outcomes were measured annually and included computational thinking, algebraic problem-solving, and enrollment in AP CS Principles. In addition, students' attitudes towards CS and interest in computing careers were tracked. By 11th grade, mathematics achievement (measured via the ACT) was compared between the 29 treatment schools and 60 similar comparison schools (Impact Study 1).

3. Impact Evaluation Results[1]

Two impact studies are being conducted for PACS. The first impact study uses a Comparative short Interrupted Time-Series design (CITS) to examine the effect of PACS intervention on students' state assessment scores in mathematics. This impact study compares the ACT mathematics achievement of students attending schools that share similar demographic characteristics, but are non-treatment schools. Selection of treatment schools was carried out in January-February 2021. Selection of comparison schools was carried out in winter 2024, before the final Spring 2024 ACT administration.

The second impact study, a school Quasi-Experimental Design (QED), was conducted for PACS. Selection of Treatment schools was carried out in January-February 2021. Selection of matched Control schools was carried out in August-October 2021. The intervention was delivered in school in 2021-22 through 2023-24, with summer training for intervention teachers in summers 2021, 2022, and 2023 and for counselors in summer 2021. Data collection and results are complete.

Chapter Section	Title	Notes
3.1	Impact Study: CITS	*Impact of the intervention on aggregate student outcomes using a comparative short interrupted time-series design (CITS)*
3.2	Impact Study: School QED	*Impact of the intervention on student outcomes (schools self-select to conditions)*

3.1. Study 1: Comparative Short Interrupted Time Series Results

The first Impact Study uses a Comparative short Interrupted Time-Series design (CITS) to examine the effect of PACS intervention on students' state assessment scores in mathematics. This impact study compares the ACT mathematics achievement of students attending schools that share similar demographic characteristics, but are non-treatment schools. Selection of treatment schools was carried out in January-February 2021. Selection of comparison schools was carried out in winter 2024, before the final Spring 2024 ACT administration. Design and analysis procedures are provided in Appendix G.

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[1] Preparation of the evaluation and research plan relied heavily on prior work from AbT Associates (e.g., Price, Goodson, & Wolf, 2018).

RQ4 Finding: PACS School Participation Had No Measurable Impact on 11th Graders' School-level Math ACT Scores at the End of 11th Grade

RQ4: What is the effect on average ACT Math scores for 11th grade students in schools receiving PACS compared to the average ACT Math scores of 11th grade students in schools in the business-as-usual comparison condition? (Treatment students may or may not have taken ECS, will have taken Algebra with Bootstrap, and may or may not have taken AP CSP; comparison students may or may not have taken ECS, will have taken Algebra I without Bootstrap, and may or may not have taken AP CSP).

This analysis draws on school-level time-series data from 2019–2024 to evaluate whether the PACS initiative influenced general computational thinking as proxied by ACT Math scores. The dataset includes 29 PACS treatment schools and 82 demographically similar control schools. The 2024 cohort represents the first group of students who could have experienced the full PACS CS pathway beginning in 9th grade (2021–22 school year).

As shown in Figure 3.1.1, both treatment and control groups experienced a peak in ACT Math scores in 2020, followed by a notable drop in 2021—likely a result of pandemic-related disruptions. From 2021 forward:

- Control schools showed a modest and consistent recovery through 2024.
- Treatment schools improved slightly from 2021 to 2023, but declined again in 2024, the first full PACS implementation year.

Figure 3.1.1: Math-ACT Trend Lines for Treatment and Control Schools

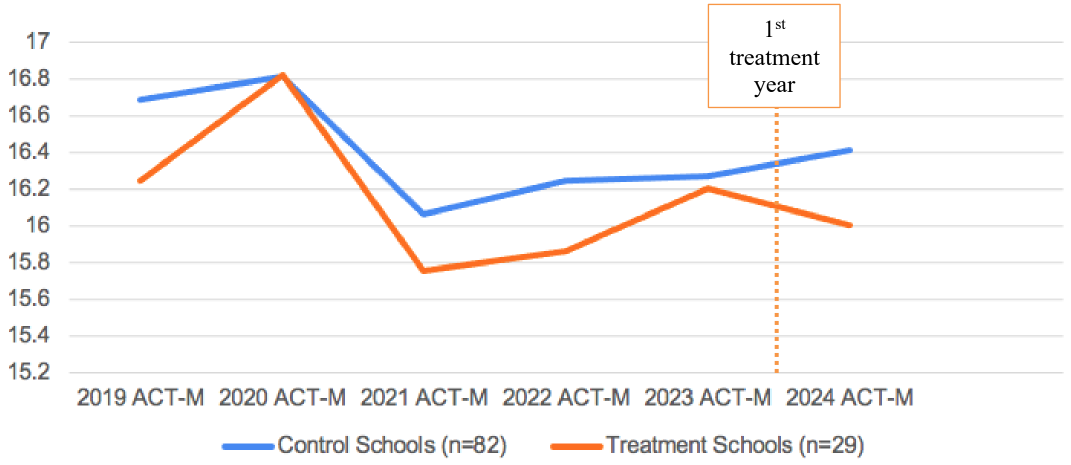
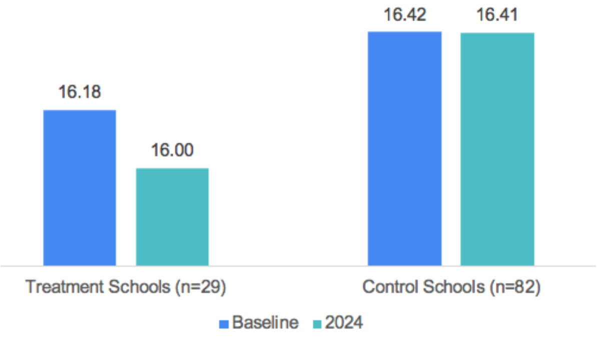


Figure 3.1.2 highlights this divergence. While control schools maintained their 2023 average ACT Math score (16.42 to 16.41), treatment schools dropped from 16.18 to 15.92. This subtle divergence slightly widened the performance gap between the two groups in 2024..

Figure 3.1.2: Math-ACT Means for Treatment and Control Schools



For Treatment Schools, the Average Math-ACT scores decreased from baseline to 2024 (1st treatment year).

For Control Schools, the baseline and 2024 Math-ACT averages were nearly identical.

Interpretation and Contextualization. The analysis of ACT Math scores for 11th graders revealed no measurable positive impact for student in Pathway schools after three years of intervention. In fact, the treatment group's slight decline in average scores from 2023 to 2024 may suggest a neutral or modestly negative short-term effect. However, several key contextual factors caution against overinterpreting this trend.

First, the ACT Math exam is not explicitly aligned with the CS-integrated curriculum emphasized by PACS—such as Bootstrap Algebra or Exploring Computer Science (ECS). As a result, the test may not fully reflect gains in computational thinking or CS fluency that PACS aims to promote.

Second, this analysis draws from school-level aggregate ACT scores rather than individual student data. Such aggregation can obscure variation within schools, particularly in smaller or rural schools where fluctuations in small student populations can disproportionately affect averages.

Third, the 2024 cohort represents the program's first implementation of each PACS-supported course, during which schools were navigating early-stage adoption. As with many whole-school innovations, initial adoption often brings uneven execution, logistical challenges, and learning curves for both educators and students.

Taken together, these factors suggest that while ACT Math is a widely accepted academic metric, it may be an imperfect lens for evaluating the early impact of a CS pathway initiative like PACS. Future analyses should consider disaggregated data, explore outcomes for specific student subgroups (such as those who took ECS, Bootstrap Algebra or AP CSP), and leverage more targeted assessments of computational thinking.

EQ10 Finding: PACS School Participation Had No Measurable Impact on 11th Graders' School-level Science ACT Scores at the End of 11th Grade

(EQ10) What is the effect on average ACT Science scores for 11th grade students in schools receiving PACS compared to the average ACT Science scores of 11th grade students in schools in the business-as-usual comparison condition?

To address this question, we examined changes in school-level average ACT Science scores over time. Data from 2019–2023 served as the pre-treatment baseline, and 2024 marked the first year in which treatment schools had a full cohort of students exposed to the PACS course sequence beginning in 9th grade. The analysis included 29 treatment schools and 82 control schools.

As shown in Figure 3.1.3, both groups demonstrated a high point in ACT Science scores in 2020, followed by a general decline. Treatment schools consistently scored below control schools throughout the observed period. In 2024, the first full treatment year, the trend line rose for control schools and declined slightly for treatment schools.

Figure 3.1.3: Science-ACT Trend Lines for Treatment and Control Schools

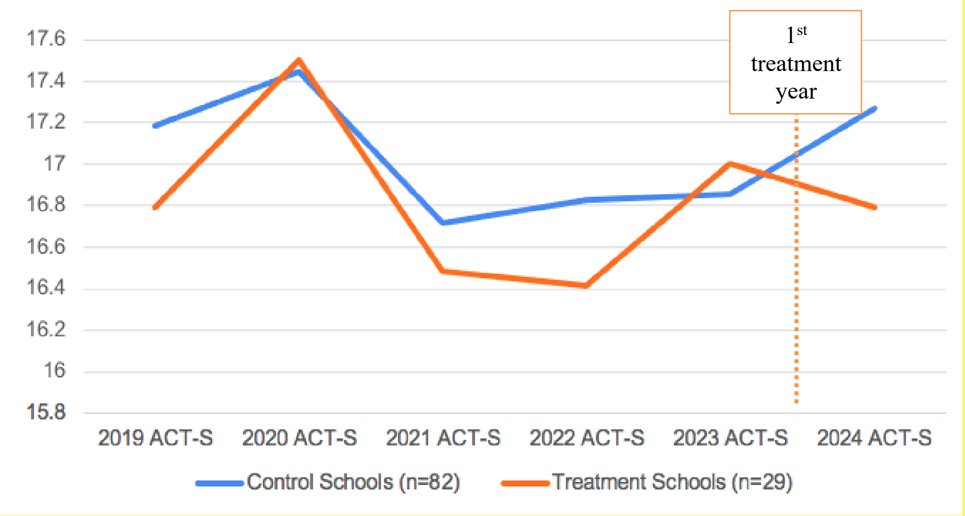
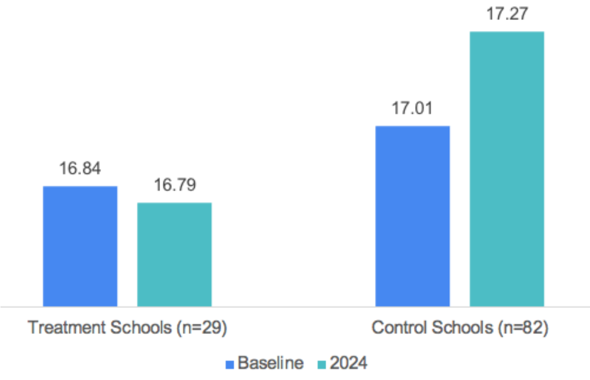


Figure 3.1.4 presents mean scores for the 2024 ACT Science test and the multi-year baseline average. Treatment schools showed little change in average performance between the baseline and 2024 (16.84 to 16.79). In contrast, control schools demonstrated a modest gain, increasing from 17.01 to 17.27.

Figure 3.1.4: Science-ACT Means for Treatment and Control Schools



For Treatment Schools (n=29), average Science-ACT scores were numerically similar from baseline to 2024.

For Control Schools, the average 2024 Science-ACT exceeded that of the baseline years.

Interpretation

Based on this evidence, there is no effect on average Science-ACT scores for 11th grade students in schools receiving PACS compared to the average Science-ACT scores of 11th graders in schools in the business-as-usual comparison condition.

This analysis addresses an *exploratory* research question, and results should be viewed as descriptive rather than causal. Based on the available school-level averages, there is no clear evidence of a positive effect of PACS participation on ACT Science scores. In 2024, average scores for treatment schools remained nearly unchanged from baseline, while control schools demonstrated a modest increase.

It is important to note that the ACT Science test is not directly aligned to the content or skills taught in the PACS computer science pathway. However, the test does emphasize analytical reasoning, data interpretation, and modeling—skills that partially overlap with the computational thinking practices PACS seeks to develop in students. Given this indirect alignment, any observed differences in Science scores may reflect broader reasoning skill development, though attribution is speculative.

As such, while these findings do not suggest a measurable benefit on Science ACT performance from PACS participation, they also do not preclude the possibility of cognitive or problem-solving gains in domains not fully captured by this assessment.

3.2. *Study 2: Quasi-Experimental Design Results*

Impact study 2 is a three-year quasi-experimental design, involving 38 schools selected in winter through fall 2021. To have been eligible, the high schools were in a rural or town locale(s) and either no CS course or only in AP CS Principles by summer of 2020. The treatment group of 29 schools began participating in PACS programs in summer 2021 and implementing the computer pathway starting in fall 2021; the control group of 9 schools was not eligible for PACS programs until summer of 2023. The study followed for three years a single cohort of 9th grade students who enrolled in the study high schools in fall 2021. The outcomes of interest are students' computational thinking, algebraic problem-solving, AP CS Principles exam score, and CS attitudes. The research questions, outcomes, baseline measures, sample, and contrasts relevant to the study being described in this section are listed in "Early 19 Contrast Tool 050122.xlsm."

Design and analysis procedures are provided in Appendix H. Baseline and outcome measures are shown in Figure 3.2.1 and described in Appendix H.

Figure 3.2.1: Impact Study 2 Design

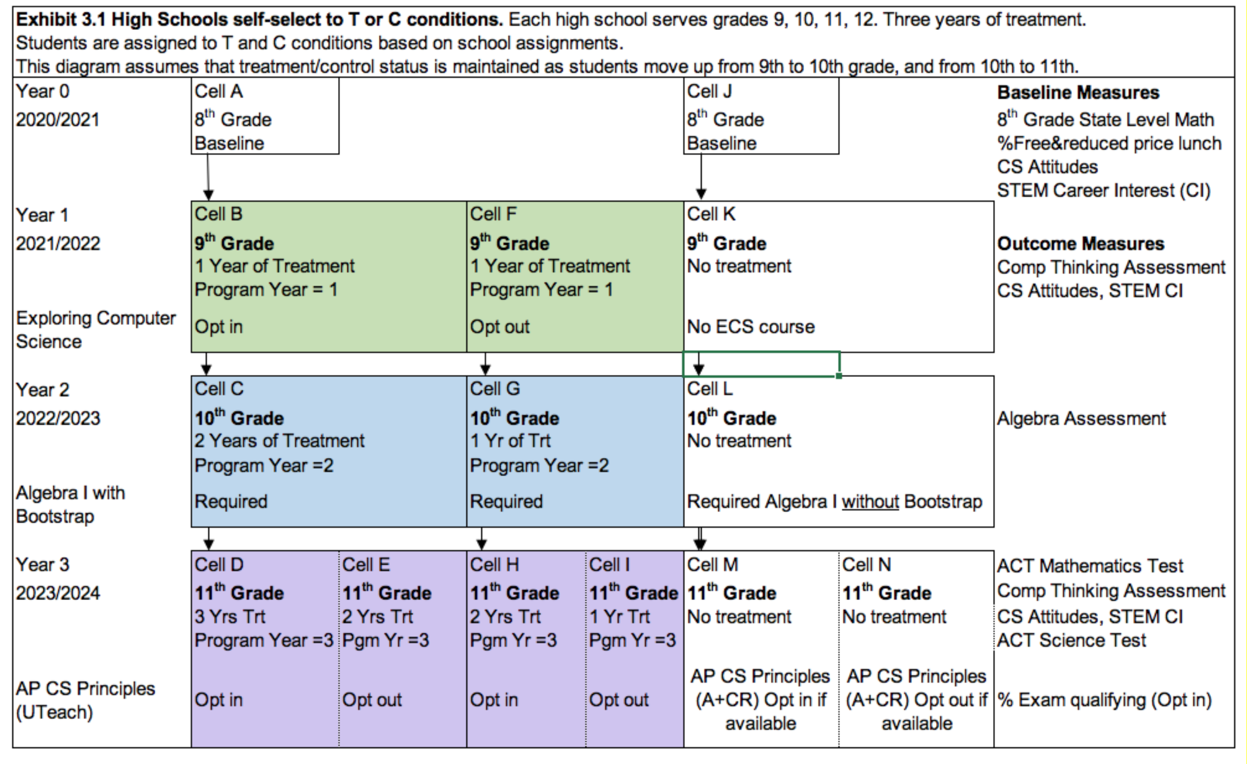


Exhibit 3.1 High Schools self-select to T or C conditions. Each high school serves grades 9, 10, 11, 12. Three years of treatment.
Students are assigned to T and C conditions based on school assignments.
This diagram assumes that treatment/control status is maintained as students move up from 9th to 10th grade, and from 10th to 11th.

Year 0 2020/2021	Cell A 8th Grade Baseline				Cell J 8th Grade Baseline		**Baseline Measures** 8th Grade State Level Math %Free&reduced price lunch CS Attitudes STEM Career Interest (CI)
Year 1 2021/2022 Exploring Computer Science	Cell B **9th Grade** 1 Year of Treatment Program Year = 1 Opt in		Cell F **9th Grade** 1 Year of Treatment Program Year = 1 Opt out		Cell K **9th Grade** No treatment No ECS course		**Outcome Measures** Comp Thinking Assessment CS Attitudes, STEM CI
Year 2 2022/2023 Algebra I with Bootstrap	Cell C **10th Grade** 2 Years of Treatment Program Year =2 Required		Cell G **10th Grade** 1 Yr of Trt Program Year =2 Required		Cell L **10th Grade** No treatment Required Algebra I without Bootstrap		Algebra Assessment
Year 3 2023/2024 AP CS Principles (UTeach)	Cell D **11th Grade** 3 Yrs Trt Program Year =3 Opt in	Cell E **11th Grade** 2 Yrs Trt Pgm Yr =3 Opt out	Cell H **11th Grade** 2 Yrs Trt Pgm Yr =3 Opt in	Cell I **11th Grade** 1 Yr Trt Pgm Yr =3 Opt out	Cell M **11th Grade** No treatment AP CS Principles (A+CR) Opt in if available	Cell N **11th Grade** No treatment AP CS Principles (A+CR) Opt out if available	ACT Mathematics Test Comp Thinking Assessment CS Attitudes, STEM CI ACT Science Test % Exam qualifying (Opt in)

Baseline Measures

8th Grade ACAP Mathematics

The 8th grade ACAP was administered by the state of Alabama in Spring of 2021. Students' scores were collected from the Pathway and Associate schools in fall of 2021. Table 3.2.1 provides data for 940 students from 29 treatment schools and 326 students from 9 comparison schools. Findings include the following main effects and interactions:

- Significant differences by treatment/comparison group
- Significant differences (across groups) by URG status, and SES. Gender is non-significant
- Between groups, the following variables show significant differences: female, male, positive URG status, non-URG status, lower SES. Higher SES does not show a between group difference

Table 3.2.1 8th Grade ACAP Baseline Comparisons

	Treatment	Comparison	Total Group	Mean Comparison[2]
Number of students	940	326	1266	
Number of schools	29	9	38	
8th grade Math ACAP – All students	Mean=489.3, SD=58.3	Mean=468.9 SD=61.4	Mean=484.0 SD=59.7	t-test, p=.000
8th grade Math ACAP – Female students	Mean=490.0, SD=55.3 N=461	Mean=472.6, SD=55.0 N=154	Mean=485.6, SD=55.7 N=615	t-test, p<.001
8th grade Math ACAP – Male students	Mean=488.5, SD=61.2 N=478	Mean=465.7, SD=66.6 N=172	Mean=482.5, SD=63.4 N=650	t-test, p<.001
8th grade Math ACAP-URG Students[3]	Mean=470.0, SD=60.8 N=297	Mean=452.3, SD=64.7 N=143	Mean=464.2, SD=62.6 N=440	t-test, p<.01
8th grade Math ACAP-Non-URG students	Mean=498.2, SD=55.0 N=640	Mean=482.0, SD=55.6 N=182	Mean=494.6, SD=55.5 N=822	t-test, p<.001
8th grade Math ACAP – Higher SES students	Mean=498.5, SD=55.4 N=451	Mean=493.1, SD=49.6 N=71	Mean=497.7, SD=54.6 N=522	t-test, n.s.
8th grade Math ACAP – Lower SES students	Mean=481.5, SD=59.4 N=481	Mean=462.2, SD=62.8 N=255	Mean=474.8, SD=61.2 N=736	t-test, p=.000

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[2] Given the group differences in this design study, valid comparisons between the two groups required statistically matched samples, using coarsened exact matching. See subsequent results.

[3] Race indication as AI, Black, Hawaiian/Pacific Islander, or Multi-racial, or Hispanic/Latinx were coded '1'

CS/STEM Attitude Surveys

The CS/STEM surveys were administered as baseline measures in fall of 2021 by Haynie Research and Evaluation Students' scores were collected from consented students in Pathway and Associate schools. Table 3.2.2 provides statistical information for these measures. Findings include:

- Neutral average scores (about 2.5 on the scale of 1=strongly disagree, 4=strongly agree) for Belonging, Interest, Confidence, and CS Career Interest
- Good reliability levels for all measures, and excellent for Interest and Career Interest
- Lower average scores for Encouragement (just above 2=disagree)
- Comparable to scale validated reliabilities levels (Haynie 2017) for Belonging, Encouragement, and Interest
- Reliability level for Confidence scale is lower than the validated reliability level[4]

Table 3.2.2 Baseline CS Attitudes and Career Interest

Measure	**Number of Respondents**	**Number of Items**	**Mean Score (Range=1- 4)**	**Std Dev**	**Reliability**	**Validated Reliability (Haynie 2017)**
Belonging	1328	5	2.47	0.66	0.841	0.850
Encouragement	1329	5	2.21	0.66	0.842	0.858
Interest	1329	6	2.49	0.73	0.918	0.932
Confidence	1325	5	2.60	0.60	0.780	0.890
CS Career Interest	1310	10	2.61	0.83	0.958	

Baseline data for students from 29 treatment schools and students from 9 comparison schools are provided in Table 3.2.3. Findings include:

- Significant T/C differences for Belonging, Interest, and Confidence
- Non-significant differences for Encouragement and CS Career Interest

Note that the treatment and comparison groups are not yet statistically matched (by race/ethnicity and by socio-economic status), therefore, this is not a valid comparison.

Table 3.2.3 Baseline Attitude Data for PACS Impact Study 2

	Treatment Group	Comparison Group	Group Mean Comparison
Number of students	749	285	
Number of schools	29	9	
Belonging	Mean=2.50, SD=0.64	Mean=2.34, SD=0.61	t-test, p<.001
Encouragement	Mean=2.21, SD=0.65	Mean=2.15, SD=0.61	t-test, n.s.
Interest	Mean=2.51, SD=0.72	Mean=2.40, SD=0.70	t-test, p<.05
Confidence	Mean=2.63, SD=0.58	Mean=2.50, SD=0.55	t-test, p<.001
CS Career Interest	Mean=2.60, SD=0.82	Mean=2.60, SD=0.83	t-test, n.s.

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[4] Minor wording changes were made to some items on this scale, compared with Haynie 2017.

Year 1 Computational Thinking Assessment for High School (CTA-HS) Analysis

Ninth grade student outcome data on the Computational Thinking Assessment for High School (CTA-HS) were collected from the 38 rural schools (29 treatment, 9 control) across Alabama. The CTA-HS was given to consenting students in the PACS efficacy study at the end of the 2021-2022 academic year. The instrument consisted of 62 items divided into 8 blocks; each student received 3 randomly selected blocks of about 24 items. Therefore, the proportion of students that received each item was about 38% of the total participating student sample.

Table 3.2.4 indicates the number of respondents, number of items, reliability, and mean percent correct for each item block in the CTA-HS. Reliability levels varied from -0.006 to 0.511. All reliability levels by block were poor or unacceptable, however given the small number of items by block this is not unexpected. The poorest performing items (i.e., item-total score correlation <0.04) were removed from item blocks, affecting blocks 5, 6, 7, and 8. New reliability levels improved but were still unacceptable. CTA-HS item blocks scores were averaged to create a total item score comprised of percent correct for three equally weighted item blocks. Item block correlations ranged from .165 to .472 between blocks, most correlations were statistically significant, and item block correlations ranged from .656 to .808 with the total score.

Table 3.2.4 CTA-HS 9th Grade Results By Item Block

Measure	N Respondents	Number of Items	Reliability	Mean P+	Removed Items	New Reliability	New Mean Score
Block 1	392	8	0.511	37.1%	X		
Block 2	402	9	0.405	32.9%	X		
Block 3	407	8	0.499	35.8%	X		
Block 4	407	8	0.397	31.9%	X		
Block 5	400	10	0.382	40.4%	2	0.471	36.0%
Block 6	399	7	0.328	32.3%	1	0.385	27.9%
Block 7	396	8	0.549	40.5%	1	0.592	44.2%
Block 8	403	6	-0.006	33.6%	3	0.143	32.7%

Students took blocks of items and the data were calibrated with item response theory (IRT) using a 2-parameter logistic model (e.g., Lord, 1980). IRT logit scale values were transformed linearly to a scaled score similar to that of the baseline measure - the 8th grade math ACAP. Items that did not meet the basic requirements of a 2-PL model were removed. The baseline and CTA-HS scales were not equated. Instead, since the control and treatment group student data differed on a number of key variables (ACAP scores, SES, HUG status), coarsened exact matching method (CEM) was used to match these groups for the purpose of comparison on the CTA-HS outcome scores.

RQ1 Finding: Participation in PACS Schools Was Associated with a Small but Statistically Significant Gain in 9th Graders' Computational Thinking

RQ1: What is the effect on computational thinking of students in PACS schools compared to the computational thinking of students in schools in the business-as-usual comparison schools?

- Focus: End- of-9th grade outcomes; treatment students may or may not have taken ECS, while comparison students were not offered ECS.

Research Focus

This analysis evaluated whether schoolwide implementation of the PACS initiative influenced 9th-grade students' computational thinking skills, as measured by the general Computational Thinking Assessment for High School (CTA). The intent was to detect school-level effects, irrespective of whether individual students were enrolled in PACS CS courses. While many students in treatment schools may have taken ECS, the treatment group was defined by school-level exposure to PACS supports (e.g., trained teachers, counselor involvement, admin buy-in). The control group consisted of students from non-PACS schools.

Coarsened exact matching (CEM) was used to reduce bias and improve comparability, following guidance from Abt Associates (2023). Students were matched on:

- **8th Grade Math ACAP scores** (standardized state assessments)
- **Socioeconomic status**, proxied by free/reduced lunch (FRPL) eligibility

Only students with parental consent and valid data were included. Data from 8th and 9th grades were merged using state student IDs. IRT modeling was used to score the CTA.

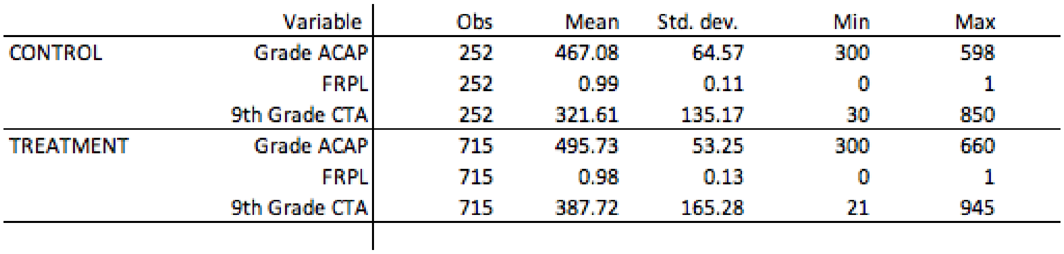
Descriptive Statistics and Matching Process

The analytic sample included 967 students: 715 in PACS schools and 252 in control schools. Slightly higher baseline achievement in the treatment group warranted statistical adjustment (Table 3.2.5). After CEM:

- L1 distance dropped from 0.2209 to 0.0000
- 14 of 20 strata successfully matched
- Retention was high (over 99% for both groups)

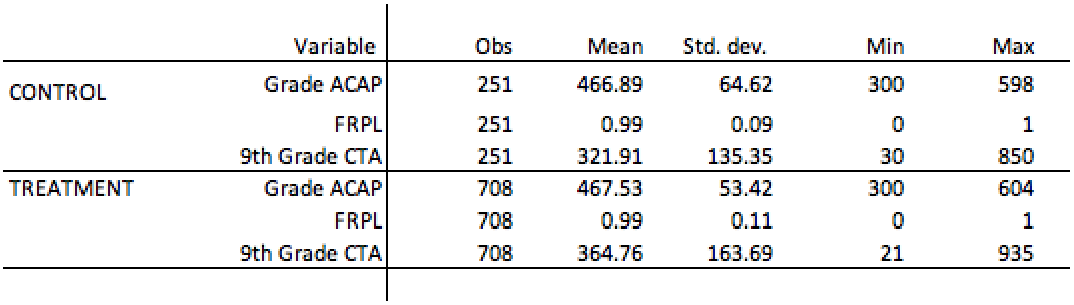
These results indicate excellent post-match equivalence (Table 3.2.6).

Table 3.2.5. RQ1 Descriptive Statistics Before Coarsened Exact Matching



	Variable	Obs	Mean	Std. dev.	Min	Max
CONTROL	Grade ACAP	252	467.08	64.57	300	598
	FRPL	252	0.99	0.11	0	1
	9th Grade CTA	252	321.61	135.17	30	850
TREATMENT	Grade ACAP	715	495.73	53.25	300	660
	FRPL	715	0.98	0.13	0	1
	9th Grade CTA	715	387.72	165.28	21	945

Table 3.2.6. RQ1 Descriptive Statistics After Coarsened Exact Matching



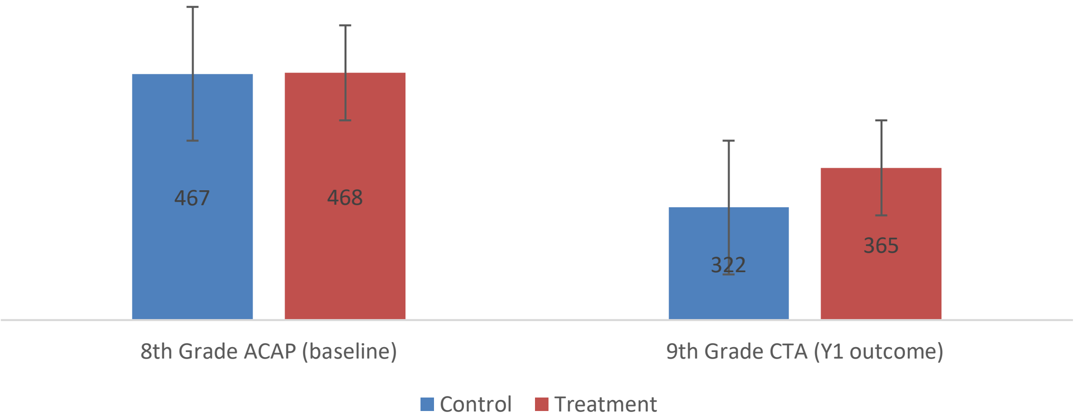
	Variable	Obs	Mean	Std. dev.	Min	Max
CONTROL	Grade ACAP	251	466.89	64.62	300	598
	FRPL	251	0.99	0.09	0	1
	9th Grade CTA	251	321.91	135.35	30	850
TREATMENT	Grade ACAP	708	467.53	53.42	300	604
	FRPL	708	0.99	0.11	0	1
	9th Grade CTA	708	364.76	163.69	21	935

Key Results

- Hedges' g**:** 0.27 **(**small to moderate effect**)**
- t-test**:** t = 4.07**,** df ≈ 526.43**,** p < .001 (highly statistically significant)

While the effect size was modest, it was statistically robust. PACS students outperformed peers in non-PACS schools, indicating early program impact (Figure 3.2.2).

Figure 3.2.2 Baseline ACAP and 9th Grade Algebra Scores After Coarsened Exact Matching



Implications and Next Steps

This analysis demonstrates that even limited exposure to a PACS-aligned school culture can measurably enhance students' computational thinking. Matching weights ensured comparability, despite uneven group sizes. Gains likely reflect early schoolwide influences—such as teacher PD, supportive scheduling, and integration into non-CS classrooms.

This finding of a small, significant effect on computational thinking after just one year in PACS schools offers encouraging early evidence of the program's potential. However, it represents only the beginning of the students' CS-integrated learning trajectory. As the same cohort progresses through the 10th grade Algebra I course with Bootstrap integration and then AP Computer Science Principles in 11th grade, deeper and more cumulative effects may emerge.

These results—though modest in size—are meaningful. They demonstrate that even in the first year of exposure to PACS-supported schools, students showed statistically significant gains in general computational thinking. This finding reinforces the PACS theory of action: that schoolwide investments in educator PD, curricular alignment, and counselor engagement can begin shifting student outcomes, even before direct course-taking is fully scaled. Importantly, these 9th graders represent the first full PACS cohort—students who will continue through the aligned pathway into 10th grade Bootstrap Algebra and 11th grade AP Computer Science Principles. The next phase of analysis will follow this same group of students, examining how three years of sustained PACS implementation shape more advanced CS learning and performance, including AP exam outcomes and college/career readiness indicators. In this way, the 9th-grade CTA findings serve as both a validation of early progress and a foundation for deeper longitudinal insights.

RQ3 Finding: Students in PACS Schools Demonstrated Modestly Higher Algebra Problem-Solving Skills by the End of 10th Grade

RQ3: What is the effect on algebra skills of 10th grade students in schools receiving PACS compared to the algebra skills of 10th grade students in schools in the business-as-usual control condition?

- *Focus* End-of-10th grade outcomes; treatment students had Bootstrap-infused Algebra I, with many having taken ECS in 9th grade. Control students had no CS-integrated instruction.

Research Focus

This analysis assessed the effect of CS-integrated Algebra I—via the Bootstrap curriculum—on students' problem-solving skills in 10th grade. Only students with valid 8th and 10th grade data and consent were included. A linear transformation of correct answers was used for scaling.

CEM matched students on:

- 8th Grade Math ACAP scores
- FRPL eligibility

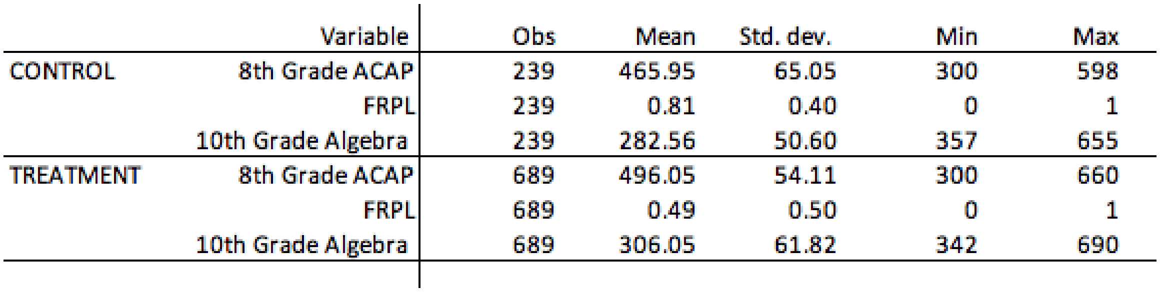
Descriptive Statistics and Matching Results

The final sample included 928 students: 689 in the treatment group and 239 in the control group. Table 3.2.7 summarizes the baseline descriptives. Pre-match imbalance was addressed via CEM:

- L1 dropped from 0.2862 to 0.0371, a nine-fold improvement
- 26 of 41 strata matched
- Retention: 90% (treatment), 69% (control)

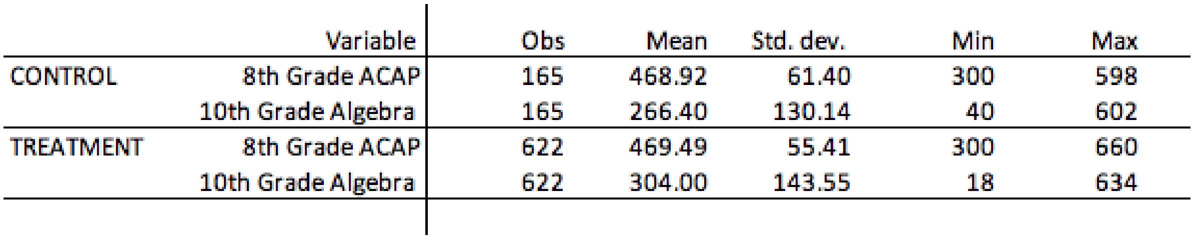
Table 3.2.7 shows pre-match descriptives; Table 3.2.8 shows post-match statistics.

Table 3.2.7. Descriptive Statistics Before Coarsened Exact Matching



	Variable	Obs	Mean	Std. dev.	Min	Max
CONTROL	8th Grade ACAP	239	465.95	65.05	300	598
	FRPL	239	0.81	0.40	0	1
	10th Grade Algebra	239	282.56	50.60	357	655
TREATMENT	8th Grade ACAP	689	496.05	54.11	300	660
	FRPL	689	0.49	0.50	0	1
	10th Grade Algebra	689	306.05	61.82	342	690

Table 3.2.8. Descriptive Statistics After Coarsened Exact Matching



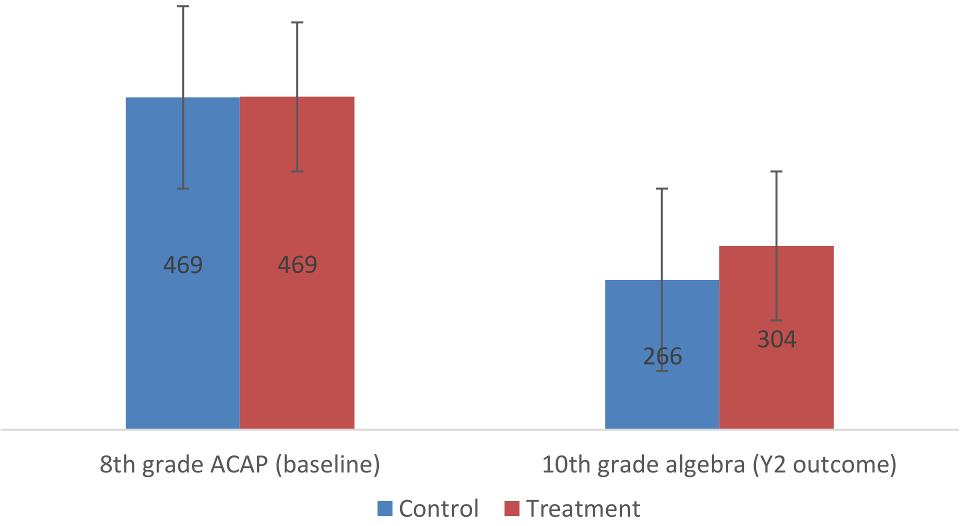
	Variable	Obs	Mean	Std. dev.	Min	Max
CONTROL	8th Grade ACAP	165	468.92	61.40	300	598
	10th Grade Algebra	165	266.40	130.14	40	602
TREATMENT	8th Grade ACAP	622	469.49	55.41	300	660
	10th Grade Algebra	622	304.00	143.55	18	634

Key Results

- **Hedges' g** = 0.267 (small to moderate effect)
- **t-test**: $t = 3.23$, df ≈ 279.27, $p < .01$

Bootstrap exposure was associated with stronger algebra performance (Figure 3.2.3), reinforcing the value of integrating computational thinking in core mathematics instruction.

Figure 3.2.3 Baseline ACAP and 10th Grade Algebra Scores After Coarsened Exact Matching



Interpretation and Contextualization. These findings indicate that participation in PACS schools was linked to modest but meaningful improvements in algebra problem-solving by the end of 10th grade. The effect size remains small but statistically significant, suggesting that early exposure to CS-integrated Algebra I—via the Bootstrap curriculum—may support gains in analytical reasoning and mathematical fluency.

Several contextual factors lend insight into this modest but meaningful improvement. First, the alignment of the measure likely enhanced the ability to detect change: unlike the ACT Math assessment, the 10th grade Algebra test directly assessed problem-solving and analytical reasoning skills emphasized in Algebra I and reinforced through Bootstrap's computational thinking approach. Second, the maturity of the cohort may have played a role—many of these students had previously taken ECS in 9th grade, building a foundation of logical reasoning and coding concepts that may have strengthened their performance in Algebra I. Third, variation in program implementation across schools may have tempered the observed effect. Students with consistent exposure to PACS-aligned instruction, particularly those who completed both ECS and Bootstrap Algebra, likely benefited more than peers in schools with partial or uneven implementation. Finally, the relatively large standard deviations reflect the weighting of small, low-performing strata within the coarsened exact matching analysis, a methodological factor that increases variance and slightly inflates uncertainty in the estimated treatment effect. Together, these considerations suggest that while the overall gains are modest, they are both plausible and consistent with the program's underlying design and developmental trajectory.

Looking Ahead: With many students now having completed two years of exposure to the PACS pathway—including optional ECS in 9th grade and required Bootstrap Algebra in 10th—the next analysis explores whether participation in a third PACS-aligned course, AP Computer Science Principles, is associated with further growth in computational thinking The 11th grade analysis uses the same general Computational Thinking Assessment applied in 9th grade, providing a basis to assess cumulative impacts of the ECS → Bootstrap → AP CSP progression. Because comparison schools offered no equivalent CS instruction, this next step offers insight into the durable value of structured CS pathways for rural Alabama students.

RQ2 Finding: Participation in PACS Schools Was Associated with Statistically Significant Growth in 11th Graders' Computational Thinking

RQ2: What is the effect on computational thinking of students in PACS schools compared to the computational thinking of students in schools in the business-as-usual comparison schools?

- *Focus:* End-of-11th grade; treatment students may or may not have taken the AP CSP course, had Bootstrap-infused algebra, and may or may not have taken ECS; comparison students will not have been offered ECS, not have had Bootstrap-infused algebra, and may have had the opportunity to take AP CSP

Research Focus

This cumulative analysis assessed 11 grade outcomes on the CTA-HS. This analysis compared outcomes between treatment students in PACS treatment schools (access to 3 years of a CS pathway of courses) with students in matched business-as-usual comparison schools who did not receive PACS-aligned instruction.

Item response theory (IRT) was used to calibrate CTA data with a two-parameter logistic model. Student-level data from 9th and 11th grades were merged using Alabama student IDs. Only students with full assessment data and valid consent were included; those with enrollment anomalies were excluded. A total of 58 items were initially scored, and 3 poorly fitting items were removed following analysis of item characteristic curves. Scaled scores were then calculated:

$$\text{Scaled score} = \theta \times 200 + 500$$

The CEM method was again to match students on two covariates:

- Eighth Grade Math ACAP scores (provided by state/ALSDE)
- Socio-economic status (proxied by Free/Reduced/Full Price lunch)

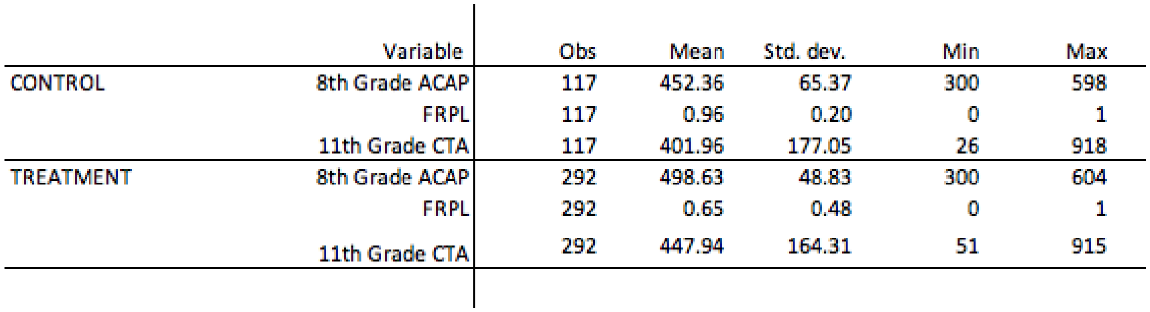
Descriptive Statistics and Matching Results

The pre-matching statistics (Table 3.2.9) included 409 students**:** 292 in treatment schools and 117 in control schools. Treatment students had higher average scores on both the 8th grade ACAP and the 11th grade CTA, reinforcing the need for matched comparison.

The CEM procedure resulted in excellent group balance (Table 3.2.10):

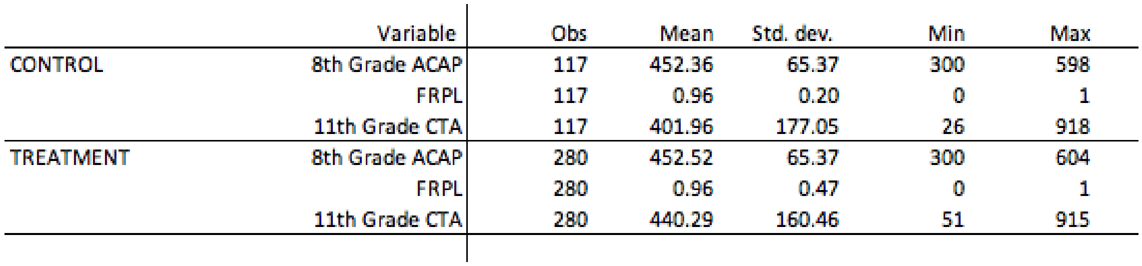
- The L1 distance dropped from 0.4437 to 0.0000.
- 13 of 13 strata were successfully matched.
- High sample retention: 96% of treatment students and 100% of control group students remained post-match.

Table 3.2.9 Descriptive Statistics Before Coarsened Exact Matching



	Variable	Obs	Mean	Std. dev.	Min	Max
CONTROL	8th Grade ACAP	117	452.36	65.37	300	598
	FRPL	117	0.96	0.20	0	1
	11th Grade CTA	117	401.96	177.05	26	918
TREATMENT	8th Grade ACAP	292	498.63	48.83	300	604
	FRPL	292	0.65	0.48	0	1
	11th Grade CTA	292	447.94	164.31	51	915

Table 3.2.10 Descriptive Statistics Before Coarsened Exact Matching



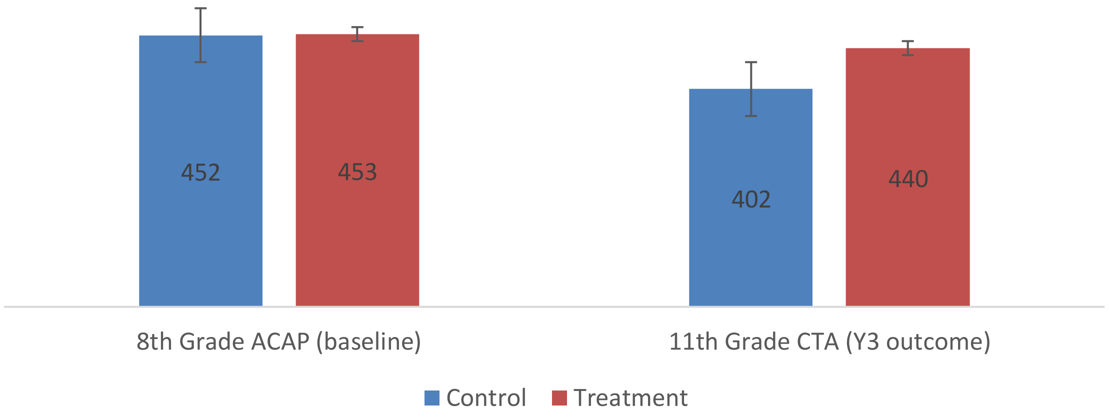
	Variable	Obs	Mean	Std. dev.	Min	Max
CONTROL	8th Grade ACAP	117	452.36	65.37	300	598
	FRPL	117	0.96	0.20	0	1
	11th Grade CTA	117	401.96	177.05	26	918
TREATMENT	8th Grade ACAP	280	452.52	65.37	300	604
	FRPL	280	0.96	0.47	0	1
	11th Grade CTA	280	440.29	160.46	51	915

Key Results

- **Hedges' g** = 0.23 (small to moderate effect)
- **t-test**: $t = 2.02$, df ≈ 199.52, $p < .05$

Students in PACS schools outperformed peers in general computational thinking (Figure 3.2.4), providing evidence for cumulative program impact over three years.

Figure 3.2.4 Baseline ACAP and 11th Grade CTA Scores After Coarsened Exact Matching



Interpretation and Implications

Students in PACS schools scored higher on the CTA-HS than students in non-PACS schools. While the effect size is modest, it is statistically significant and consistent with the program's theory of action. Hedges' *g* accounts for group size and variance differences, affirming a small but meaningful treatment effect.

Several factors strengthen the interpretation of these findings. Perfect matching across covariates enhances confidence in the validity of comparisons. Post-match, both groups were balanced on baseline achievement and socioeconomic status. The longitudinal nature of the PACS pathway matters: many treatment students had now experienced at least two years of CS-integrated instruction (Bootstrap Algebra in 10th grade and AP CSP in 11th), potentially building deep conceptual understanding over time. Although ECS in 9th grade was not universally required, many treatment students participated, making this cohort the first to fully experience the PACS three-course sequence. High variance in scores**,** particularly in the control group, likely reflects differences in exposure and may obscure stronger effects in subgroups with sustained, high-fidelity PACS exposure.

Looking Forward

This statistically significant difference in computational thinking by the end of 11th grade provides encouraging evidence that a multi-year, schoolwide investment in CS-integrated learning can improve student outcomes—even in rural or under-resourced settings.

EQ9 Finding: Participation in PACS Schools Was Associated with Significantly Higher Rates of AP CSP Exam-Taking

EQ9: What is the effect on AP CSP qualifying exam score rates for 11th grade students in schools receiving PACS compared to the AP CSP qualifying exam score rates of 11th grade students in schools in the business-as-usual control condition?

> *Focus:* This exploratory analysis compared exam participation and qualification rates for students enrolled in the AP CSP course in PACS versus non-PACS schools. PACS students were taught by teachers who had received PACS PD and schoolwide supports, had access to Bootstrap Algebra, and may or may not have taken ECS in 9th grade. Comparison students took AP CSP but did not receive ECS, Bootstrap, or instruction from PACS-trained teachers.

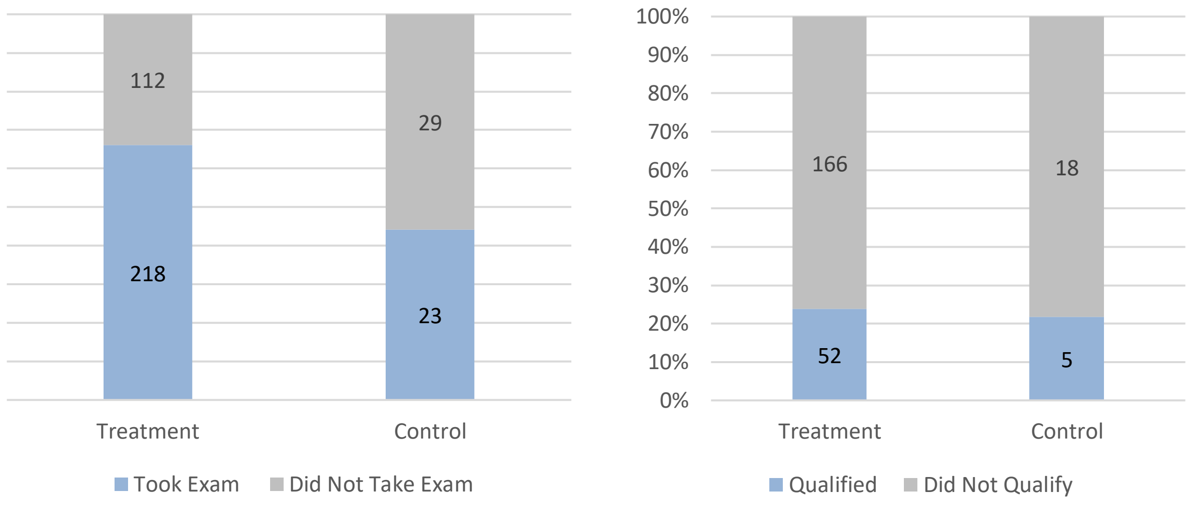
Research Focus

This analysis examined two related outcomes based on the May 2024 AP CSP exam:

1. Exam Participation**:** Whether enrolled students took the end-of-course AP exam.
2. Qualification Rate**:** Whether exam takers achieved a qualifying score of 3 or higher.

The treatment group consisted of 330 students across 21 PACS-trained teachers, while the comparison group included 52 students taught by 5 non-PACS-trained teachers. Because of small sample sizes, this analysis included all students in the classes regardless of grade level.

Figure 3.2.5 AP CSP Exam-taking and Qualification Rates



Key Results

Exam Participation

- PACS**:** 218 of 330 students took the exam → 66.1%
- Non-PACS: 23 of 52 students took the exam → 44.2%
- Statistical Test: Two-proportion z-test (two-tailed)
    - Z-score**:** 3.17
    - p-value**:** 0.0015 (statistically significant)
- Effect Size (Cohen's *h*): 0.443 → Medium effect size

Students in PACS schools were significantly more likely to take the AP CSP exam compared to students in non-PACS schools. The difference is both statistically significant and practically meaningful, reflecting impact of systemic supports and incentives built into the PACS initiative.

Exam Qualification (Among Test-Takers)

- PACS**:** 52 of 218 students qualified → 23.9%
- Non-PACS**:** 5 of 23 students qualified → 21.7%
- Effect Size (Cohen's *h*): 0.050 → Very small (negligible)

Among students who took the exam, qualification rates were similar across both groups. While performance parity is encouraging, the result suggests that broader participation does not yet translate to performance gains for all.

Interpretation and Implications

Students in PACS schools demonstrated: (1) higher computational thinking proficiency by end of 11th grade (per CTA-HS results in RQ2), (2) greater likelihood of AP CSP exam participation, and (3) similar pass rates**,** once they reached the exam (based on small sample sizes). These patterns suggest PACS implementation was effective at broadening participation in advanced computing coursework**,** especially through teacher preparation, schoolwide pathways, and financial incentives tied to exam-taking. However, raising qualification rates will require continued investment in exam-aligned instruction**,** test preparation**,** or additional instructional supports**.**

This finding supports PACS's theory of change: expanding access and opportunity—especially in rural, underrepresented settings—is a necessary first step. The statistically significant gains in computational thinking (RQ2) and much higher rates of AP exam-taking (EQ9) indicate system-level progress toward equitable CS participation.

EQ5 Finding: Participation in PACS Schools Was Not Associated with Significantly Higher Attitudes for 9th Grade Students

EQ5: What is the effect on CS attitudes of students in schools receiving PACS compared to the CS attitudes of students in schools in the business-as-usual comparison condition?

- *Focus:* For all students at the end of 9th grade? (Treatment students may or may not have taken ECS; comparison students will not have been offered ECS)

Overview

This exploratory analysis compared four key attitude constructs—Belonging, Encouragement**,** Interest, and Confidence—between students in PACS and non-PACS schools, measured at the beginning (Baseline) and end (Year 1) of 9th grade. While some students in the treatment group were enrolled in Exploring Computer Science (ECS), this was not universal. Control students did not take ECS in 9th grade.

Belonging

Descriptive statistics are shown in Table 3.2.11 and Figure 3.2.6. All variables range from 1.0-4.0.

Table 3.2.11 Descriptive Statistics for Belonging, Baseline and Year 1

Timepoint	Group	N	Mean	Std Dev
Baseline	Treatment	960	2.51	0.44
Baseline	Control	371	2.35	0.41
Year 1	Treatment	796	2.37	0.45
Year 1	Control	275	2.24	0.47

Skewness for the treatment group at baseline was -0.14, indicating approximate symmetry. Shapiro-Wilk tests showed significant deviations from normality across groups ($p < .001$); however, ANOVA is robust to non-normality given large samples. Levene's test for homogeneity of variance could not be computed, likely due to unbalanced subgroup sizes.

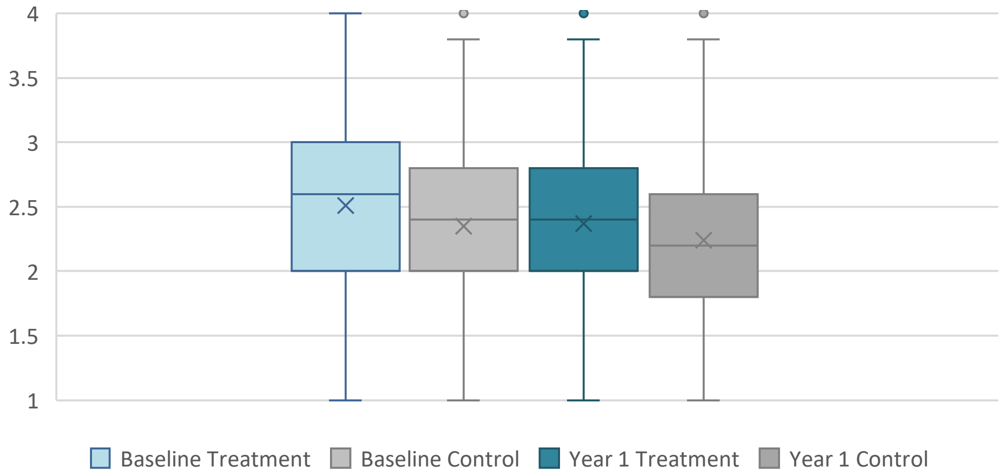
Key Findings for Belonging

Two-way ANOVA revealed:

- A main effect for group: treatment vs. control differed overall ($p < .001$)
- A main effect for time: attitudes changed from baseline to Year 1 ($p < .001$)
- No interaction effect: both groups declined similarly over time

Thus, although treatment students reported higher belonging overall, PACS participation did not significantly change the *trajectory* of belonging relative to controls.

Figure 3.2.6 Belonging at Baseline and Year 1



Encouragement

Descriptive statistics are shown in Table 3.2.12 and Figure 3.2.7. All variables range from 1.0-4.0.

Table 3.2.12 Descriptive Statistics for Encouragement Baseline and Year 1

Timepoint	Group	N	Mean	Std Dev
Baseline	Treatment	960	2.22	0.45
Baseline	Control	371	2.16	0.41
Year 1	Treatment	796	2.21	0.47
Year 1	Control	275	2.14	0.49

Skewness was 0.178, well within the acceptable range. Levene's test confirmed equal variances across groups.

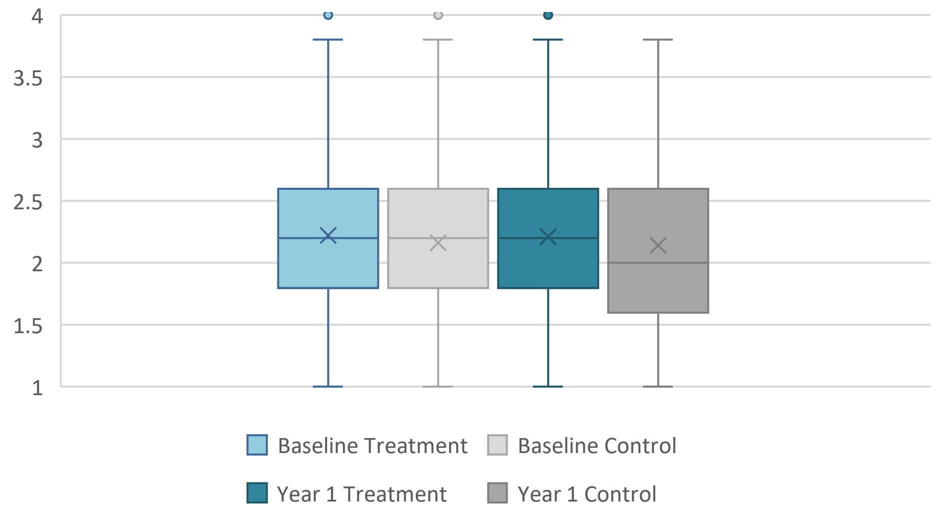
Key Findings

Two-way ANOVA showed:

- A significant main effect for group ($p < .05$)
- No effect for time
- No group × time interaction

This indicates a consistent group difference, with no evidence that treatment students improved more than controls in perceived encouragement.

Figure 3.2.7 Encouragement at Baseline and Year 1



Interest

Descriptive statistics are shown in Table 3.2.13 and Figure 3.2.8. All variables range from 1.0-4.0.

Table 3.2.13 Descriptive Statistics for Interest Baseline and Year 1

Timepoint	Group	N	Mean	Std Dev
Baseline	Treatment	960	2.51	0.55
Baseline	Control	371	2.41	0.51
Year 1	Treatment	796	2.42	0.56
Year 1	Control	275	2.33	0.57

Levene’s test confirmed homogeneity of variance. The Shapiro-Wilk test indicated non-normal residuals (p < .05), though ANOVA is robust with large samples.

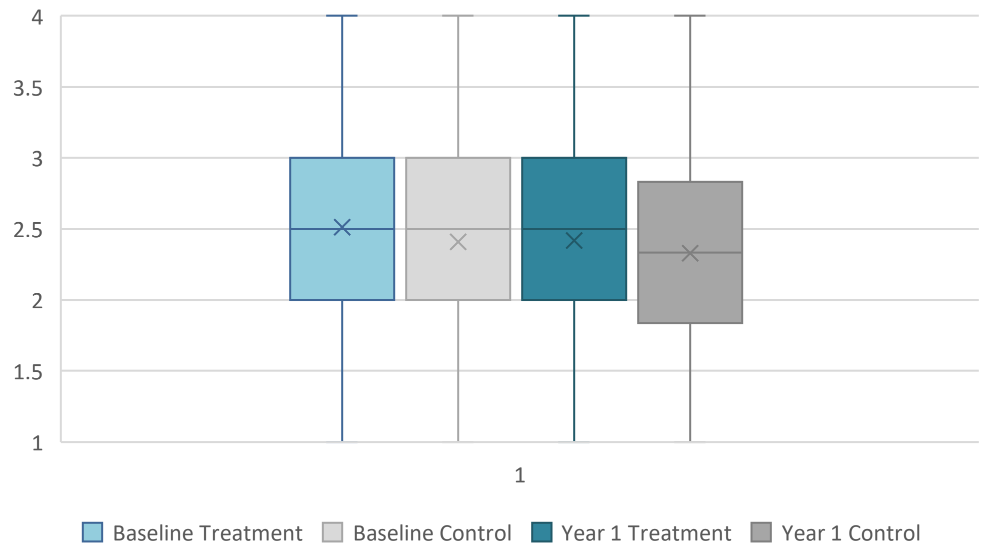
Key Findings

A two-way ANOVA found:

- A significant group effect (p = .005)
- A significant time effect (p = .002)
- No significant interaction

Although treatment students expressed greater interest overall, both groups declined similarly over time. Again, the treatment did not significantly alter the rate of decline.

Figure 3.2.8 Interest at Baseline and Year 1



Confidence

Descriptive statistics are shown in Table 3.2.14 and Figure 3.2.9. All variables range from 1.0-4.0.

Table 3.2.14 Descriptive Statistics for Interest Baseline and Year 1

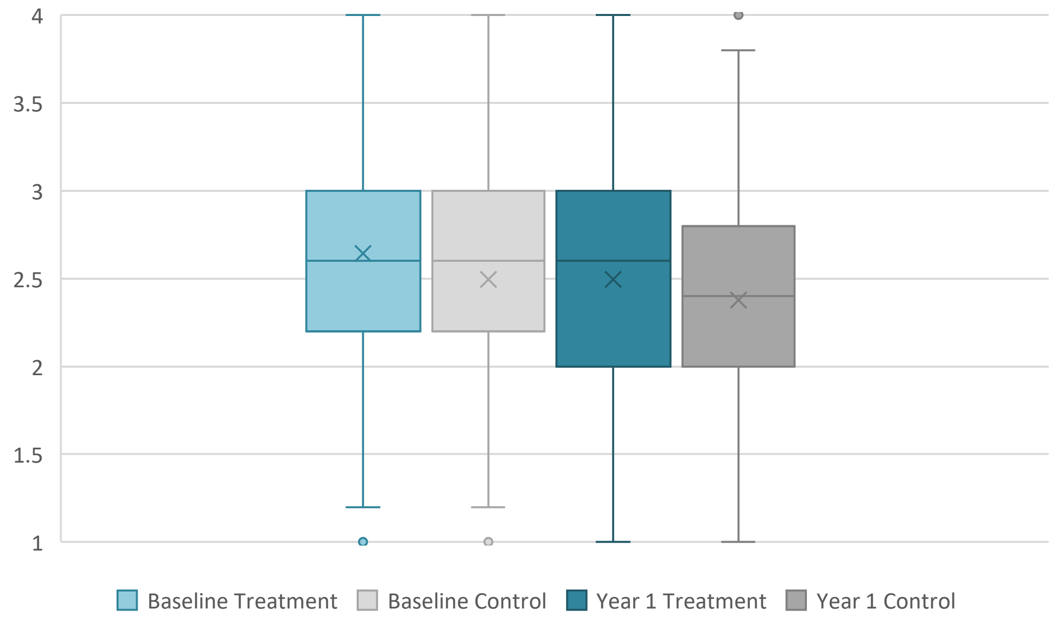
Timepoint	Group	N	Mean	Std Dev
Baseline	Treatment	960	2.64	0.37
Baseline	Control	371	2.50	0.33
Year 1	Treatment	796	2.50	0.43
Year 1	Control	275	2.38	0.39

Levene's test supported equal variance; Shapiro-Wilk was significant, indicating non-normality, which is not concerning given large N.

Key Findings

A two-way ANOVA results:
- Significant group effect (p < .001)
- Significant time effect (p < .001)
- No significant interaction

Figure 3.2.9 Confidence at Baseline and Year 1



Interpretation and Implications

Across all four constructs, students in PACS schools generally reported higher baseline and Year 1 attitudes compared to controls. A two-way ANOVA analysis of 9th grade students' attitudes toward computer science—including Belonging, Encouragement, Interest, and Confidence—revealed no statistically significant interaction between time and treatment condition. While treatment group students in PACS schools consistently reported slightly higher baseline attitudes than their peers in business-as-usual schools, both groups experienced comparable declines across all constructs from baseline to the end of Year 1. Main effects for group and time were occasionally significant (e.g., Belonging and Confidence), but the lack of a treatment-by-time interaction suggests the PACS intervention did not meaningfully shift the trajectory of student attitudes during the first year. These findings point to the difficulty of moving attitudinal outcomes through schoolwide exposure alone—particularly in the absence of guaranteed ECS enrollment in 9th grade. Subsequent years of the pathway may reveal delayed or cumulative effects on student motivation and identity in computing.

EQ6 Finding: Participation in PACS Schools Was Associated with Small Group Differences in CS Attitudes for 11th Grade Students

EQ6: What is the effect on CS attitudes of students in schools receiving PACS compared to the CS attitudes of students in schools in the business-as-usual comparison condition?

- *Focus:* For all students at the end of 11th grade? (Treatment students may or may not have taken ECS, will have taken Bootstrap Algebra, may or may not have taken AP CSP; comparison students will not have been offered ECS, will not have taken Algebra with Bootstrap, and may or may not have taken AP CSP)

Overview

This exploratory analysis compared four key attitude constructs—Belonging**,** Encouragement**,** Interest, and Confidence—between students in PACS and non-PACS schools, measured at the beginning (Baseline) and end (Year 1) of 9th grade, and at the end of (Year 3) 11th grade. Students in Treatment schools were offered a three-years CS Pathway through PACS; students in comparison schools were not.

Belonging

Descriptive statistics are shown in Table 3.2.15 and Figure 3.2.10. All variables range from 1-4.

Table 3.2.15 Descriptive Statistics for Belonging, Baseline, Year 1, and Year 3

Timepoint	Group	N	Mean	Std Dev
Baseline	Treatment	799	2.41	0.37
Baseline	Control	371	2.35	0.41
Year 1	Treatment	796	2.37	0.45
Year 1	Control	275	2.24	0.47
Year 3	Treatment	544	2.39	0.50
Year 3	Control	258	2.36	0.41

Shapiro-Wilk Tests for Normality were used within each subgroup (by Time and Group). All p-values were less than .001, indicating significant deviations from normality for all combinations. ANOVA is generally robust to violations of normality in large samples Levene's Test for Homogeneity of Variance was not significant, indicating equal variances across groups — satisfying this ANOVA assumption.

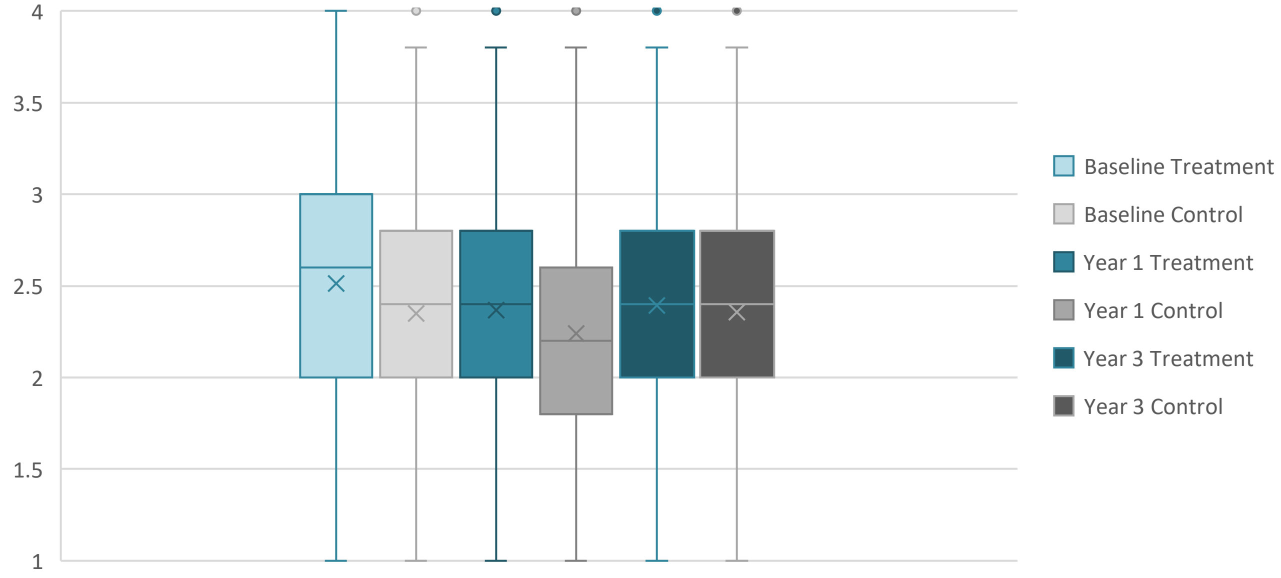
Key Findings

Two-Way ANOVA Results for Belonging

Source	Sum of Squares	df	F	p-value
Time	10.92	2	12.18	< .001
Group	9.19	1	20.51	< .001
Time × Group	1.71	2	1.9	0.149
Residual	1433.42	3198		

Time and Group main effects were both significant. Students' sense of belonging varied significantly across timepoints and between treatment and control groups overall. There was no significant Time × Group interaction, meaning the pattern of change over time did not differ significantly between groups.

Figure 3.2.10 Belonging at Baseline, Year 1, and Year 3



Belonging scores increased or shifted over time, and PACS vs. non-PACS schools differed in overall belonging scores. However, the interaction was not significant, so while both time and group had effects, the PACS impact on change over time was not statistically distinct from business-as-usual. The main effects of both time and group suggest that students in PACS schools felt a higher sense of belonging overall. All students, regardless of group, showed significant differences in belonging across years. However, no interaction indicates PACS did not specifically drive that change. Students may develop greater belonging through typical high school experiences; PACS schools showed slightly higher belonging, but the change wasn't attributable to the PACS intervention specifically.

Encouragement

Descriptive statistics are shown in Table 3.2.16 and Figure 3.2.11. All variables range from 1-4.

Table 3.2.16 Descriptive Statistics for Encouragement Baseline, Year 1, and Year 3

Timepoint	Group	N	Mean	Std Dev
Baseline	Treatment	799	2.13	0.38
Baseline	Control	371	2.16	0.41
Year 1	Treatment	796	2.21	0.47
Year 1	Control	275	2.14	0.49
Year 3	Treatment	544	2.26	0.52
Year 3	Control	258	2.24	0.47

Shapiro-Wilk tests showed significant deviations from normality in most groups (as expected with large samples). Baseline Control values could not be tested due to missing data. Levene's test for homogeneity of variance could not be computing.

Key Findings

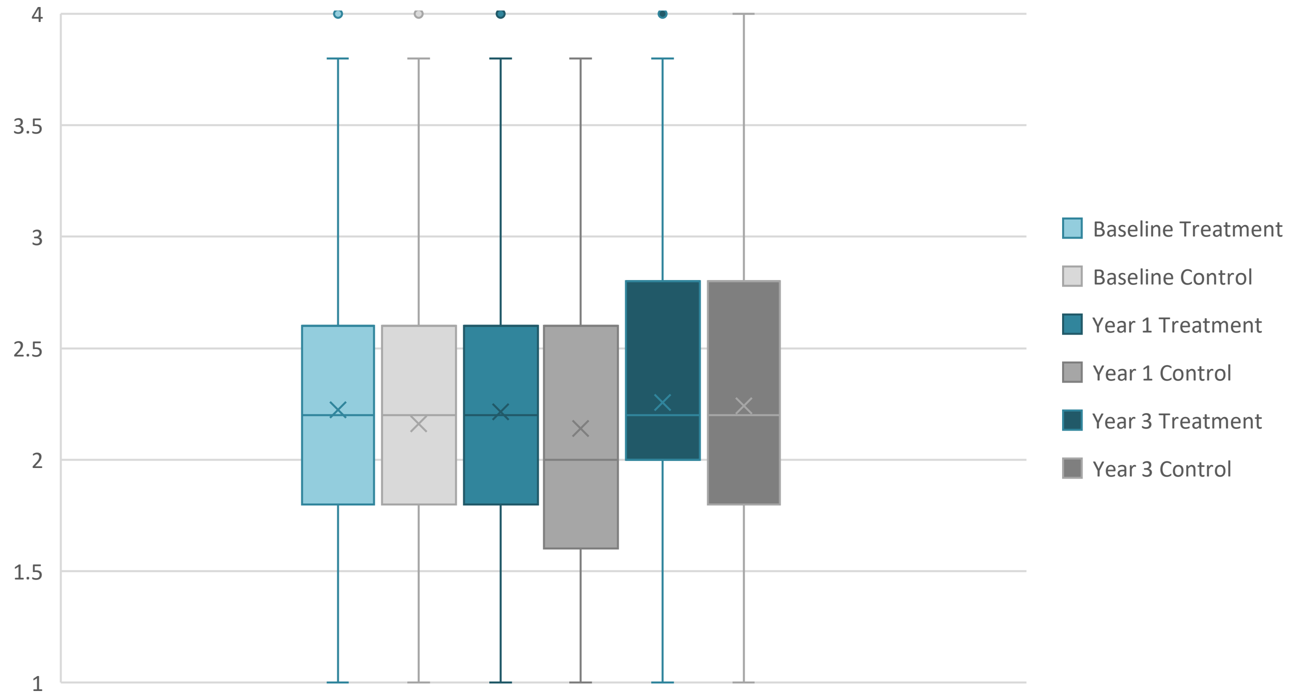
Two-Way ANOVA Results for Encouragement

Source	Sum of Squares	df	F-value	p-value
Time	1.75	2	1.87	0.154
Group	1.84	1	3.94	0.047
Time × Group	0.36	2	0.38	0.682
Residual	1493.86	3198		

Interpretation

There was a Group main effect. The difference in encouragement scores between the treatment and control groups was statistically significant at the p < .05 level. This suggests that, when averaged across timepoints, students in PACS schools (treatment) reported higher encouragement to pursue computing than those in comparison schools. There no significant Time main effect or Time x Group interaction, meaning the pattern of change over time was

Figure 3.2.11 Encouragement at Baseline, Year 1, and Year 3



A main effect of Group indicates that PACS students reported higher encouragement levels on average. However, no Time effect or interaction was found. PACS schools consistently foster a more encouraging environment, possibly through teacher development, educated counselors, culture, or peer networks—but encouragement did not change significantly over time within either group.

Interest

Descriptive statistics are shown in Table 3.2.17 and Figure 3.2.12. All variables range from 1-4.

Table 3.2.17 Descriptive Statistics for Interest Baseline, Year 1, and Year 3

Timepoint	Group	N	Mean	Std Dev
Baseline	Treatment	799	2.38	0.46
Baseline	Control	371	2.41	0.51
Year 1	Treatment	796	2.42	0.56
Year 1	Control	275	2.33	0.57
Year 3	Treatment	544	2.40	0.58
Year 3	Control	258	2.42	0.52

Levene's test confirmed homogeneity of variance. Normality tests by group and timepoint show significant deviations from normality (p < .001 in all cases).

Key Findings
Two-Way ANOVA Results for Interest

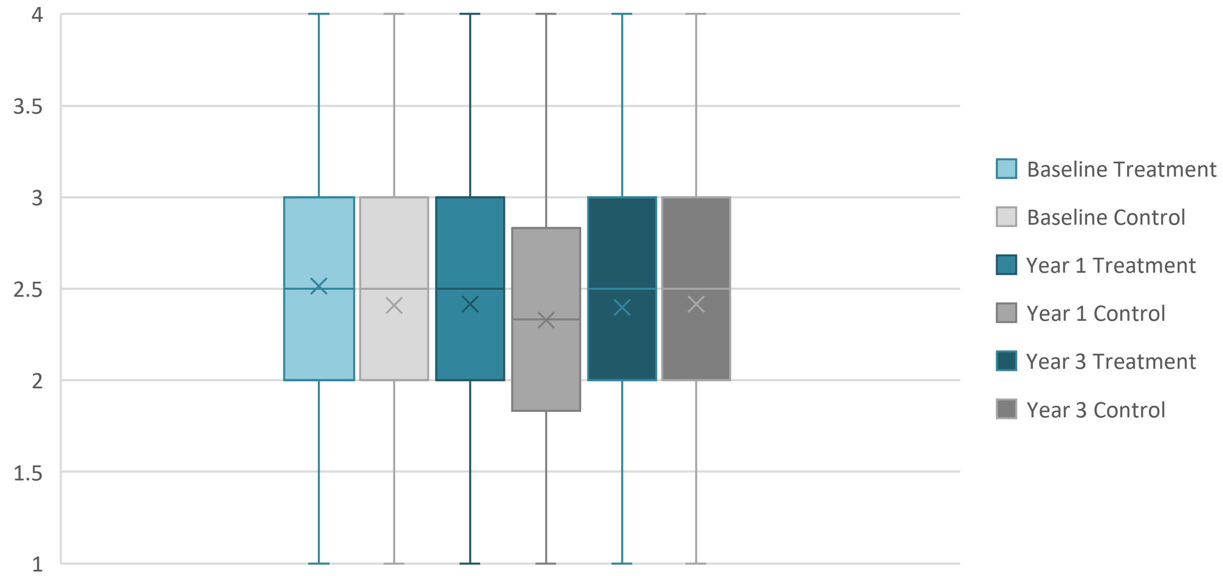
Effect	SS	df	F	p-value
Time	5.9	2	5.34	0.0048
Group	2.69	1	4.88	0.0273
Time × Group	1.75	2	1.59	0.205
Residual	1766.88	3198		

Although treatment students expressed greater interest overall, both groups declined similarly over time. Again, the treatment did not significantly alter the rate of decline.

Interpretation

There was a Group main effect. Students' interest levels changed across timepoints. The difference in interest scores between the treatment and control groups was statistically significant at the p < .05 level. This suggests that, when averaged across timepoints, students in PACS schools (treatment) reported higher interest to pursue computing than those in comparison schools. There was no significant Time main effect or Time x Group interaction, meaning the pattern of change over time was similar for both treatment and control group – no evidence of diverging or converging trends.

Figure 3.2.12 Interest at Baseline, Year 1, and Year 3



Interest declined over time in both groups. There was a Group effect, favoring PACS schools, but no interaction. While PACS students were more interested in computing overall, their interest waned just as it did for comparison students. This suggests structural or motivational challenges in sustaining CS interest through high school, even with extended exposure.

Confidence

Descriptive statistics are shown in Table 3.2.18 and Figure 3.2.13. All variables range from 1-4.

Table 3.2.18 Descriptive Statistics for Confidence, Baseline, Year 1, and Year 3

Timepoint	Group	N	Mean	Std Dev
Baseline	Treatment	799	2.57	0.33
Baseline	Control	371	2.50	0.33
Year 1	Treatment	796	2.50	0.43
Year 1	Control	275	2.38	0.39
Year 3	Treatment	544	2.51	0.44
Year 3	Control	258	2.54	0.35

Shapiro-Wilk was significant, indicating non-normality, which is not concerning given large N. The Shapiro-Wilk test results for normality (by group and timepoint) show that all subgroups significantly deviate from normality (p-values < .05), which is common in large samples. This result is statistically significant, indicating unequal variances across groups. Caution is advised when interpreting ANOVA results, though this test can be overly sensitive in large samples.

Key Findings

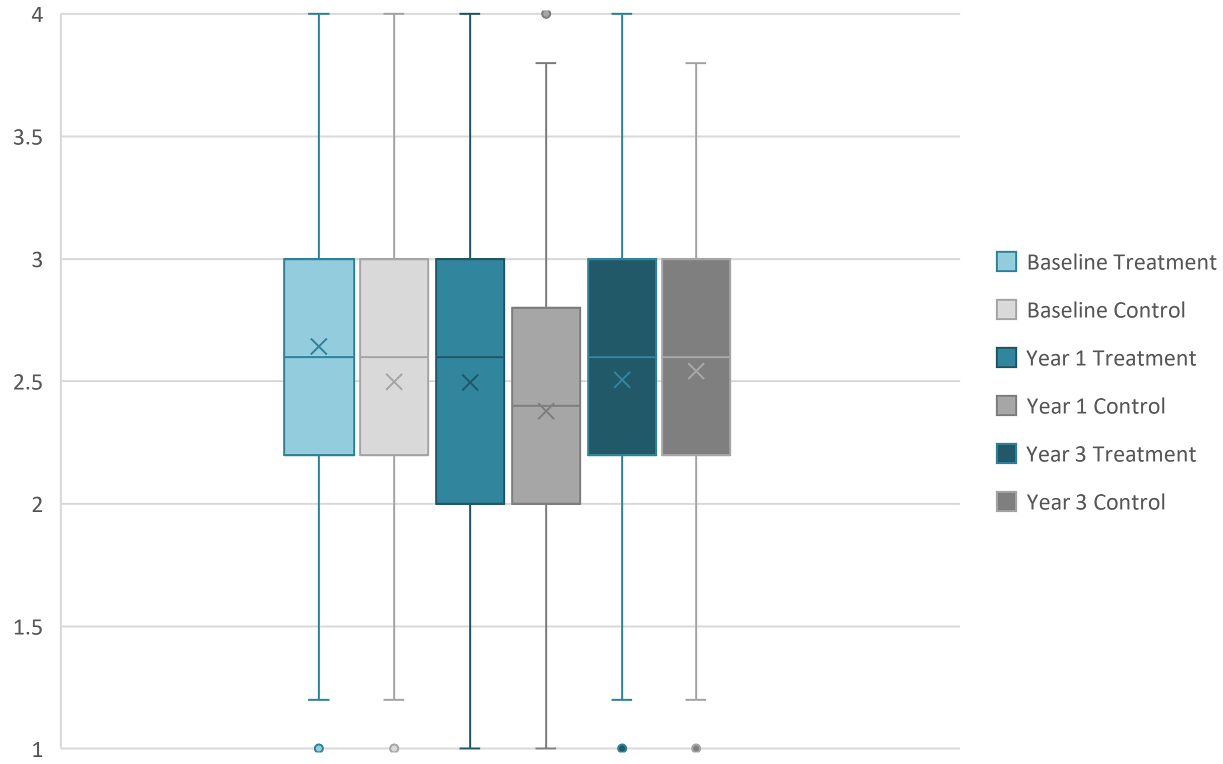
Two-way ANOVA results:

Source	Sum Sq	df	F	p-value
Group	5.07	1	12.92	0.00033
Time	11.47	2	14.62	<0.000001
Time × Group	3.73	2	4.75	0.0087
Residual	1254.95	3198	—	—

Interpretation

All effects were significant. The Group main effect indicates that PACS participation was associated with higher confidence across timepoints. The main effect of Time indicates confidence levels changed over time. The effects of PACS varied by timepoint, suggesting a differential trajectory for PACS students (more stable scores) compared with control students.

Figure 3.2.13 Confidence at Baseline, Year 1, and Year 3



Interpretation and Implications

PACS schools showed higher overall CS confidence. In addition, confidence patterns differed slightly between PACS and non-PACS students. This supports the notion that sustained exposure to PACS may contribute to student confidence in computing.

<u>EQ7 Finding</u>: Participation in PACS Schools Was Not Associated with Significantly Higher CS Career Interest for 9th Grade Students

EQ7: What is the effect on CS career interest of students in schools receiving PACS compared to the CS attitudes of students in schools in the business-as-usual comparison condition?

- For all students at the end of 9th grade? (Treatment students may or may not have taken ECS; comparison students will not have been offered ECS)

Overview

This exploratory analysis focused on 9th grade students' interest in computing careers, comparing those in PACS schools to peers in non-PACS schools at two timepoint: the beginning (Baseline) and end (Year 1) of 9th grade. The CS Career Interest construct measured how important students considered a future job that involved various computing roles that included: innovation in computing, web development, software design and development, network support, programming, system administration, cybersecurity, and business IT and community tech support. Each item was rated 1.0-4.0, with higher scores indicating greater interest.

Descriptive statistics are shown in Table 3.2.19 and Figure 3.2.14.

Table 3.2.19 Descriptive Statistics for CS Career Interest, Baseline and Year 1

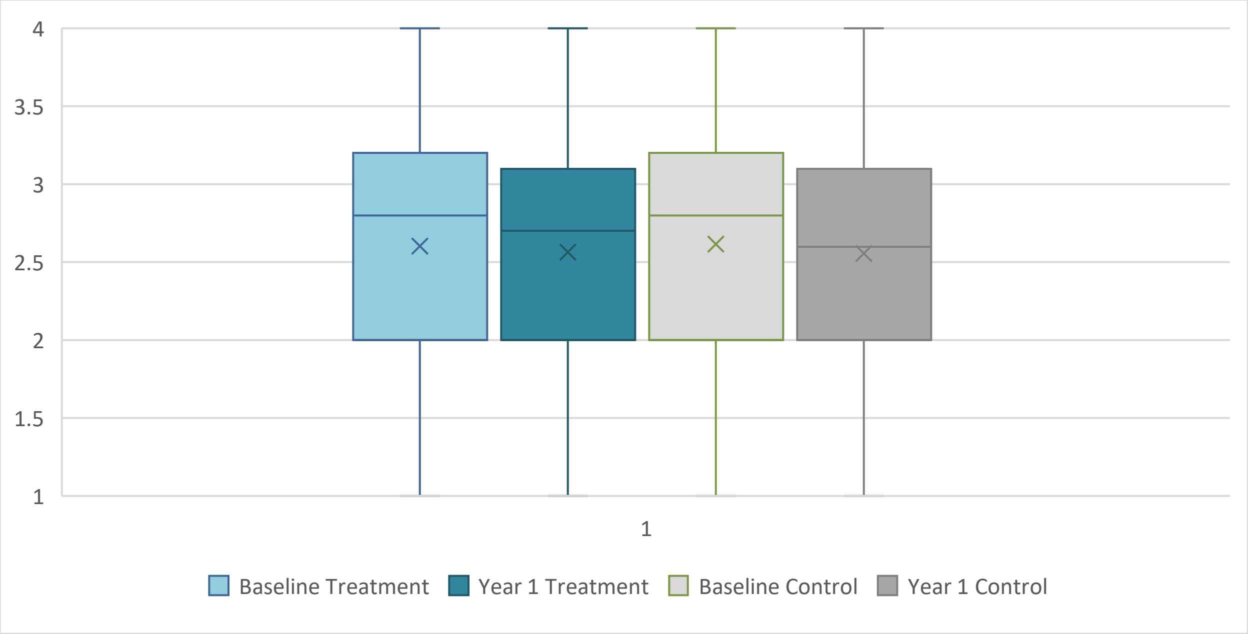
Timepoint	Group	N	Mean	Std Dev
Baseline	Treatment	960	2.60	0.68
Baseline	Control	371	2.62	0.69
Year 1	Treatment	796	2.57	0.70
Year 1	Control	275	2.56	0.65

Shapiro-Wilk tests showed significant deviations from normality for each subgroup ($p < .001$) which is common in large samples; however, ANOVA is robust to non-normality given large samples. Levene's test for homogeneity of variance was p=0.787, indicating similar variances across groups.

Key Findings

A two-way ANOVA found no statistically significant main effects for group or time, and no interaction effect between group and time. This suggests that students' interest in computing careers remained stable from the beginning to the end of 9th grade—regardless of whether they attended a PACS school

Figure 3.2.14 CS Career Interest at Baseline and Year 1



Interpretation and Implications

Students' interest in computing careers remained relatively stable over the course of 9th grade, with no statistically significant differences between students in PACS (Pathway) and comparison schools. Students in Pathway schools had limited exposure to ECS in 9th grade (participation was optional), which likely contributed to the null result. This result suggests that exposure to PACS school environments alone—without guaranteed ECS course participation or deeper program engagement—may not be sufficient to influence career interest in computing in the short term.

The findings reinforce the idea that students' career aspirations in computing may be relatively stable by 9th grade, at least within this rural Alabama population. Further analyses of students with direct course participation or multi-year pathway engagement may reveal more targeted impacts.

EQ8 Finding: Participation in PACS Schools Was Not Associated with Significantly Higher CS Career Interest for 11th Grade Students

EQ8: What is the effect on CS career interest of students in schools receiving PACS compared to the CS attitudes of students in schools in the business-as-usual comparison condition?

- For all students at the end of 11th grade? (Treatment students may or may not have taken ECS, will have taken Bootstrap Algebra, may or may not have taken AP CSP; comparison students will not have been offered ECS, will not have taken Algebra with Bootstrap, and may or may not have taken AP CSP)

Overview

This exploratory analysis compared 11th grade students' interest in computing careers, comparing those in PACS schools to peers in non-PACS schools at three timepoints: the beginning (Baseline)of Year 1, the end (Year 1) of 9th grade, and the end of 11th grade. The CS Career Interest construct measured how important students considered a future job that involved various computing roles that included: innovation in computing, web development, software design and development, network support, programming, system administration, cybersecurity, and business IT and community tech support. Each item was rated 1.0-4.0, with higher scores indicating greater interest.

Descriptive statistics are shown in Table 3.2.20 and Figure 3.2.15.

Table 3.2.20 Descriptive Statistics for CS Career Interest, Baseline, Year 1, and Year 3

Timepoint	Group	N	Mean	Std Dev
Baseline	Treatment	960	2.60	0.68
Baseline	Control	371	2.62	0.69
Year 1	Treatment	796	2.57	0.70
Year 1	Control	275	2.56	0.65
Year 3	Treatment	539	2.50	0.89
Year 3	Control	254	2.55	0.84

Shapiro-Wilk tests showed all subgroups significantly deviated from normality (p < .001) which is expected in large samples and not a major concern for ANOVA. Levene's test for homogeneity of variance was p=0.17, indicating similar variances across groups.

Key Findings

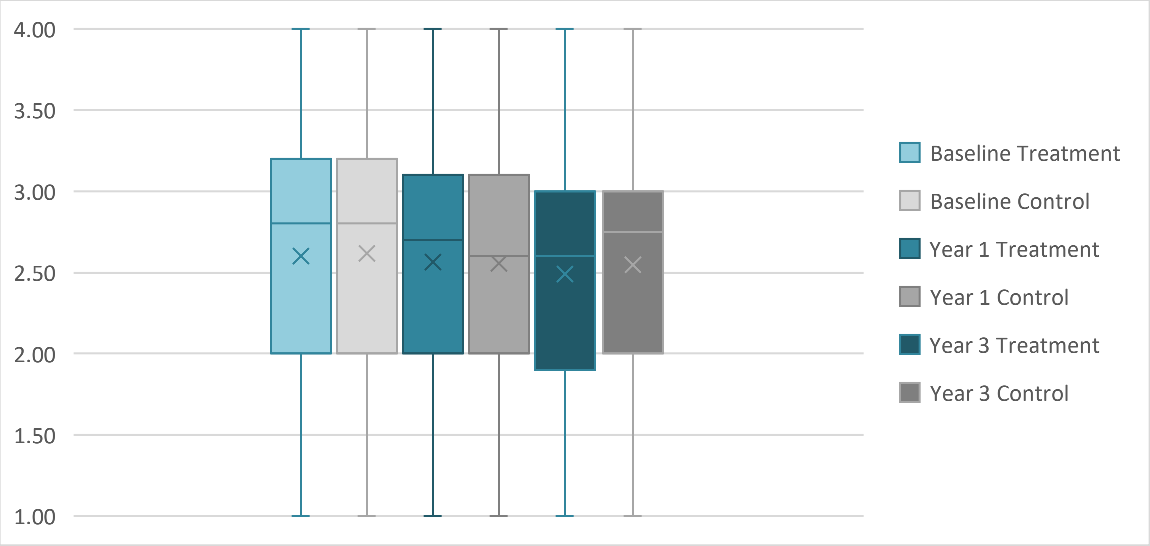
Two-way ANOVA results:

Source	SS	df	F	p-value
Time	4.5	2	3.19	0.041
Group	0.2	1	0.29	0.592
Time × Group	0.35	2	0.25	0.78
Residual	2251.15	3197		

Interpretation

Students' computing career interest declined slightly over time, regardless of school type. There were no Group main effects or interaction effects – no difference between students from Pathway and comparison schools, and patterns of change over time were similar between groups.

Figure 3.2.15 CS Career Interest at Baseline, Year 1, and Year 3



Across 9th and 11th grades, students in PACS (Pathway) schools did not show significantly different levels or trajectories of interest in computing careers compared to peers in non-PACS schools. A two-way ANOVA of CS Career Interest scores found no significant main Group effects and no interaction effects, indicating that participation in PACS did not lead to detectable changes in student aspirations toward computing careers. While a slight decline in interest was observed across all students from 9th to 11th grade, this trend did not differ by treatment condition. These findings suggest that light-touch or indirect exposure to computing environments may be insufficient to shift career goals without consistent, multi-year, course-based engagement.

4. Evaluation of Implementation Results: Summer 2025 and Across Years (2020-2024)

Over the past six years, the Pathways for Alabama Computer Science initiative fundamentally expanded computer science capacity in Alabama's rural schools. Launched in 2020 during the height of the COVID-19 pandemic, PACS offered multiple professional development strands to strengthen the capacity of teachers and counselors across the state. These strands included Exploring Computer Science (2020-2025), Bootstrap Algebra (2020-2024), Bootstrap Data Science (2025), AP Computer Science Principles (2020-2024), and Counselors for Computing (2020-2025). Support for school-based communities of practices was also provided by PACS.

The PACS evaluation team designed and conducted an evaluation study of implementation of the intervention, providing high-quality data and performance feedback. It has yielded important information about when, why, and how the intervention worked. Data were collected through observations and participant surveys, with attention to participant experience, program impact, and quality across teachers and cohorts. This section presents results from summer 2025, while previous reports (Haynie et al., 2020-2024) provided detailed analyses for summers 2020 through 2024. Summaries of implementation fidelity are provided across Years 0 through 5 for each program.

4.1. Framing the Implementation Study of the Intervention

Using observational and survey methods, implementation fidelity of PACS courses and school-level community of practice were evaluated for quality across teachers, schools and cohorts.

Logic Model for the Intervention

The logic model for the PACS intervention is provided below (Exhibit 4.1.1). The key components of the intervention are to provide:

- Exploring Computer Science PD to Teachers
- Bootstrap Algebra PD to Teachers
- UTeach AP CS Principles PD to Teachers
- CS Professional Development to Counselors
- Support for School-level Communities of Practice (School-level CoP)

Projects mediators (a result of the key components, and linked to project outcomes) are:

- Teachers implement CS pathways within schools
- Counselors support students in studying CS
- School-level Communities of Practice (School-level CoPs) form and pursue CS pathway goals

Outcomes include:

- Students receive CS-infused instruction and supports for studying CS
- School CS culture is built and CS pathways are established at rural/town high schools
- Students increase in computational thinking concepts and practices, algebraic problem-solving, math achievement, CS attitudes, and interest in CS-STEM careers
- Students elect CS courses, move through CS pathways, and engage in CS-related workforce development and higher education

Research Questions for Evaluation of Implementation

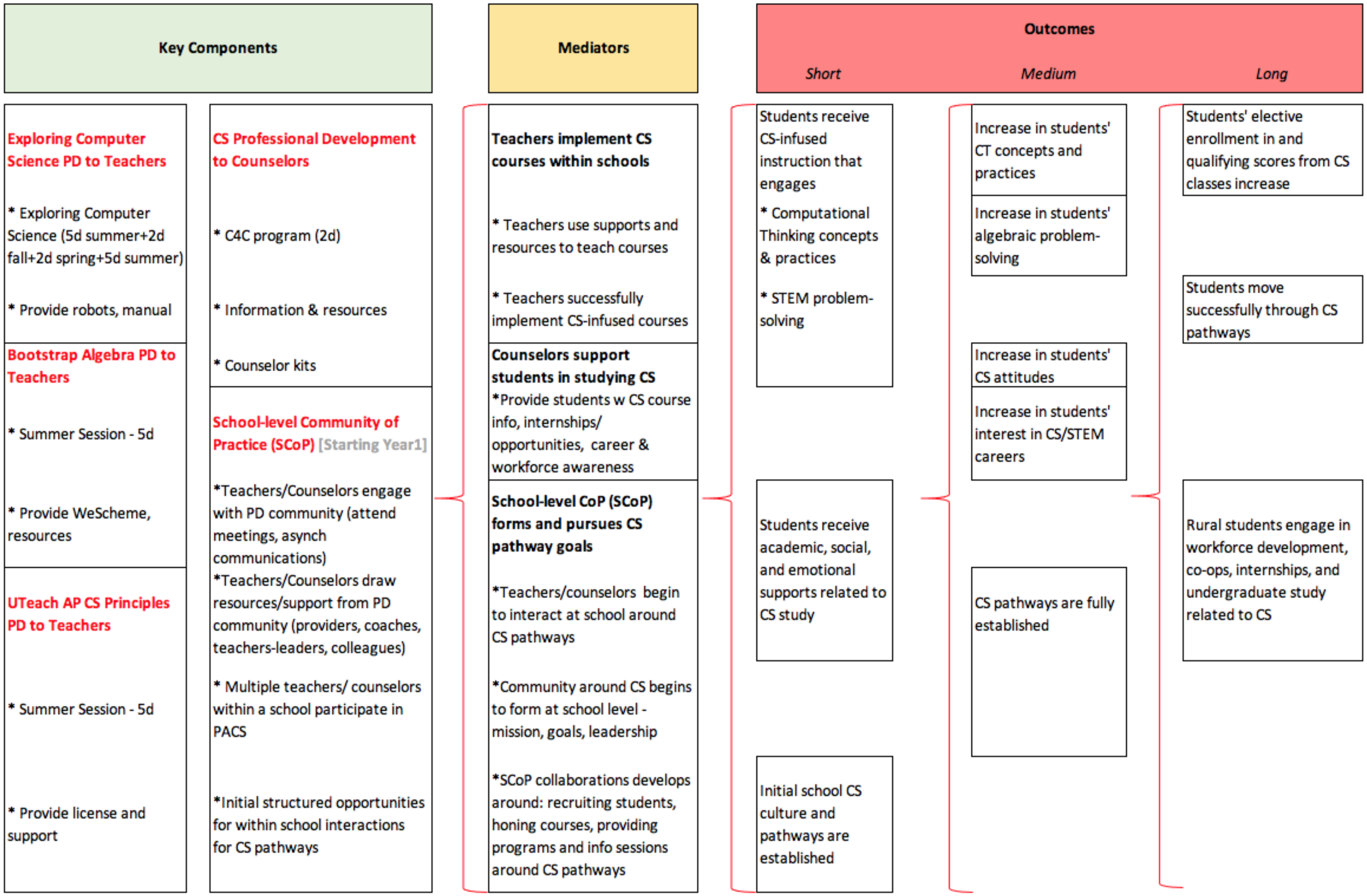
The implementation of key components was carried out in implementation years 0 through 5 of PACS (summers 2020 through 2025). Research questions and performance measures for the evaluation of implementation are shown below. Fidelity analysis performance measures are shown in Appendices B through F.

Questions	***Performance Measure***
FIQ1. Was Exploring Computer Science PD implemented for teachers with fidelity?	Fidelity analysis for professional development: Appendix B
FIQ2. Was Bootstrap Algebra PD implemented for teachers with fidelity?	Fidelity analysis for professional development: Appendix C
FIQ3. Was UTeach AP CS Principles PD implemented for teachers with fidelity?	Fidelity analysis for professional development: Appendix D
FIQ4. Was Counselors for Computing (C4C) PD implemented for counselors with fidelity?	Fidelity analysis for professional development: Appendix E
FIQ5. Was the School-level Community of Practice (CoP) implemented for educators with fidelity?	Fidelity analysis for School-level Community of Practice (School-level CoP): Appendix F

Implementation Results, Summer 2025 and Across Years

Using observational and teacher survey methods, the implementation fidelity of PACS courses were evaluated for quality across teachers, school districts, and cohorts. This section will discuss outcomes for Exploring Computer Science PD (FIQ1), Bootstrap Algebra PD (FIQ2), UTeach CS Principles PD (FIQ3), Counselors for Computing PD (FIQ4), and School-level Community of Practice for 2022-2023 (FIQ5).

Exhibit 4.1.1. Mediator Logic Model for PACS



Key Components

Exploring Computer Science PD to Teachers

- * Exploring Computer Science (5d summer+2d fall+2d spring+5d summer)
- * Provide robots, manual

Bootstrap Algebra PD to Teachers

- * Summer Session - 5d
- * Provide WeScheme, resources

UTeach AP CS Principles PD to Teachers

- * Summer Session - 5d
- * Provide license and support

CS Professional Development to Counselors

- * C4C program (2d)
- * Information & resources
- * Counselor kits

School-level Community of Practice (SCoP) [Starting Year1]

- *Teachers/Counselors engage with PD community (attend meetings, asynch communications)
- *Teachers/Counselors draw resources/support from PD community (providers, coaches, teachers-leaders, colleagues)
- * Multiple teachers/ counselors within a school participate in PACS
- *Initial structured opportunities for within school interactions for CS pathways

Mediators

Teachers implement CS courses within schools

- * Teachers use supports and resources to teach courses
- * Teachers successfully implement CS-infused courses

Counselors support students in studying CS

- *Provide students w CS course info, internships/ opportunities, career & workforce awareness

School-level CoP (SCoP) forms and pursues CS pathway goals

- *Teachers/counselors begin to interact at school around CS pathways
- *Community around CS begins to form at school level - mission, goals, leadership
- *SCoP collaborations develops around: recruiting students, honing courses, providing programs and info sessions around CS pathways

Outcomes

Short

Students receive CS-infused instruction that engages

- * Computational Thinking concepts & practices
- * STEM problem-solving

Students receive academic, social, and emotional supports related to CS study

Initial school CS culture and pathways are established

Medium

Increase in students' CT concepts and practices

Increase in students' algebraic problem-solving

Increase in students' CS attitudes

Increase in students' interest in CS/STEM careers

CS pathways are fully established

Long

Students' elective enrollment in and qualifying scores from CS classes increase

Students move successfully through CS pathways

Rural students engage in workforce development, co-ops, internships, and undergraduate study related to CS

4.2. Fidelity of Exploring Computer Science, Summer 2025

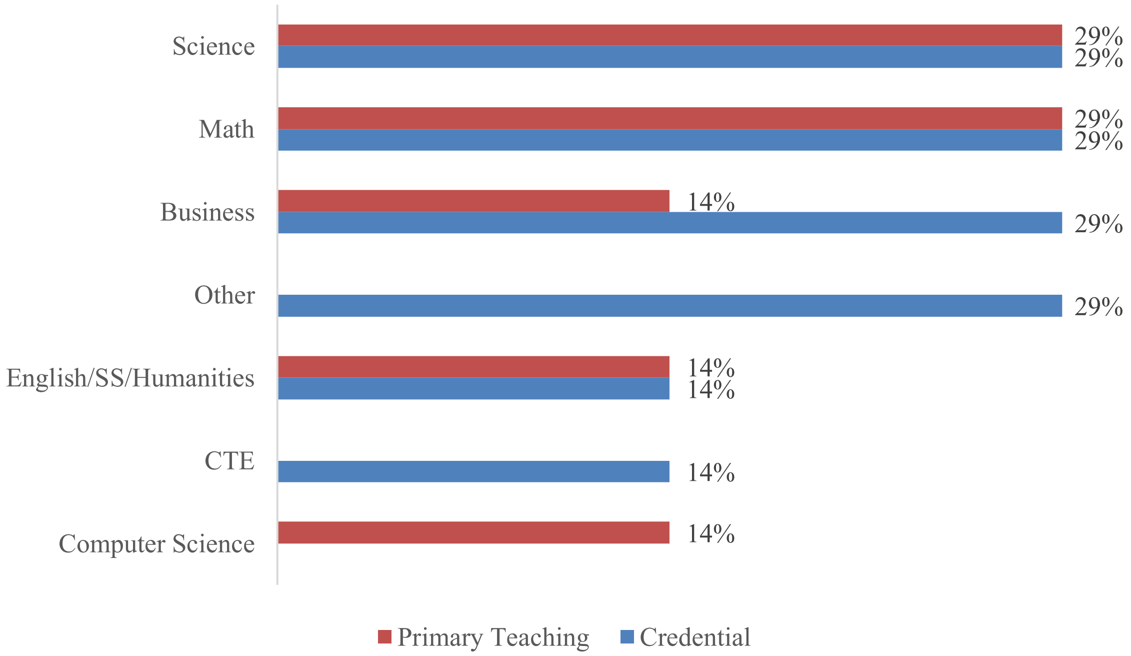
The 2025 Exploring Computer Science (ECS) PD at Tuskegee University, July 14-18, served ~60 teachers, with seven second year PACS-funded respondents averaging 17 years' experience across grades 9-12 and multiple subject areas. Satisfaction, participation, and preparation ratings were uniformly high (4.57–4.86/5), with the strongest marks for time use and facilitators' content knowledge. Observations documented an active "teacher-as-learner" model: rotating, group-led lessons, consistent journaling, and Teacher-Learner-Observer debriefs featuring units on sustainability, Web 2.0/data privacy, culturally situated design tools, and AI/media literacy. Participants valued collaboration, peer modeling, and resources.

A total of approximately sixty teachers (funded by both PACS and other sources) participated in the PD activities, with seven PACS-funded participants completing the funded PACS survey. Among the survey respondents, 43% identified as female and 57% as male. In terms of race and ethnicity, 43% identified as Black or African American, 43% identified as White, and 14% preferred not to answer. Fourteen percent of respondents also indicated a disability.

Participants represented a wide range of teaching fields (Figure 4.2.1), including science (29%), mathematics (29%), business (14% primary assignment but 29% credentialed), English/social studies/humanities (14%), career and technical education (14%), computer science (14%), and other disciplines such as elementary education and physical education (29%).

On average, respondents reported 17 years of teaching experience, with 29% having taught between 1-10 years, 43% with 11-20 years, and 29% with 21-35 years of experience. Teachers typically taught across multiple grade levels, with 57% teaching ninth grade, 57% teaching tenth grade, 71% teaching eleventh grade, and 71% teaching twelfth grade. This distribution reflects the program's reach across the high school curriculum and highlights the breadth of instructional experience among participating educators.

Figure 4.2.1: Teaching Fields and Credentials for ECS Participants, Summer 2025



Program Quality

Overall, participant satisfaction with the PD was very strong (Figure 4.2.2). Survey responses (n=7) reflected consistently high ratings across all categories, with scores ranging from 4.57 to 4.86 on a 5-point scale. These results demonstrate that participants viewed the PD as both relevant and effective in supporting their professional practice.

- Highest-rated areas (4.86): efficient use of time, presenters' content knowledge

These results highlight that participants felt the sessions were well-paced and delivered by facilitators with strong expertise.

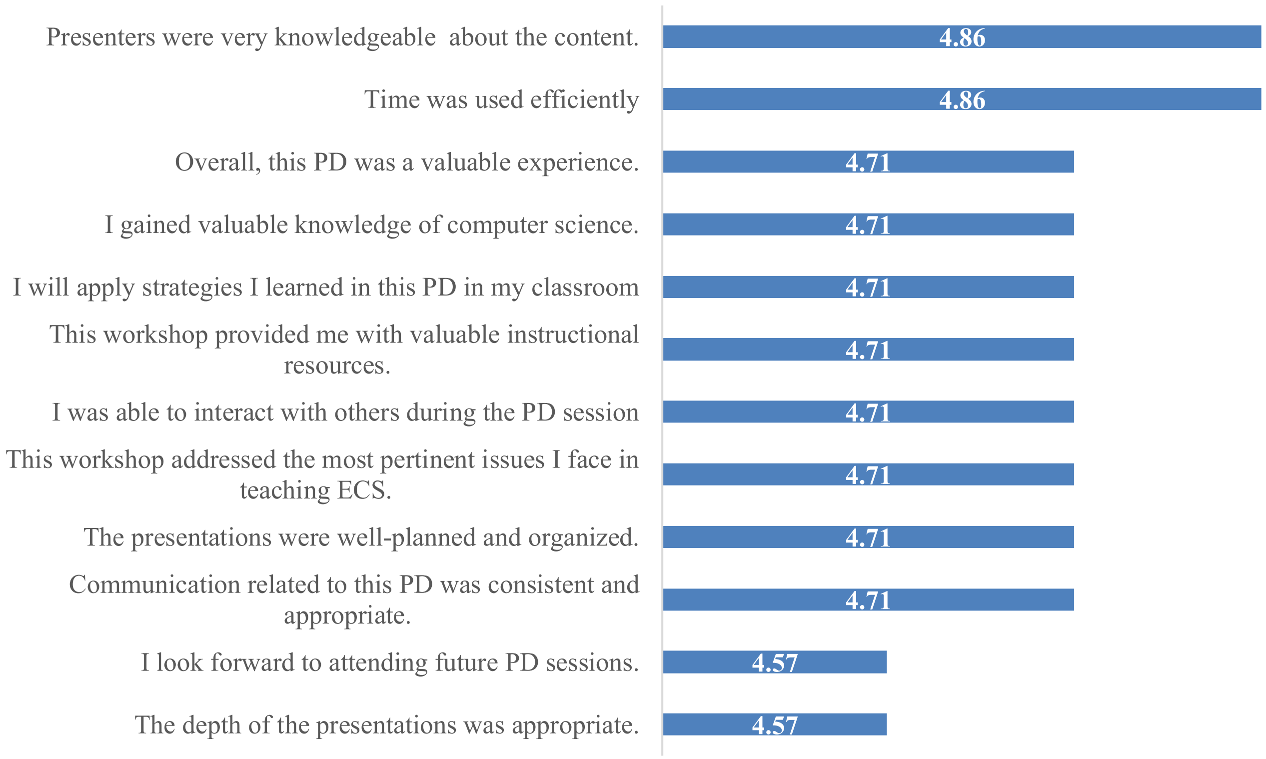
- Strong satisfaction (4.71): organization of the workshop, relevance to teaching ECS, opportunities for interaction, value of provided resources, applicability of strategies to classroom teaching, gains in computer science knowledge, overall value of the PD experience

These consistently high ratings reflect the program's effectiveness in providing practical, immediately applicable tools for teaching.

- Slightly lower but still very positive ratings (4.57): appropriateness of the depth of presentations, interest in attending future PD sessions

While slightly lower, these results remain highly favorable, suggesting room for refining the balance of depth and pacing in future workshops.

Figure 4.2.2: Satisfaction Levels for Summer 2025 ECS PD



Participation and Preparation

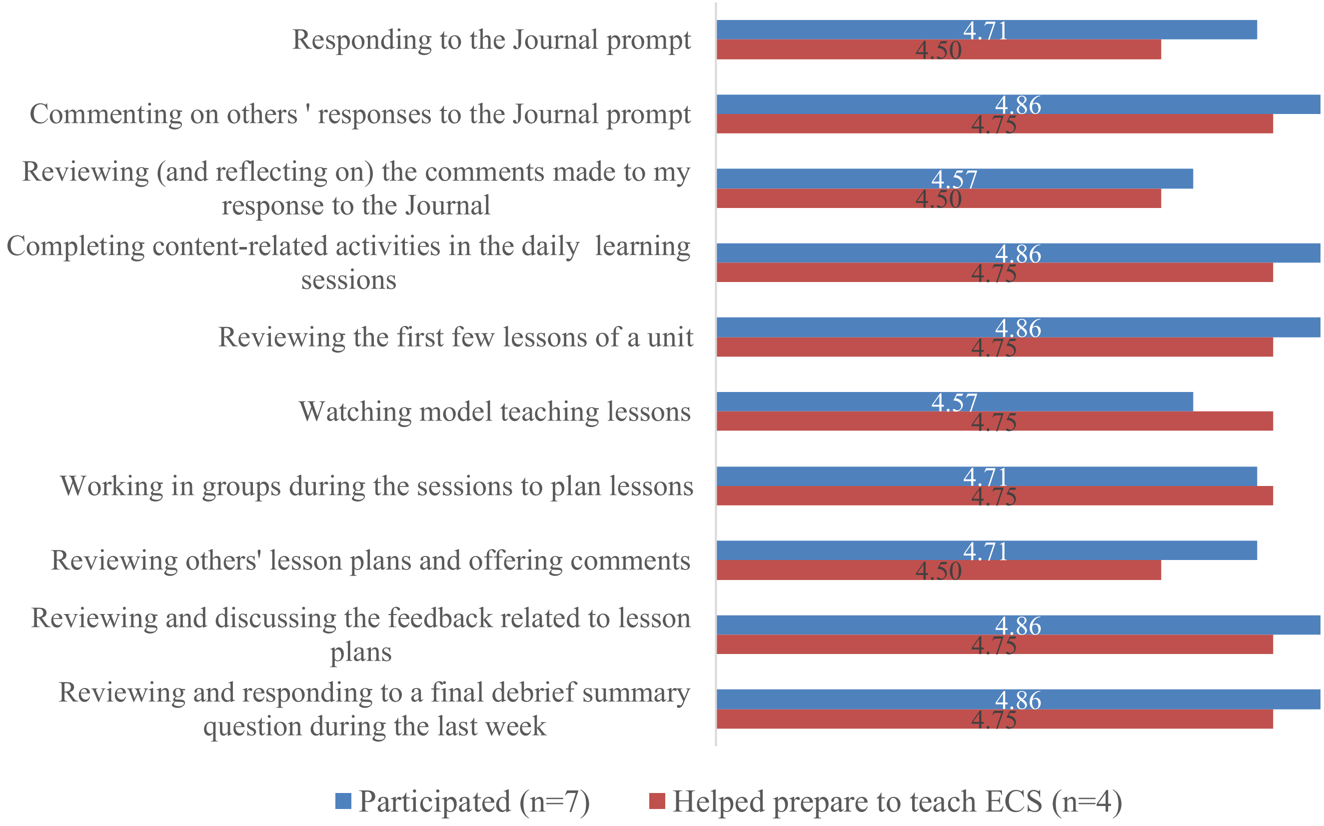
Based on the 5-point agreement scale (1=SD to 5=SA) participants in the ECS PD reported very high levels of agreement that activities were valuable and effective (Figure 4.2.3). For Participation, all average ratings (n=7) ranged from 4.57 to 4.86, indicating strong agreement across all activities. The highest-rated activities (4.86) included:

- Commenting on others' responses to the journal prompt
- Completing content-related activities in the daily learning sessions
- Reviewing the first few lessons of a unit
- Reviewing and discussing feedback on lesson plans
- Reviewing and responding to a final debrief summary question

For 'Helped prepare me to teach ECS', average ratings (n=4) were also consistently high, from 4.50 to 4.75. No single activity fell below strong agreement, and several tied at 4.75, suggesting that participants found multiple aspects of the PD equally beneficial for teaching preparation.

Participants exhibited uniformly strong positive perceptions of the PD activities, with only slight variation between participation levels and 'felt preparation to teach' levels. Activities involving interactive engagement (peer commenting, group work, reviewing feedback) received the highest ratings, indicating that collaborative and reflective elements were particularly valued.

Figure 4.2.3: Participation and Preparation Levels for ECS PD Summer 2025



Observational Overview

Over two observation days, the ECS PD ran as an active, teacher-as-learner model with rotating group-led lessons, constant journaling, and structured debriefs using the Teacher-Learner-Observer protocol. In Room 2 (July 15), teams modeled Unit 1/2 lessons on sustainability and device materials, Web 2.0/data privacy, and “Telling a Story with Data,” punctuated by Kahoot hooks, gallery walks, and evidence-gathering from articles and videos; equity was foregrounded through a shared reading of *Stuck in the Shallow End* and reflection prompts that connected content to school contexts. Facilitation emphasized inquiry (questions first, products second), frequent turn-and-talks, and visible objectives; observers highlighted strong engagement and also noted moments where clearer transitions and task directions would reduce confusion.

In Room 1 (July 16), facilitators launched with an AI media literacy opener (real vs. AI-generated images) leading to group posters on prior knowledge, ethics, bias, and classroom implications, followed by culturally situated design tools (bead loom, symmetry) and communication/identity activities that linked culture to computation. Journals framed each segment (“What is intelligence?”, “What does the data not tell you?”), and debriefs pushed teachers to plan adaptations (accessibility, relevance, classroom management) and to articulate ECS elevator speeches. Overall, the PD effectively modeled equitable, inquiry-driven CS pedagogy—teachers experienced the lessons as students, analyzed them as instructors, and left with concrete strategies, content extensions, and reflection routines to transfer to their own classrooms.

Participant Value and Classroom Application

Participants identified collaboration, shared resources, and peer modeling as the most valuable aspects of the professional development. They valued opportunities to work with lead teachers and colleagues to “gain insight and additional resources for teaching” and appreciated “hearing different perspectives and gaining insight into different techniques” during group discussions. Observing others teach and present the curriculum, as well as receiving instructional resources and sample lessons, were also highlighted as especially beneficial.

Equitable Practices. The PD emphasized the importance of equitable practices in computer science education. Participants emphasized that true equity requires adapting instruction to meet the unique needs of individual learners rather than treating all students the same. Differentiation, scaffolding, and intentional strategies to increase access and engagement were discussed as key tools for ensuring that underrepresented students feel represented and supported. The PD sessions modeled these practices through icebreakers, sample lessons, and facilitated discussions, giving participants concrete examples of how to embed equity into classroom routines. These activities reinforced the idea that teachers must proactively design for inclusivity to avoid unintentionally excluding students from meaningful participation.

Inquiry Practices. Inquiry-based learning was another major focus, with participants recognizing its essential role in classroom facilitation. Teachers reflected on the shift from direct instruction toward guiding students to investigate, research, and construct their own understanding. Strategies for prompting deeper student thinking-- beyond surface-level answers-- were explored, helping participants see how inquiry promotes critical thinking and engagement with core lesson content. The PD highlighted that inquiry is built into every ECS lesson, and this was made especially clear through group presentations and hands-on activities. Participants left with reinforced confidence in using inquiry practices to foster student curiosity and ownership of learning.

Computer Science Content. Finally, the PD expanded participants’ understanding of the breadth and depth of computer science content. Many participants noted that their perception of CS grew beyond programming and working with computers, to include its interdisciplinary nature, connections to problem-solving, data, networks, and societal impacts. They came to recognize that CS concepts can often be taught without direct computer use and that nearly every lesson can be linked back to core computer science principles. Some participants reported learning new concrete concepts—such as binary numbers and computational practices—while others confirmed and deepened their prior knowledge. Regardless of starting point, all participants gained a stronger grasp of how to make CS content both accessible and meaningful for their students.

These second year ECS participants deepened their abilities to foster equitable, inquiry-based classrooms by tailoring instruction to individual needs, guiding student-driven exploration, and embedding critical thinking into every lesson. They also broadened and strengthened their understanding of computer science as an interdisciplinary field, recognizing its applications beyond programming.

Classroom Application. Six of seven participants (86%) had taught the ECS course in 2024-2025. All participants plan to teach ECS in the 2025-2026 school year: 43% traditional yearlong, 29% block schedule-fall, 43% block schedule spring, and 14% schedule currently unknown.

Participants indicated that they plan to apply what they learned by integrating equitable practices into their classrooms, such as meeting diverse student needs and ensuring fairness in content access. Several mentioned using journaling, both to capture student ideas and as a daily routine in ECS classes, and adopting a facilitator role to encourage student creativity while maintaining equity. Others plan to implement new concepts, tips, and varied activities (e.g., rotating tasks) to keep students engaged and prevent burnout. A few participants shared:

"I will definitely use the tips and tricks I picked up from the other participants and the facilitators"

"Be a facilitator and let students be creative with their assignments while making content equitable"

"By rotating through different activities to make sure students do not get burned out."

Summary and Recommendations

The 2025 Exploring Computer Science Professional Development at Tuskegee University demonstrated high fidelity in both implementation and participant outcomes. Serving approximately 60 teachers, with detailed survey responses from seven PACS-funded participants, the PD received uniformly strong satisfaction ratings (4.57-4.86/5), especially for time use and facilitator content knowledge. Observational data confirmed an active, inquiry-driven, teacher-as-learner model that integrated equity-focused content (e.g., media literacy, culturally situated design tools), group collaboration, and reflective journaling. Participants, representing diverse backgrounds and teaching fields, valued peer modeling, actionable strategies, and an expanded understanding of computer science as interdisciplinary and accessible. Most notably, participants reported increased confidence in applying equitable and inquiry-based practices, including differentiated instruction, student-driven exploration, and reflective tools like journaling. All planned to teach ECS in the 2025-2026 school year, applying techniques such as rotating classroom activities and emphasizing student creativity to enhance engagement and inclusion. These findings suggest the ECS PD effectively supported teacher preparation and modeled pedagogical practices aligned with PACS goals of equity and sustainability in rural CS education.

After reviewing the quantitative and qualitative data collected, I offer three recommendations:

Recommendation #1: Deepen Computer Science Content and Rigor

Participants requested more robust engagement with CS concepts and exposure to lessons beyond the core ECS curriculum. I recommend expanding content-rich sessions to include advanced topics such as data ethics, AI, and cybersecurity, alongside additional practice with foundational CS skills. Teachers also need more support for commonly taught but underutilized units, especially Unit 5. These additions will strengthen pedagogical content knowledge and better equip teachers to deliver rigorous, relevant instruction.

Recommendation #2: Improve Accessibility and Equity of PD

Logistical challenges, particularly for rural teachers, hindered participation. To expand equitable access, I recommend hosting PD in regionally distributed locations or offering hybrid delivery. Travel stipends and housing support can further reduce barriers. These improvements would ensure that educators from high-need districts can participate fully and benefit from the training.

Recommendation #3: Provide Ongoing Support and Differentiated Follow-Up

To reinforce implementation and sustain growth, I recommend a system of ongoing supports that includes:

- **Regular check-ins** for collaborative problem-solving and reflection
- **On-demand guidance** through coaching or virtual office hours
- **Professional learning community** support for lesson adaptation and peer support
- **Advanced sessions** for experienced teachers to deepen expertise and mentor others

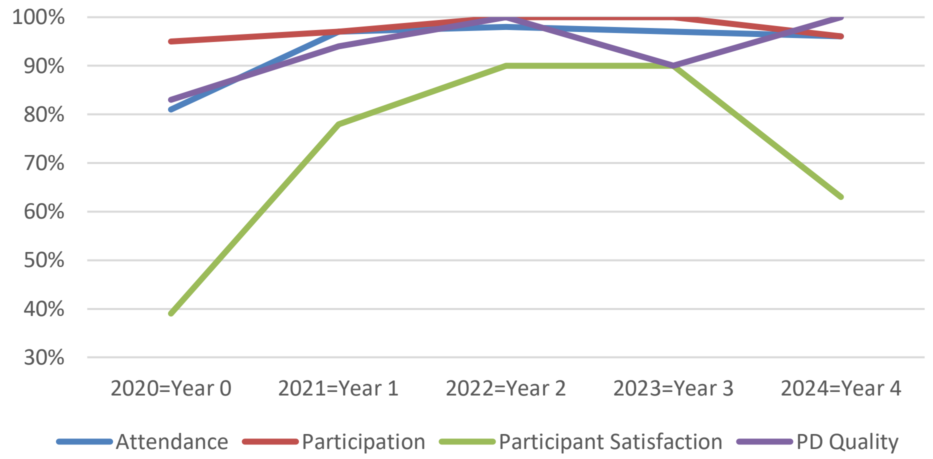
Participants also emphasized the need for more resources (especially for Unit 5) and differentiated support for first-time and returning ECS teachers.

4.3. Fidelity of Exploring Computer Science, 2020-2024

The Pathways for Alabama Computer Science initiative sought to expand high-quality CS education in Alabama by equipping teachers with the knowledge, pedagogical strategies, and support structures necessary to teach computer science effectively. The Exploring Computer Science strand of PACS was central to this effort.

Between 2020 and 2024, and prior to summer 2025, PACS implemented five consecutive years of professional development. During that time ECS PD evolved in format, content, and scale--beginning with virtual workshops during the COVID-19 pandemic, then transitioning to hybrid and fully in-person sessions. Each year built on lessons learned from the prior summer, with increasing attention to equity, inquiry-based pedagogy, and the differentiation of support for new and returning teachers. This section provides a year-by-year account of ECS PD implementation, noting dates, sample sizes, challenges, accomplishments, and key outcomes and highlighting cross-year accomplishments. It concludes with reflections and recommendations for sustaining impact. Fidelity of implementation analyses (e.g., Figure 4.3.1) utilize categories and thresholds defined in Year 0 of the project (see Appendix B).

Figure 4.3.1: Fidelity of Exploring Computer Science PD Implementation, Years 0-4



Year 0 (2020): Launching ECS PD in a Pandemic Context

- **Dates:** July 13–17, 2020 (virtual)
- **Sample Size:** 21 Alabama high school instructors

The inaugural PACS-supported ECS PD took place virtually from July 13–17, 2020, serving 21 Alabama high school instructors. This five-day workshop offered approximately 16 hours of synchronous instruction and 14 hours of asynchronous activities, designed to introduce teachers to ECS content, pedagogy, and community. Despite the challenges of delivering PD in an online format, attendance and participation were strong: 81% of teachers attended all five days, and 95%

met participation benchmarks. Teachers collaborated through video conferencing, online forums, and group projects, forming the foundation of a statewide ECS teacher network.

Evaluation revealed mixed outcomes. On the positive side, 83% of PD quality ratings met or exceeded expectations, particularly in content delivery and participant learning. However, only 39% of participants rated satisfaction above the threshold, citing challenges with pacing, technical issues, and limited opportunities for deeper computer science content. Two key recommendations emerged: integrate more CS content for interested teachers and provide stronger technical support for online delivery.

Year 1: Adapting to Hybrid Delivery (2021)

- **Dates:** June 21–25, 2021 (hybrid, Prattville, AL, part of CS PD week)
  July 19–23, 2021 (virtual makeup session)
- **Sample Size:** 30 teachers (13 in-person, 17 virtual)

In summer 2021, ECS PD was delivered in a hybrid model with 30 teachers (13 in-person, 17 virtual). This approach responded to lingering COVID-19 disruptions while offering greater accessibility. The outcomes highlighted the advantages and challenges of hybrid delivery. In-person participants had an overwhelmingly positive experience, with 100% attendance, full participation, and 92% satisfaction ratings. Virtual participants, while engaged, reported lower satisfaction (64% meeting the threshold) due to audio/video limitations and reduced social interaction. Importantly, the year's training demonstrated the value of integrated cohorts, where teachers in both modalities engaged in collaborative activities. This fostered community-building despite the split format. Recommendations focused on improving the virtual experience through better audio, visual, and session design supports.

Year 2: Scaling Up and Building Depth (2022)

- **Dates:** June 27–July 1, 2022 (in person, University of Alabama, CS PD Week)
- **Sample Size:** 42 teachers (26 first-year ECS teachers, 16 second-year ECS teachers)

By summer 2022, ECS PD had scaled significantly, with 42 participants attending in-person at the University of Alabama. For the first time, cohorts included both first-year (n=26) and second-year (n=16) ECS teachers, allowing for peer mentorship and deeper exploration of the curriculum. Evaluation results were exemplary: 98% attendance, 100% participation, 90% satisfaction, and 100% of PD quality ratings meeting or exceeding expectations. Facilitators' expertise, coupled with the mix of first- and second-year participants, created an atmosphere of trust, collaboration, and rigorous inquiry. Teacher feedback was glowing, with participants praising the facilitators' skill and the collaborative culture. However, second-year teachers requested more advanced content, particularly in later ECS units, robotics, and coding. Recommendations emphasized differentiation to meet the needs of both new and experienced ECS teachers.

Year 3: Refining Practice and Equity Focus (2023)

- **Dates:** July 10–14, 2023 (in person, University of Alabama, CS PD Week)

- **Sample Size:** 30 teachers (17 first-year ECS teachers, 12 second-year ECS teachers)

In summer 2023, 30 Alabama teachers (17 first-year, 12 second-year) participated in ECS PD during CS PD Week. The sessions emphasized equity, inquiry-based pedagogy, and reflective practice. Facilitators used low-tech, high-touch strategies such as posters, gallery walks, and journaling to model classroom activities. Attendance and engagement remained strong (97% attendance; 100% participation). Participant satisfaction was also high (90% meeting the threshold), though PD quality ratings fell slightly below the goal (90% vs. 100% threshold). Teacher feedback reinforced the value of collaboration and modeling, but many participants requested more explicit CS content and technical depth. Recommendations included enhancing facilitator training, increasing rigor in CS content delivery, and updating curriculum resources.

Year 4: Deepening Community, Balancing Needs (2024)

- **Dates:** June 24-28, 2024 (in person, University of Alabama, CS PD Week)
- **Sample Size:** 28 teachers (19 first-year ECS teachers, 9 second-year ECS teachers)

The summer 2024 ECS PD, with 28 participants (19 first-year, 9 second-year) was in-person at the University of Alabama. The PD maintained its focus on equity and inquiry-based pedagogy, while also attempting to meet the diverging needs of new and returning participants. Attendance and participation were strong (96% attendance, 96% participation), and all PD quality ratings met or exceeded expectations (100%). However, only 63% of teachers reported satisfaction above the threshold, with second-year participants in particular calling for more coding, technical content, and differentiated sessions. The 2024 sessions reinforced the importance of teacher collaboration, equitable practices, and culturally relevant pedagogy, but also surfaced a pressing need for greater differentiation by teacher experience level and increased depth in CS content knowledge.

Cross-Year Accomplishments

Across five years, ECS PD achieved significant milestones:

- **Reach and Growth**: Trained more than 140 Alabama high school teachers, expanding CS capacity across Pathway and non-Pathway schools.
- **Community Building**: Created a statewide professional learning community for ECS educators, fostering collaboration, mentorship, and resource-sharing.
- **Equity and Pedagogy**: Consistently emphasized equity-focused, inquiry-based pedagogy, aligning with PACS goals of broadening participation in CS.
- **Resilience and Adaptation**: Demonstrated flexibility in delivery formats (virtual, hybrid, in-person) in response to the pandemic and evolving teacher needs.
- **Continuous Improvement**: Annual evaluation cycles informed refinements, from technical support in Year 0 to some differentiation strategies in later years.

Conclusion

The five-year implementation of ECS PD under PACS has made a transformative impact on Alabama's CS education landscape. Teachers consistently reported growth in pedagogy, equity practices, and confidence in delivering ECS content. While challenges remain, particularly in balancing first- and second-year needs and expanding CS content depth, the ECS PD strand has laid a strong foundation for sustained computer science education statewide.

Looking forward, the priority for ECS PD should be differentiating training for new and returning teachers, enhancing CS content rigor, and strengthening facilitator preparation. By continuing to build on its successes and address these growth areas, ECS PD can sustain its role as a cornerstone of equitable computer science education in Alabama.

4.4. Fidelity of Bootstrap Data Science PD, Summer 2025

The 2025 Bootstrap Data Science Professional Development workshop was held July 7-11, 2025, in Montgomery, Alabama. This was PACS's inaugural pilot of Bootstrap Data Science. The training convened 17 educators, Bootstrap Algebra veterans and primarily high school math teachers and also with strong representation from middle school grades. Most participants taught Algebra 2, with others teaching Algebra I, 8th grade math, and other related courses, bringing a broad range of perspectives from across secondary education.

Overall program quality was rated extremely high. On a 10-point scale, the average likelihood of recommending the PD was 9.5, with 82% "extremely likely" to recommend it. In addition, 88% reported the workshop was "much better" than other PD they had attended. Facilitator expertise was a standout strength: 94% strongly agreed that instructors were knowledgeable and created a positive learning environment, and all participants affirmed that facilitators were respectful, responsive, and qualified. Workshop components received very strong ratings, ranging from 4.53 to 4.76 on a 5-point scale. The highest-rated areas were learning value (4.76) and workshop materials (4.76), followed closely by instruction and small group work (4.71). While still strong, slightly lower ratings were given to Pyret (4.53) and workbook activities (4.59), suggesting minor opportunities for refinement.

Participants left with notably high confidence: 95% felt confident in teaching Data Science concepts via Bootstrap, 90% in equity-focused practices, and 85% in teaching the module successfully. Confidence was slightly lower, though still strong, for coding in Pyret (80-85%). Most reported feeling comfortable or very comfortable with core Data Science and Algebra topics, with only a few noting lower confidence in advanced areas such as contracts for tables or exponential models.

Qualitative feedback highlighted Bootstrap's most valuable features: practical resources, real-world connections, collaborative learning, and coding skill development. Teachers appreciated the curriculum's flexibility and relevance, noting its strong potential to engage students from diverse backgrounds. Staff support--especially the facilitators' knowledge, energy, and responsiveness--was consistently praised as one of the workshop's greatest strengths.

Areas for growth centered on time, pacing, and school-level CoPe. About 40-45% of participants requested more time for practice or an extended PD. Others recommended sequencing Data Science before Algebra, differentiating pathways between the two, and incorporating more advanced coding opportunities. A smaller number called for explicit supports for grading and classroom implementation.

In sum, the workshop was highly successful in building teacher confidence, providing practical and engaging resources, and strengthening connections between mathematics and data science. Future refinements should focus on extending practice time, balancing pacing, differentiating content pathways, and enhancing technical and classroom supports, while sustaining the strong facilitation and real-world relevance that made the workshop such a positive experience.

Sample Demographics

The participant survey group (n=17) consisted mainly of high school math teachers, with a strong presence of middle school teachers. A small number taught across both levels or held broader 6-12 roles. While most teach Algebra 2, others taught Algebra I, 8th grade math, and Math Modeling, bringing a broad range of perspectives from secondary and middle grades.

Program Quality, Confidence Ratings, and Critiques

Overall, 82% of participants were ’extremely likely’ to recommend the Bootstrap Data Science PD workshop to another teacher. The remaining 18% of participants rated their likelihood 7 or 8 on the 10-point scale, producing an overall average of 9.5. In addition, 88% indicated that the PD was ‘much better’ than other professional development they had attended. All participants (n=17) strongly agreed that the presenters were: respectful at all times, established a positive environment, responsive to questions and concerns, and qualified to lead the workshop. In addition, nearly all participants agreed or strongly agreed that the PD goals were clear and the content was relevant, highlighting the strong alignment of the workshop with teacher needs. Participants indicated that this workshop was of higher quality in comparison to others they had attended, suggesting a particularly impactful experience.

Participant feedback on program quality was overwhelmingly positive across all nine evaluation statements (Figure 4.4.1). All statements received favorable ratings, demonstrating effectiveness across organization, instructional design, and delivery. Ratings were highest for facilitator expertise and support. Nearly all participants strongly agreed that facilitators were knowledgeable about the course materials and created a positive learning environment (94% each). Endorsement was slightly lower on content alignment and pacing. Just over half strongly agreed the training matched their experience level (53%), and only 59% said pacing was appropriate, suggesting a need for more differentiation and pacing adjustments.

Respondents widely saw a role for Bootstrap Data Science and/or Algebra 2 in their teaching and anticipated that their students would enjoy the material and projects. Nearly all participants reported learning computer science through the workshop. The programming in Bootstrap: Data Science was viewed as approachable and rated positively by almost all participants. Overall, the program was highly successful, with strong recognition of facilitator quality and a positive learning environment, requiring only minor adjustments needed for pacing and differentiation.

Workshop Components

Participants rated all components of the workshop highly (Figure 4.4.2), with averages ranging from 4.53 to 4.76. The highest rated areas were workshop materials and learning value (both 4.76), followed by instruction and small group work (4.71). Areas with slightly lower power ratings include: Pyret (4.53), workbook activities (4.59), and Zoom platform (4.64). While still very positive, these suggest opportunities for refinement. Taken together, these results confirm that participants experienced the workshop as consistently high-quality, with particularly strong impacts on their learning and access to useful materials.

Figure 4.4.1: Participant Quality Ratings (N=16) for Bootstrap Data Science in Summer 2025

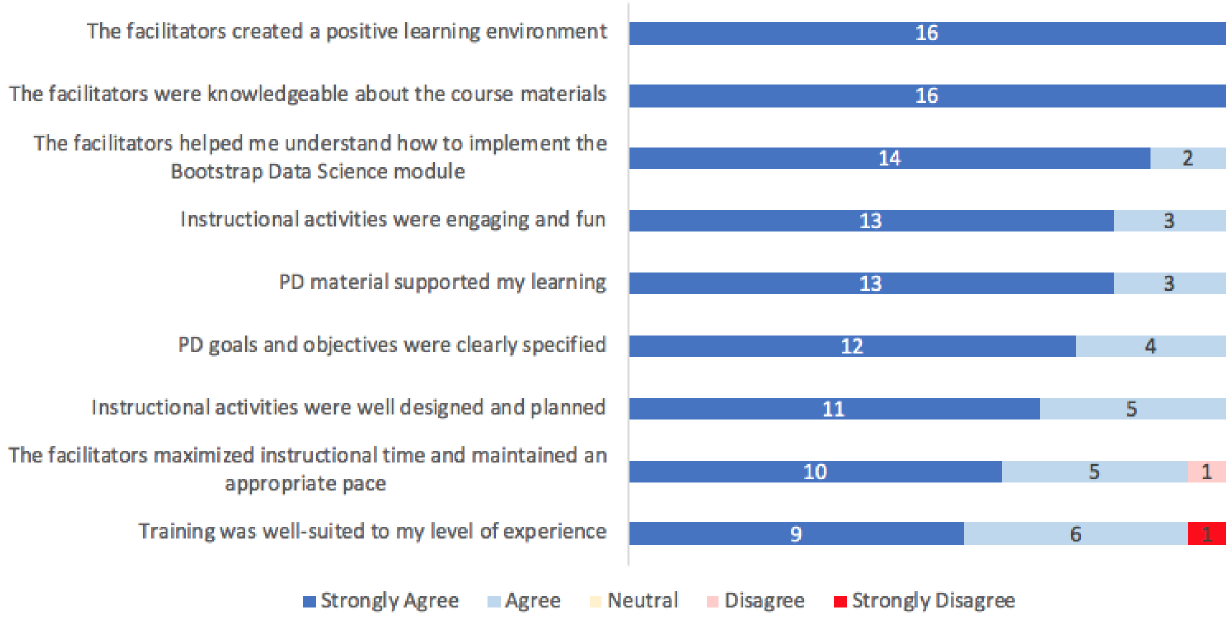


Figure 4.4.2: Participant Component Quality Ratings (N=17) for Bootstrap Data Science

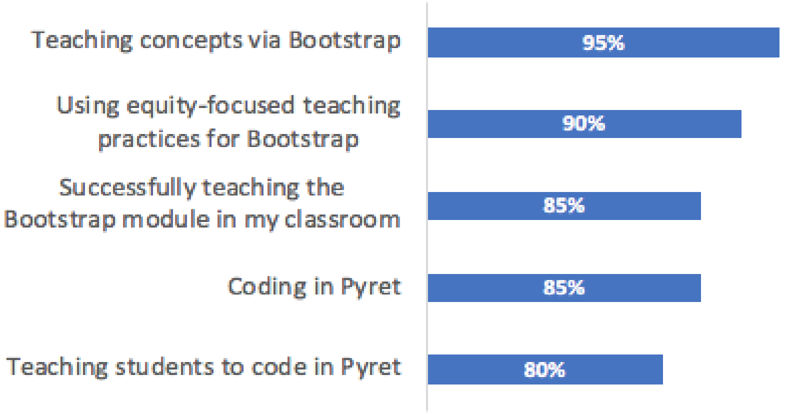
Comfort with Workshop Topics

Participants reported strong levels of comfort across both Bootstrap Data Science topics. The majority indicated they were either “Comfortable” or “Very comfortable” with each area, with very few selecting “Somewhat comfortable.” The highest areas of comfort were with: linear models, dot plots, scatterplots, and measures of center. Consistently strong areas were: data cycle, data visualizations, and basic programming. A few participants noted less comfort with contracts for tables and rows and exponential models. Overall, the workshop provided a strong foundation across a wide range of data science and algebra concepts, leaving participants confident, with only a few areas that may benefit from additional scaffolding.

Participant Confidence Levels

Participant confidence levels on the last day of PD (Figure 4.4.3) were consistently strong across all areas, with between 80% and 95% of participants reporting they felt confident or very confident. Participants indicated the highest confidence in teaching concepts via Bootstrap (95% confident). Strong confidence was reported in equity-focused teaching practices (90%) and teaching the module (85%). Coding in Pyret had an 85% confidence level, and 80% felt confident teaching students to code in Pyret. Overall, participants left the training well-prepared to implement Bootstrap in their classrooms, with only modest variation across coding-related areas.

Figure 4.4.3: Participant Confidence Ratings (N=17) for Bootstrap Data Science



Critiques and Suggestions for Improvement

The most common critiques of the workshop centered on time, pacing, school-level CoPe, and technical constraints. Many participants requested additional time for practice, suggesting that a longer or extended-format workshop would better support learning and application. As one teacher shared, “More time for teachers to practice the programming,” while another reflected, “Make it longer, it was so engaging and I learned a lot, wanted more (two weeks).” Others suggested adding a sixth day to extend the experience. Regarding school-level CoPe and content balance, participants called for more focused pathways, with clearer separation between Data Science and Algebra 2. One participant recommended, “Do one or the other—Algebra 2 or Data Science,” while another urged, “I would drive deeper into Data Science and not so the Algebra 2 or vice versa.” Several also suggested sequencing the content so that Data Science precedes its application in Algebra. Finally, technical and curricular constraints were noted, particularly regarding the

Pyret programming language and limitations in available coding functions. One participant commented, “Allow more of the contracts that Pyret allows to be used in Bootstrap. I felt handcuffed because of the base coding that was allowed,” while another observed, “More time could be spent on contracts.” Together, this feedback points to a well-received workshop that could be further strengthened by expanding practice time, refining pacing and content sequencing, and enhancing technical supports for implementation.

Observational Overview

During the training, participants progressed steadily from foundational concepts to more advanced modeling and programming. On Day 1, facilitators built participants’ comfort with the data cycle and visualizations, including dot plots and histograms. Most felt comfortable, though a few experienced challenges due to limited prior experience. Day 2 introduced scatter plots and programming in Pyret, with activities like a gallery walk and personalized plots described as engaging and rewarding. While some participants noted fatigue or programming difficulties, overall engagement remained high. On Day 3, the focus shifted to connecting algebra content with data science through linear and quadratic models. Tools like Desmos helped make these connections more tangible, and participants found the real-world applications both relevant and motivating. Day 4 continued the modeling and programming work, with strong comfort levels reported in using Pyret. Although some mixed feedback emerged around pacing, open-ended responses were overwhelmingly positive, with participants describing the lessons as “perfect” and “fantastic.” Overall, participants began the workshop with varied levels of confidence but quickly developed both technical skills and pedagogical insights. Their learning was reinforced by real-world relevance, interactive activities, and strong staff support. By the end, participants were not only comfortable but enthusiastic about applying the material in their classrooms.

Positive Staff Interactions

Participants consistently praised the workshop staff, especially facilitator Joy. She was described as “a lot of fun and engaging” and someone whose “energy is always positive.” Others emphasized her attentiveness: “Joy was so helpful during each session to identify coding errors I had and very knowledgeable in answering my questions.” Several participants also highlighted the supportive environment created by all staff, noting that “they were all positive” and praising strategies such as “using the posters to implement the stuff we learned.” Overall, participants experienced staff interactions as overwhelmingly positive, with repeated recognition of Joy’s enthusiasm and the broader team’s encouragement and responsiveness.

Most Valuable Aspects of the Bootstrap Data Science Professional Development

Participants reported substantial learning gains. When asked how much they learned overall, nearly all indicated “a lot” (10 responses) or “a great deal” (5), with only two selecting more moderate levels. Similarly, when comparing learning to expectations, most participants reported “a great deal” (8) or “a lot” (6), while just three indicated smaller-than-expected gains. These findings suggest that the workshop not only provided meaningful learning but also exceeded expectations for most participants.

Participants highlighted a range of elements they found most valuable, with recurring themes around usable resources, classroom application, coding skills, and collaborative learning. Many emphasized the practicality of the materials and their immediate relevance. One teacher shared that "resources that I can use/implement in my classroom" were especially meaningful, while another appreciated that "the curriculum [is] flexible so that we can pick and choose which portions to drop into our courses." Technical skill development also stood out. Participants valued learning new coding tools and analytical techniques. One described "learning a new coding language" as particularly valuable, and another emphasized "learning how to use contracts and strings." Others highlighted the significance of connecting coding to classroom contexts, noting the "connection of data science to my course" and the value of seeing "real world application to different topics using Pyret." Finally, the collaborative and interactive structure of the workshop was a consistent highlight. One participant stated, "The hands-on approach was most valuable to me because I learn better that way, and it gave me an opportunity to ask questions along the way." Another reflected on "the interaction with teachers and working through the problems" as a key takeaway.

These reflections emphasize the PD's greatest strengths: relevant resources, skill-building opportunities, meaningful real-world connections, and interactive learning experiences. Together, these elements provided participants with both confidence and concrete strategies for implementation in their classrooms.

Equity-Focused Teaching Practices

Participants described the workshop as both reinforcing and broadening their understanding of equity-focused teaching. Some noted that the PD confirmed practices they already valued: "I saw them being upheld within lessons" and "I had a pretty good understanding already so it just reinforced it." Others highlighted how the workshop expanded their perspective on accessibility and relevance. One teacher observed, "This workshop showed me that this can be used at different entry levels. Some students may have never used CS before and some may have," while another said, "It offered an additional approach to have relevant materials for all students." Several also connected equity to classroom strategies and content. One participant noted, "It gave me an idea of how to teach the ethics behind analyzing data," while another emphasized that the workshop "encouraged the use of praise and allowing students to strive for a better answer." Overall, the PD both confirmed existing commitments and introduced new ways to embed equity, particularly through inclusive entry points, ethical considerations, and supportive classroom practices.

Participant Testimonials on Bootstrap Data Science Workshop Value

When asked what another teacher might appreciate about the workshop, participants overwhelmingly emphasized its meaningful integration of mathematics, data science, and real-world relevance. One teacher remarked on "the connection from data science to Algebra 2" as a central strength, while another appreciated the "correlation of data science to your core subjects." The real-world applicability stood out for many, as highlighted by comments such as "the connection to real-world information for students" and how "Bootstrap integrates math and the real world for students." Participants also praised the workshop's engaging and interactive structure. Several described the experience as "hands-on and engaging," with one noting "the hands-on approach it has," and another valuing "the relaxed atmosphere and engagement."

The inclusivity and accessibility of the materials were also appreciated. One participant noted, "They would like how the content will engage and meet all students of diverse backgrounds," pointing to the workshop's potential to reach a broad range of learners. Others emphasized practical benefits, such as the fact that "the lessons are already prepared," making it easier to implement in the classroom. Taken together, these reflections depict the workshop as engaging, relevant, inclusive, and well-aligned with the instructional needs of today's classrooms.

Impact on Interest and Applications

All participants reported either sustained or increased interest in teaching Data Science following the workshop. About half said they "came in interested and am still interested," while the other half noted, "I am more interested than before the workshop." No one reported a decline, indicating the PD successfully built or reinforced enthusiasm.

Teachers identified a wide range of topics they plan to incorporate into their classrooms. These include core practices like "the data cycle," "exploring datasets," and "visual representations of data"; mathematical concepts such as "linear models, quadratics, exponentials, scatterplots," and "measures of tendency"; and broader applications like "functions, contracts, graphing." One teacher shared, "I plan to incorporate the Data Science and Algebra 2 functions into my course," reflecting a sense that Bootstrap materials are relevant across multiple content areas. A few participants did mention limitations, particularly regarding exponential functions, often due to curriculum or time constraints. For example: "Exponential functions because I am not teaching that standard this year," and "Exponential function, time." Others expressed uncertainty, stating, "I am not sure at this time," or "Some of the more difficult topics or confusing topics for me."

Overall, these responses demonstrate that the workshop not only boosted teacher interest in Data Science but also inspired plans to implement a broad range of topics. While most participants expect to use multiple components, some anticipate omitting more advanced or less applicable content based on their teaching context.

Planned Use of Bootstrap Data Science in Classrooms

Participants described a variety of ways they plan to bring Bootstrap Data Science into their teaching, ranging from full-module implementation to more selective integration aligned with standards. Several teachers expressed strong intentions to adopt the curriculum extensively. One noted, "I want to teach the full module, hoping students grow in their ability to question and reason," emphasizing student-centered learning and critical thinking. Another affirmed, "I will definitely be teaching the Data Science modules and how to apply them to the Algebra 2 standards in my classroom," highlighting alignment with core instructional goals.

Others envisioned weaving Bootstrap into specific units or existing standards-based sequences. One teacher shared, "I'm planning to use the relevant data science lessons as the data/probability unit in my 8th grade math course," pointing to a natural curricular fit. Another noted, "I plan to use the activities with lessons that are aligned with the standards that I am required to teach," underscoring the value of Bootstrap's modular design and instructional flexibility.

Participants also emphasized how Bootstrap supports student engagement and concept mastery. A teacher described plans to use the program to "expose students to reading data tables and building their own questions based on data," while another explained, "I will use it to reinforce data analysis and draw connections to students' real-world experiences." One participant commented on how the materials "help students discover patterns and explore multiple solutions," suggesting that the curriculum supports mathematical thinking beyond rote learning.

For others, selective use of Bootstrap materials allowed for targeted application. Comments included: "As supplemental," "I plan to implement the different topics offered on Bootstrap website," and "I will incorporate individual lessons where it makes sense in my online curriculum and where I am allowed." These responses reflect both enthusiasm and pragmatism—an appreciation for the resource's instructional value paired with attention to local constraints.

Across responses, the common thread was clear: teachers found Bootstrap to be a meaningful addition to their instructional toolkit, whether used comprehensively or strategically. Many were drawn to its capacity to foster student agency, connect mathematics to real-world data, and support a more exploratory, inquiry-driven classroom environment.

Overall, while some teachers plan comprehensive adoption, many will integrate Bootstrap flexibly into existing units or use it as a supplement, demonstrating both commitment to the approach and adaptability to local classroom contexts.

Anticipated Challenges

Participants identified several obstacles that may hinder successful implementation of Bootstrap Data Science, primarily centered on time constraints**,** curricular alignment**,** and technical or instructional readiness**.**

Time and Pacing Pressures. The most frequently cited challenge was lack of time. Teachers noted difficulty fitting Bootstrap into packed or inflexible curricula. One participant explained, "Not sure how I can work it into all my courses because of my district's pacing guide," while another simply wrote, "Time." A few also raised concerns about workshop length and classroom pacing post-PD.

Curricular and Administrative Constraints. Several teachers highlighted tension between using Bootstrap and adhering to required curricula or school mandates. One participant shared, "The fact that I have a new principal and I am required to use an online curriculum in my class," while another mentioned "some administrative push back," reflecting broader institutional resistance that could limit innovation or adaptation.

Technical and Classroom Management Barriers. Logistical hurdles also emerged, especially around device compatibility and student navigation of Pyret. One teacher noted, “Last year, our students had problems with the Chromebooks not running certain programs,” while another worried about common user errors: “I accidently hit the left side of Pyret a few times and deleted lines… the students will have the same difficulty.”

Individual Learning Curve. A smaller number of participants pointed to their own need for continued learning, particularly around Pyret syntax and programming logic. Comments like “Remembering the contracts” and “writing the strings to write the contracts” reflect confidence gaps that may extend to students as well.

Despite these concerns, a few participants reported no major barriers at this time. However, the most common themes-- time limitations, curriculum fit, and technology access-- highlight key areas where additional support may be needed to ensure smooth and sustained implementation.

Future Needs for Support

Participants expressed a desire for additional support in three key areas to enhance their implementation of Bootstrap Data Science. First, several emphasized the need for improved sequencing and curriculum alignment, recommending that “Data Science should be taught before the Algebra” and suggesting, “Teachers take the Data Science course before Algebra 1.” Second, others voiced interest in advancing their technical skills, asking for deeper exploration of Pyret: “I would like to get into more complex functions in Pyret” and “Incorporate more functions.” Finally, some participants requested more practical classroom strategies, especially around assessment, including “showing teachers how they can incorporate giving the students actual grades.” These responses highlight a need for resources that deepen content mastery, align with existing curricula, and provide clear pathways for classroom implementation.

Summary and Recommendations

The 2025 Bootstrap Data Science Professional Development workshop, held July 7–11 in Montgomery, Alabama, marked PACS’s inaugural pilot of the Bootstrap Data Science curriculum and yielded exceptionally strong results. Seventeen middle and high school math educators rated the PD among the best they had attended, citing high facilitator expertise, engaging instruction, and strong real-world relevance. On average, participants scored the training 9.5/10 for likelihood to recommend and 4.5–4.8/5 across workshop quality indicators, with especially high marks for learning value and materials. Teachers left with high confidence in teaching data science (95%) and equity-focused practices (90%), though some expressed a need for more time to practice coding and deepen their understanding of Pyret. Qualitative feedback underscored the PD’s strengths in practical classroom resources, real-world applications, and collaborative learning, while recommending longer sessions, differentiated pathways for Algebra and Data Science, and enhanced technical support. Participants anticipated using Bootstrap to enrich a range of courses—including Algebra I, Algebra II, and Data Science—by integrating data visualization, modeling, and coding into their instruction. Many described plans to use most or all of the module, citing its flexibility, accessibility, and relevance to diverse learners. Overall, the workshop was a major success—building teacher confidence, expanding capacity for data-driven instruction, and advancing equitable, inquiry-based integration of data science into math classes across Alabama.

Drawing from participant surveys and open-ended feedback, several key recommendations have emerged to further strengthen the design and delivery of Bootstrap Data Science professional development. These suggestions reflect teachers' desire for enhanced scaffolding, improved pacing, differentiated pathways, and greater classroom applicability, all while sustaining the program's strong instructional quality and real-world relevance. To build on the success of this initial implementation, teachers identified several opportunities for improvement that could strengthen future workshops.

Recommendation 1: Provide Additional Scaffolding for Coding and Technical Concepts

Participants expressed enthusiasm for coding in Pyret but noted that challenges with syntax, functions, and debugging sometimes hindered progress. To build teacher confidence and make technical learning more accessible, future workshops should include structured coding supports such as reference guides, annotated code samples, and targeted practice activities.

Recommendation 2: Extend Time and Opportunities for Practice

A significant portion of participants requested additional time for guided and independent practice. Extending the workshop duration, adding an optional sixth day, or embedding longer work sessions throughout the week would allow for deeper learning and stronger content retention.

Recommendation 3: Refine Pacing and Instructional Sequencing

While overall pacing was positively rated, participants offered mixed feedback regarding the order and tempo of content delivery. Many participants recommended teaching foundational data science concepts before introducing algebraic applications, noting this sequencing better supports comprehension and classroom transfer, and adjusting the daily schedule to allow more time for reflection and breaks could help sustain engagement.

Recommendation 4: Differentiate Content Pathways for Data Science and Algebra 2

Several participants felt that the workshop attempted to cover too much breadth. Offering separate instructional tracks-- one emphasizing foundational data science, the other focused on Algebra 2 integration-- would better support the varied course loads and content expertise of participating teachers.

Recommendation 5: Continue Emphasizing Real-World Applications

Real-world connections were consistently cited as among the most valuable aspects of the PD. Sustaining and expanding this focus—through authentic datasets, context-rich problems, and cross-disciplinary examples—will continue to drive relevance and student engagement in classroom practice.

Recommendation 6: Strengthen Support for Pyret and Technical Tools

While overall satisfaction with Pyret was high, it was the lowest-rated individual component of the workshop, suggesting a need for more hands-on time and scaffolding around its advanced features. Future iterations should provide more opportunities for hands-on exploration of advanced features, troubleshooting techniques, and strategies for classroom management of technical tools.

Recommendation 7: Expand Classroom Implementation Supports

Participants appreciated the provided instructional materials but requested additional support for classroom use, including grading strategies, assessment tools, and examples of differentiated implementation. These resources would help bridge the gap between workshop learning and classroom realities.

Recommendation 8: Sustain High-Quality Facilitation and Staff Support

Facilitators were widely praised for their expertise, responsiveness, and positive energy. Preserving this level of instructional excellence—through rigorous facilitator preparation and continued investment in staff support—remains essential to the program's success.

Recommendation 9: Address System-level Implementation Barriers

Several participants cited challenges aligning Bootstrap with district pacing guides, required curricula, or administrative directives. Future implementations could benefit from resources or planning guides that support alignment with state standards, help build administrative buy-in, and offer strategies for local adaptation.

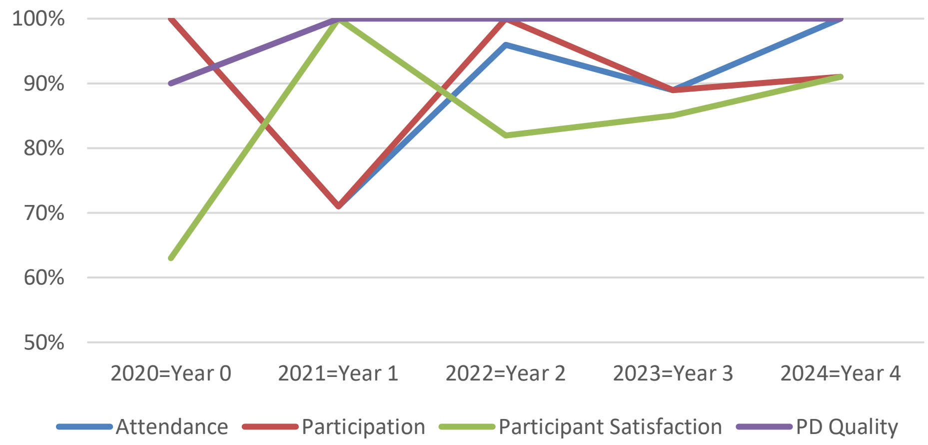
Facilitators were widely praised for their expertise, responsiveness, and positive energy. Preserving this level of instructional excellence—through rigorous facilitator preparation and continued investment in staff support—remains essential to the program's success. The 2025 Bootstrap Data Science PD workshop was highly effective in building teacher confidence, enhancing instructional capacity, and inspiring real-world integration of data science into math classrooms. These recommendations aim to preserve the program's core strengths while addressing areas for refinement, ensuring that future workshops continue to meet educators' evolving needs and instructional goals.

4.5. Fidelity of Bootstrap Algebra, 2020-2024

The Pathways for Alabama Computer Science initiative was designed to expand opportunities for Alabama students to engage with computer science concepts within core academic courses. A central component was training Algebra I teachers to integrate the Bootstrap Algebra curriculum, which teaches algebraic reasoning through the engaging context of video game design. Between 2020 and 2024, PACS implemented five consecutive years of Bootstrap Algebra PD to prepare mathematics teachers across the state. Each summer PD was structured to strengthen technical knowledge, model effective pedagogy, and promote fidelity of implementation through high attendance, active participation, and teacher satisfaction.

This section is a narrative synthesis of the Bootstrap Algebra PD across Years 0-4, noting dates, sample sizes, challenges, accomplishments, and key outcomes. Fidelity of implementation analyses (Figure 4.5.1) utilize categories and thresholds defined in Year 0 (Appendix D).

Figure 4.5.1: Fidelity Results for Bootstrap Algebra PD Implementation, Years 0-4



Year 0 (2020): Pilot Under Pandemic Conditions

- **Dates:** July 20–24, 2020 (virtual)
- **Sample Size:** 8 Algebra I teachers (plus 12 AMSTI leaders and 2 ALSDE observers)

The pilot year of Bootstrap Algebra PD coincided with the height of the COVID-19 pandemic, requiring a fully virtual model. Sessions were delivered via Zoom, supported by Peardeck slides, "check your pulse" surveys, and the WeScheme programming platform. Despite pandemic constraints, the eight participating teachers demonstrated strong commitment. Attendance and participation were perfect (Figure 4.5.1): 100% of teachers attended all sessions and engaged actively on video, in chat, and verbally. However, only 63% met the satisfaction threshold, largely due to frustration with the virtual platform and the challenges of remote collaboration. Still, the PD achieved its goal of introducing Bootstrap Algebra, giving teachers their first hands-on experience with algebraic video game design. The year established a foundation while also revealing the need for adjustments to delivery and support.

Year 1 (2021): Virtual Continuation and Early Struggles

- **Dates:** June 21–25, 2021(virtual, CSPD Week)
- **Sample Size:** 7 Algebra I teachers

Bootstrap Algebra PD remained virtual in 2021, and used the Pyret platform. Teachers engaged in five consecutive days of training, alternating between whole-group instruction and breakout collaboration. Attendance and participation were weaker this year, with only 71% of teachers meeting fidelity thresholds due to technology challenges and inconsistent video presence. Despite this, teacher satisfaction rose markedly: all six reporting teachers (100%) agreed that the PD was valuable, well-designed, and facilitated effectively. Year 1 highlighted the limits of virtual PD. While teachers who fully engaged expressed eagerness to implement Bootstrap in their classrooms, the program did not meet overall fidelity thresholds because of lower attendance and participation.

Year 2 (2022): Transition to In-Person and Expansion

- **Dates:** June 27–July 1, 2022 (in person, University of Alabama, CS PD Week)
- **Sample Size:** 20 Algebra I teachers and 5 AMSTI math specialists (25 total participants)

Year 2 marked a pivotal transition: the PD was offered in person for the first time during Alabama's statewide CS PD Week. The return to in-person learning dramatically improved outcomes across all fidelity indicators. Attendance rose to 96% (Figure 4.5.1), participation was 100%, and satisfaction reached 82%. Teachers benefited from active learning structures including pair programming, gallery walks, collaborative coding, and reflective debriefs. The inclusion of AMSTI math specialists expanded the program's sustainability, creating a system of ongoing regional support for classroom implementation. Teachers not only gained confidence in their ability to use Bootstrap but also began to plan concretely for how the materials would align with Algebra I instruction in the fall.

Year 3 (2023): Broadening Reach and Strengthening Fidelity

- **Dates:** June 26–30, 2023 (in person, University of Alabama, CS PD week)
- **Sample Size:** 27 Algebra I teachers and 2 AMSTI specialists (29 total participants)

Year 3 saw Bootstrap PD mature into a robust, large-scale experience. Facilitators refined their approach, incorporating structured reflection, peer modeling, and role-play to demonstrate classroom implementation. Attendance (89%) and participation (89%) remained strong. Satisfaction was high (85%), particularly regarding the positive learning environment and facilitator expertise. PD quality again met 100% of benchmarks. This year also saw greater participant diversity in teaching backgrounds, years of experience, and demographics. Teachers left the PD not only with technical knowledge but with clear implementation plans, supported by AMSTI and professional peer networks.

Year 4 (2024): Consolidation and High-Fidelity Implementation

- **Dates:** June 24–28, 2024 (University of Alabama, CS PD week)
- **Sample Size:** 11 Algebra I teachers

The final year of the five-year cycle consolidated Bootstrap PD as a high-quality, sustainable program. Eleven teachers participated in five days of intensive training that combined whole-group instruction, small-group collaboration, pair programming, and implementation planning. Attendance was 100%, participation exceeded thresholds (91%), and satisfaction was very high (91%). Teachers praised the facilitator expertise, engaging materials, and practical planning time built into the sessions. With a smaller cohort, facilitators were able to provide individualized coaching, deepening teacher confidence and readiness. By Year 4, Bootstrap Algebra PD had achieved stability and consistency, producing teachers who were not only satisfied but fully equipped to implement the program effectively in their classrooms.

Cross-Year Accomplishments

Across the five years, the Bootstrap Algebra PD accomplished several milestones:

1. **Growth in Participation:** From 8 teachers in 2020 to 27 in 2023, the program steadily broadened its reach before consolidating into a smaller, highly engaged group in 2024.
2. **Transition to In-Person Delivery:** The move in 2022 marked a turning point, dramatically improving attendance, participation, and satisfaction.
3. **Satisfaction Gains:** Satisfaction grew from 63% in Year 0 to over 90% in Year 4, reflecting improved delivery and stronger alignment with teacher needs.
4. **Sustainability via AMSTI:** Beginning in 2022, AMSTI specialists ensured ongoing regional support, embedding Bootstrap within Alabama's professional learning infrastructure.
5. **Consistently High PD Quality:** Across all years, PD quality scores met or exceeded expectations, demonstrating strong program design and facilitation.
6. **Teacher Readiness:** By 2024, participants were consistently leaving PD with implementation plans and high confidence in their ability to integrate Bootstrap Algebra.

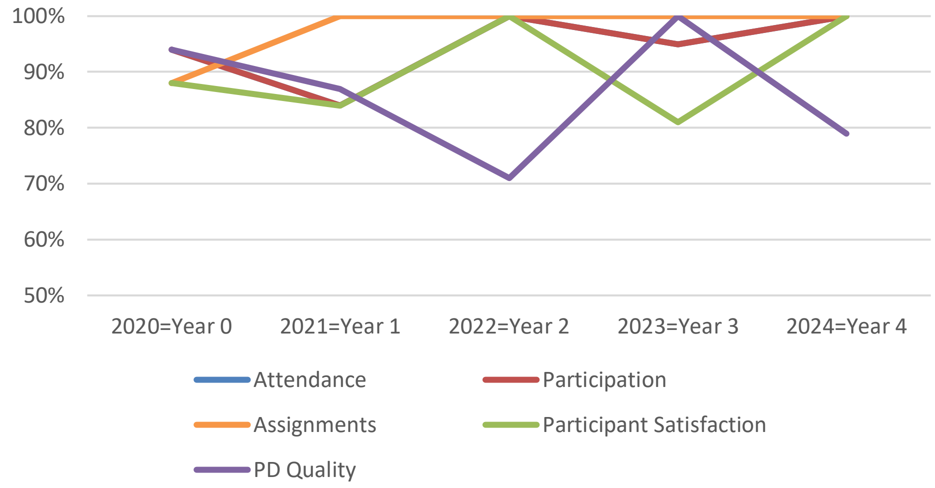
Conclusion

The Bootstrap Algebra PD journey from 2020-2024 demonstrates how a well-designed program can adapt, mature, and achieve sustained fidelity over time. Beginning under pandemic conditions, the PD transitioned into an effective, in-person experience that strengthened teacher engagement, satisfaction, and preparedness. Across five years, the program trained more than 70 Alabama teachers and AMSTI specialists, building both individual capacity and systemic support. Teachers left not only more skilled but also more confident and motivated to integrate computer science into their mathematics instruction. The accomplishments of Bootstrap PD within PACS stand as a model for how professional development can scale effectively, maintain quality, and contribute to lasting educational change in computer science education.

4.6. Fidelity of AP CS Principles PD, 2020-2024

Pathways for Alabama Computer Science initiative supported a series of PD workshops for Alabama high school teachers to build the knowledge, skills, and confidence necessary to implement AP Computer Science Principles (AP CSP). Over five consecutive years (2020–2024[5]), PD offerings evolved from virtual delivery during the pandemic to robust in-person sessions, with hybrid models adopted along the way. Each year's PD was designed around fidelity measures that captured attendance, participation, assignment completion, satisfaction, and PD quality. Across the five-year period, more than 50 Alabama educators participated in these AP CSP trainings, representing diverse teaching backgrounds, years of experience, and school contexts. Evaluation data were collected through surveys, observations, platform analytics, and facilitator reports, providing rich understandings of both program impact and opportunities for improvement. This section synthesizes findings year by year, highlights cross-year accomplishments, and concludes with overarching insights on the success and future directions of PACS AP CSP PD. Fidelity of implementation analyses (Figure 4.6.1) utilize categories and thresholds defined in Year 0 of the project (Appendix D).

Figure 4.6.1: Fidelity Results for AP CS Principles PD Implementation, Years 0-4



Year 0 (2020): Virtual Pilot

Dates: July 13–17, 2020 (virtual)
Participants: 17 Alabama high school teachers

The inaugural AP CSP PD workshop was held entirely online due to COVID-19. Using the UTeach Canvas platform, teachers engaged in daily three-hour synchronous sessions with lecture and group work, followed by asynchronous assignments and discussion board participation.

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[5] AP CS Principles PD was not offered in Summer 2025.

Attendance was high, with 94% of participants present for all five days. Participation rates were equally strong: 94% of teachers posted consistently to discussion boards and engaged during synchronous video sessions. Assignment completion exceeded expectations, with 88% completing at least 21 of 24 required assignments. Satisfaction ratings were very high, with 88% of teachers agreeing with all satisfaction items. PD quality, measured by evaluator rubrics, exceeded thresholds in nearly every category, with 94% of items meeting or surpassing expectations. Key recommendations were to slow the pace and extend synchronous time to reduce participant overwhelm, and to incorporate structured reflection after breakout activities.

Year 1 (2021): Hybrid Delivery

Dates: June 21–25, 2021 (hybrid, Prattville, AL, CS PD week)
Participants: 9 Alabama high school teachers (6 teachers in-person, 3 teachers virtual)

With the pandemic still shaping delivery, the Year 1 workshop was offered in both in-person and virtual formats. This hybrid model provided important lessons about equity of access and quality. The face-to-face group achieved 100% attendance, strong participation, and 100% assignment completion; satisfaction and PD quality ratings exceeded 95%. The virtual group struggled with attendance and engagement - only 67% met thresholds for satisfaction and participation; also PD quality ratings fell below expectations (76%). Virtual teachers cited difficulties hearing and staying engaged. Key recommendations were to improve virtual integration by ensuring equal visibility and interaction with in-person participants, and to dedicate more time for participant reflection.

Year 2 (2022): Fully In-Person Return

Dates: June 27–July 1, 2022 (in person, University of Alabama, CS PD Week)
Participants: 5 Alabama high school teachers

Returning to a fully in-person format, Year 2 PD provided a highly cohesive learning experience. Teachers met daily at UA, guided by two facilitators (a UTeach trainer and an Alabama-based AP CSP expert). All five participants achieved perfect attendance, full assignment completion (35 assignments), and maximum satisfaction scores. Teachers reported substantial growth in confidence and readiness to teach AP CSP, and enthusiasm for Scratch, Codio, and AP Classroom. However, evaluator quality ratings showed room for growth, particularly in planning, pacing, and variety of instructional formats. Key recommendations were to provide instructors with Codio access weeks ahead of PD, incorporate more varied and interactive learning formats to reduce screen fatigue, and strengthen collaboration and sequencing between facilitators.

Year 3 (2023): Expanded Participation (in person, University of Alabama, CS PD Week)

Dates: July 10–14, 2023 (in person, University of Alabama, CS PD Week)
Participants: 21 Alabama high school teachers

Year 3 marked a major expansion, with over 20 teachers attending the PD. The workshop balanced morning sessions on Scratch and Codio and afternoon sessions on the AP CSP framework and exam preparation. Attendance and participation were strong, with 95% present for all five days and active in discussions. Assignment completion was 100%, building on the momentum of pre-work tasks. Satisfaction levels remained high, with 81% agreeing or strongly agreeing with all items. Teachers particularly valued access to Codio, collaborative discussions, exam preparation, and support from experienced facilitators. Gains in self-assessed readiness averaged +1.33 on a four-point scale, with significant jumps for teachers initially "not at all prepared." Key recommendations included differentiating instruction to accommodate teachers with wide-ranging CS experience, providing more varied learning formats (small groups, presentations, reflections), strengthening facilitator collaboration to avoid redundancy between Codio/AP content, and potentially offering a second summer PD for AP CSP teachers needing additional support.

Year 4 (2024): Small-Group Intensive

Dates: June 24–28, 2024 (in person, University of Alabama)
Participants: 3 Alabama high school teachers + 1 pre-service teacher

In Year 4, fewer participants enabled a more personalized and intensive PD experience. Facilitators led sessions on Scratch, Python, Codio, and AP CSP exam prep, with added focus on Alabama's state-level CS context. Attendance and engagement were 100%, with strong participation in discussions and paired programming. Assignment completion was high, though one pre-service teacher struggled despite scaffolding. Satisfaction ratings were maximum, and all participants gave the workshop a "10". Evaluator rubrics showed mixed results, only 79% of PD quality items met expectations, pointing to needs for stronger facilitator collaboration, more interactive learning, and earlier access to Codio. Key recommendations included providing pre-PD Codio access, expanding interactive learning and peer collaboration, engaging more formative assessment, fostering a reflection, and differentiating instruction for those with limited CS background.

Cross-Year Accomplishments

Across five years, PACS AP CSP professional development achieved several important outcomes:

- **High Engagement:** Attendance and participation consistently exceeded thresholds, with the majority of teachers staying fully engaged across formats.
- **Strong Teacher Growth:** Teachers reported significant gains in content knowledge, programming skills, and readiness to teach AP CSP.
- **Sustained Satisfaction:** Post-PD survey ratings were consistently high, with most years showing 80-100% of participants agreeing that the PD met their needs.
- **Adaptability:** PACS successfully delivered PD in virtual, hybrid, and in-person formats, adjusting to teacher needs and pandemic realities.
- **Community Building:** Teachers valued opportunities to connect with peers and facilitators, often citing collaboration and networking as key aspects of PD week.

Conclusion

Over five years, the PACS AP Computer Science Principles PD series demonstrated strong implementation fidelity, instructional impact, and adaptability, particularly in serving educators from rural and under-resourced Alabama schools. More than 50 teachers participated, representing a wide range of school contexts and experience levels. Despite early challenges with virtual and hybrid formats, attendance and engagement consistently exceeded 90%, and satisfaction ratings climbed steadily--reaching 100% in later years. Teachers praised the hands-on coding experiences, peer collaboration, and real-world relevance of the curriculum. While evaluator scores for PD quality varied (ranging from 70% to 95%), they showed improvement over time, especially in pacing, facilitation, and technical readiness. Key lessons included the value of pre-PD access to platforms like Codio, the need for differentiated support based on CS experience, and the importance of interactive, collaborative learning environments. Overall, PACS AP CSP PD successfully built teacher confidence, broadened access to computer science instruction in rural Alabama, and laid a strong foundation for continued expansion of equitable, high-quality computer science education statewide.

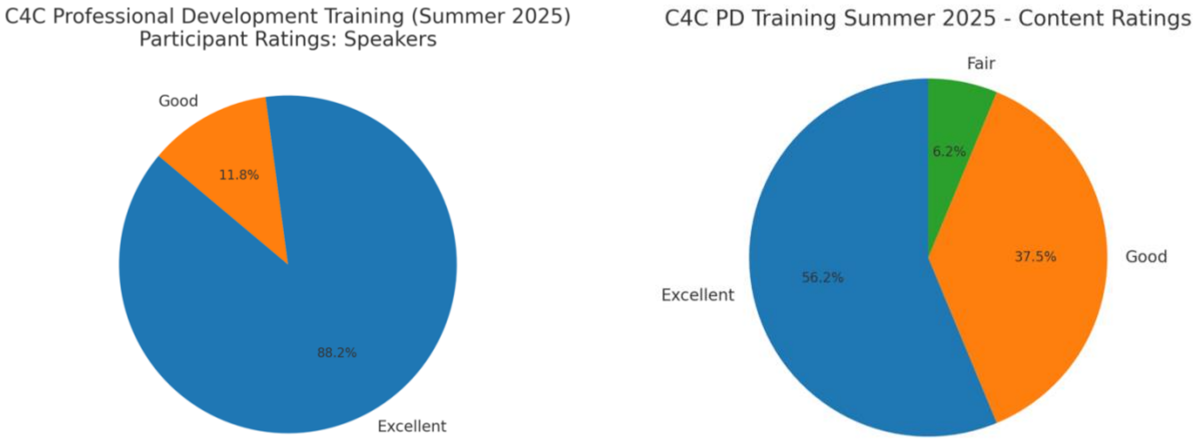
4.7. Fidelity of Counselors for Computing PD, Summer 2025

Held on July 7–8, 2025, the Counselors for Computing (C4C) professional development workshop offered Alabama school counselors a powerful and inspiring two-day experience. The workshop aimed to deepen counselor knowledge about computer science careers, build familiarity with the PACS CS pathway, and empower counselors to serve as enthusiastic advocates and implementation leaders within their schools. Through a mix of engaging speakers, hands-on coding, timely computing topics, and peer networking, the event emphasized both the relevance of computer science and counselors' critical roles in expanding student access—particularly among underrepresented groups. Seventeen participants completed the post-event survey, providing valuable feedback on impact and future needs.

High Ratings for Quality and Value

Counselors rated the 2025 C4C workshop exceptionally well (Figure 4.7.1). Speaker quality was a standout strength, receiving an average rating of 4.76 out of 5, with nearly 90% of participants selecting "Excellent." Content quality was also positively reviewed, averaging 3.82 out of 5, with 94% of counselors rating it "Excellent" or "Good." Participant comments reinforced the positive reception: "Great presenters and very organized!" and "This was a wonderful informative conference." These high satisfaction levels reflect the workshop's thoughtful structure, quality facilitation, and relevance to counselors' daily work with students.

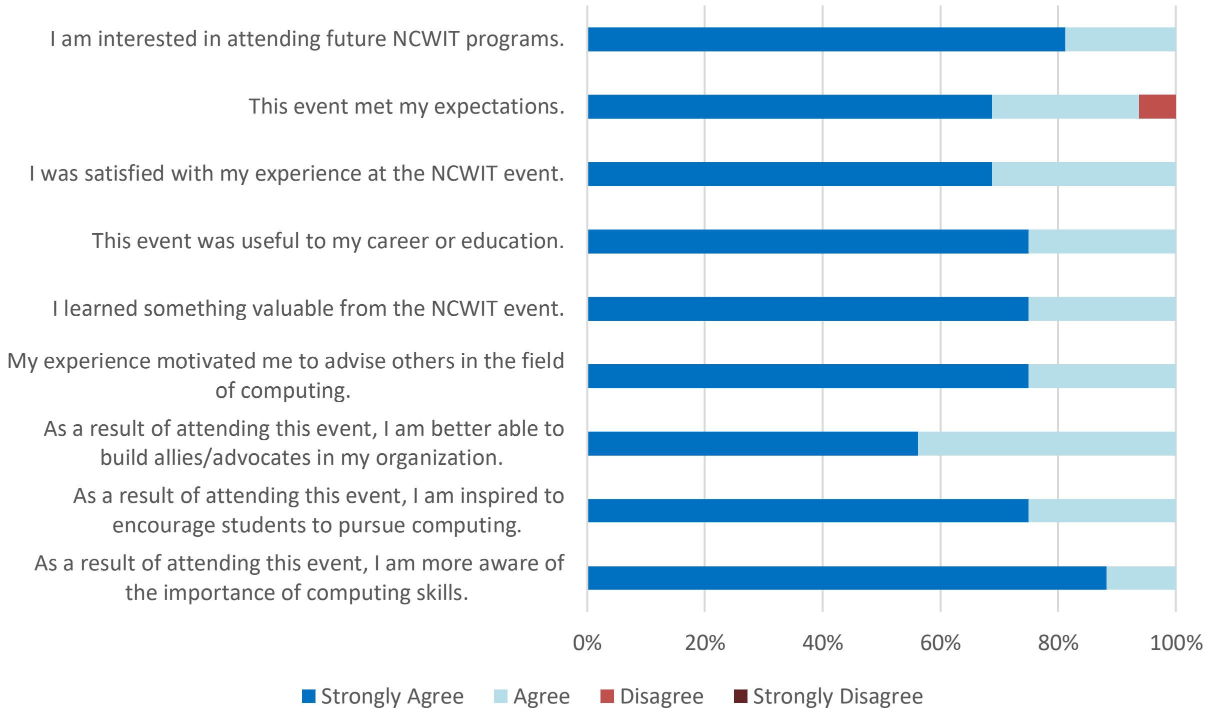
Figure 4.7.1: C4C PD Training, Summer 2025, Speakers and Content



Measurable Impact and Counselor Motivation

Survey data revealed that counselors left the workshop with a renewed sense of purpose and actionable insights. Nearly all participants reported strong agreement (Figure 4.7.2) that the workshop positively impacted their understanding of computing skills and career opportunities. Fifteen of the seventeen participants "strongly agreed" that their awareness of CS had increased, and nearly all felt more motivated to promote computing among students. This enthusiasm signals potential ripple effects across schools, with one counselor affirming: “Great job!! Two thumbs up!!!” While the workshop also supported growth in advocacy skills—such as building allies and influencing decision-makers—this was the lowest-rated area for strong agreement, suggesting room for future professional development that offers more practical tools for systemic change.

Figure 4.7.2: Quality of Summer 2025 C4C PD



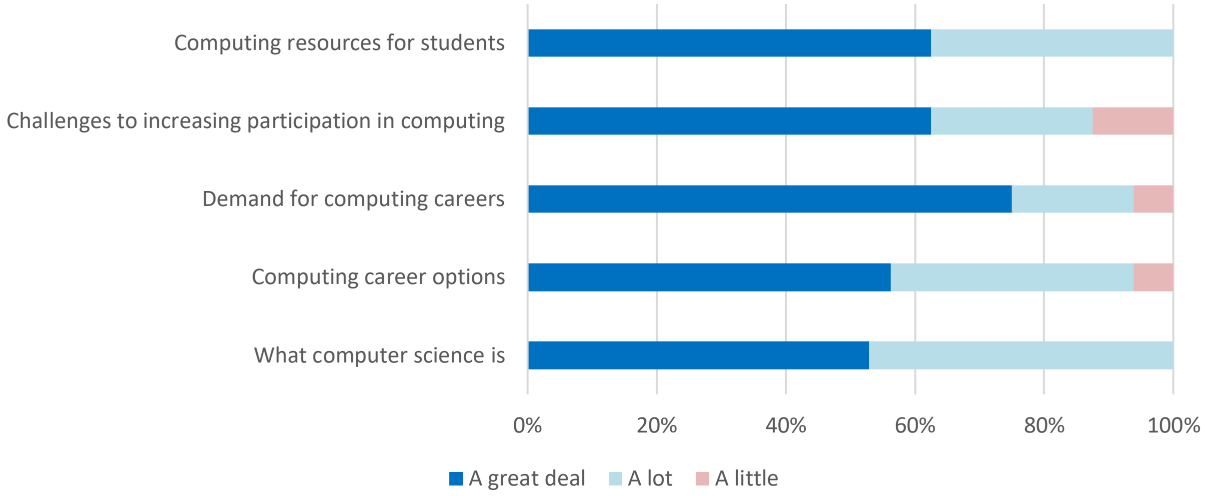
Significant Learning Gains

Counselors reported substantial gains across all key learning domains (Figure 4.7.3). The most prominent improvements were in understanding what computer science is and the growing demand for computing careers—foundational knowledge for effective student guidance. While most respondents also reported growth in understanding CS career pathways and equity challenges, these areas showed slightly smaller gains, indicating a need for deeper exploration and applied strategies in future C4C programming. As one counselor noted: “The museums were a great mix to what we learned at Computer Science,” highlighting the value of contextual, experiential learning in reinforcing key concepts.

What Counselors Valued Most

Participants appreciated the opportunity to clarify misconceptions about computing, explore Artificial Intelligence, and understand emerging career trends. They especially valued how computing concepts could be integrated into their existing counseling strategies. Topics such as computational thinking, CS+ career connections, and school/community partnerships were particularly relevant. One participant remarked: “I enjoy the workshop every year. It always brings something new.” This balance of professional enrichment and hands-on, future-oriented learning left counselors better prepared—and more energized—to support students’ computing pathways.

Figure 4.7.3: C4C PD Training, Summer 2025, Knowledge/Understanding Gains



Immediate Implementation Plans and Ongoing Support Needs

Counselors left the workshop with clear and concrete plans for immediate action. Many committed to: advocating for the inclusion and accessibility of CS courses, reviewing master schedules to identify potential barriers to enrollment, and integrating computing activities into counseling sessions. Many also committed to encouraging student participation in programs like Aspirations in Computing and to expanding initiatives such as Girls’ STEM Camps, CS events, and clubs.

To sustain momentum, counselors emphasized the need for continued engagement and support from the C4C leadership team. They requested ongoing PD opportunities, access to ready-to-use resources such as websites and handouts, and advocacy support--particularly for communicating the importance of CS to school and district leaders. Additionally, counselors highlighted the value of equity-focused programming that motivates girls and underrepresented students to pursue computing, along with continued availability of C4C staff to offer practical guidance as they implement these changes in their schools.

Summary and Recommendations

The 2025 C4C workshop successfully inspired and equipped a cohort of counselors to become more effective advocates for computing education. Counselors praised the engaging speakers, useful content, and supportive learning environment. They left not only more informed but also prepared to take real steps toward expanding CS access in their schools. Still, counselors voiced a clear need for continued resources and advocacy strategies to sustain momentum. The following recommendations reflect their feedback.

Recommendation 1: Strengthen Content Depth and Relevance. To raise content ratings to match the exceptional speaker scores, incorporate more robust exploration of CS career pathways and equity strategies. Provide in-depth tools for linking computing to specific academic trajectories and addressing systemic barriers.

Recommendation 2: Expand Advocacy and Implementation Support. Develop and provide toolkits, slide decks, and co-presenter resources that counselors can use to engage school leaders and stakeholders. Support them in navigating resistance and building allies for CS implementation.

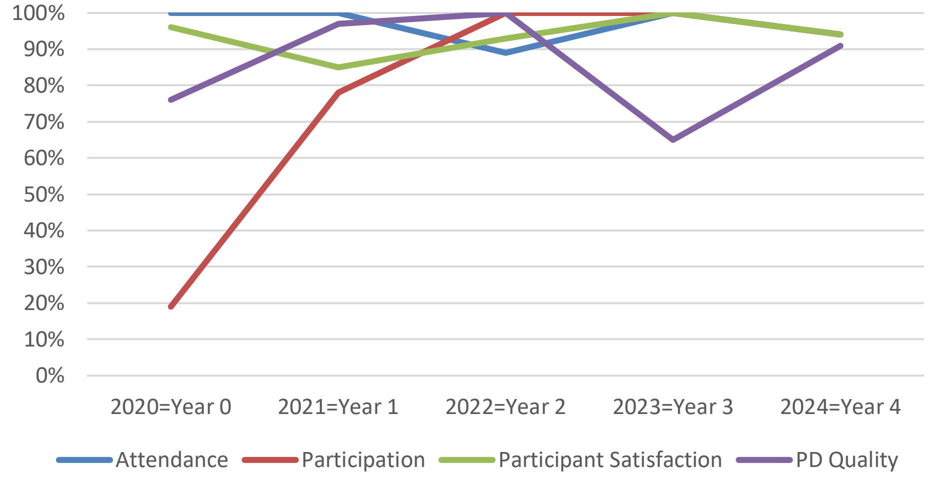
Recommendation 3: Provide Ongoing PD and Resource Access. Offer virtual refresher sessions, a centralized resource hub, and updated handouts throughout the year. Counselors consistently requested easy-to-access materials to reinforce their efforts and share with students.

Recommendation 4: Prioritize Equity and Student Engagement. Continue emphasizing equity through programming like *Aspirations in Computing*, Girls' STEM Camps, and after-school opportunities. These initiatives not only promote inclusion but also energize counselors and students alike.

4.8. Fidelity of Counselors for Computing, 2020-2024

From the outset, the Pathways for Alabama Computer Science initiative recognized a key insight: expanding equitable access to computer science requires more than preparing teachers—it requires empowering the adults who guide student choices every day. School counselors serve as critical influencers in student academic and career trajectories. They recommend courses, support students in exploring new subjects, communicate with families, and help students envision their futures. Without a clear understanding of what CS is or how it fits into career pathways, even well-meaning counselors might inadvertently steer students away from this vital field. To address this, PACS partnered with the National Center for Women & Information Technology (NCWIT) to bring the *Counselors for Computing (C4C)* program to Alabama. Over five summers (2020–2024), C4C workshops were held annually to strengthen counselor understanding of computer science, introduce the Alabama CS pathway, and equip counselors with tools to advocate for student participation in CS. These professional development (PD) experiences emphasized both conceptual understanding and practical application, positioning counselors as essential members. Fidelity of implementation was evaluated (Figure 4.8.1) utilizing categories and thresholds defined in Year 0 of the project (Appendix E). What follows is the narrative of how the C4C strand evolved, adapted, and strengthened its impact over the course of five years.

Figure 4.8.1: Fidelity Results for Counselors for Computing PD Implementation, Years 0-4



Year 0 (2020): Virtual Pilot During the Pandemic

Dates: June 22–23, 2020 (virtual)
Sample Size: 58 high school counselors

The first C4C PD was held virtually on June 22–23, 2020, at the height of the COVID-19 pandemic. Fifty-eight counselors participated, marking the largest single-year group in the program's history. Though new to online professional learning, counselors approached the two-day event with enthusiasm. Each day began with informal "coffee chats" on Zoom, creating a sense of community despite the distance. Counselors were introduced to CS through hands-on experiences with coding and virtual reality, explored interactive applications, and connected what they were learning to career opportunities for their students. Engagement was mixed. While all participants attended both days, only a small percentage consistently used cameras and microphones. Most preferred to contribute via the chat, where 88% were active. Satisfaction was high-- 96% reported being pleased with the experience-- but the overall PD quality rating fell short of benchmarks at 76%. Evaluators noted that for over half of the counselors, this was their first virtual PD. The challenges of online delivery limited collaboration and reflection, but the pilot demonstrated that counselors were eager to learn about CS and open to becoming advocates.

Year 1 (2021): Hybrid Delivery and Emerging Strength

Dates: June 22-23, 2021 (hybrid, Prattville, AL, CS PD week)
Sample Size: 31 high school counselors (10 in-person, 21 virtual)

In June 2021, C4C returned with a hybrid format, again spanning two days with a follow-up makeup session in July. The hybrid model offered clear lessons. Counselors who attended in person engaged deeply in the activities-- coding with Makey Makey, exploring interactive apps, reading and discussing *Stuck in the Shallow End*, and hearing from CS students. Their attendance, participation, and satisfaction met or exceeded all thresholds, and evaluators rated the PD quality at 100%. Virtual participants, however, continued to struggle with engagement. While all attended, only two-thirds met participation thresholds, with many reluctant to use video or microphones. Still, satisfaction remained strong at 88%, and quality indicators were nearly as high (96%). This year confirmed what many had suspected: face-to-face learning was significantly more effective for this audience. Counselors valued the networking, the energy of hands-on activities, and the opportunity to plan together. Evaluators recommended prioritizing in-person delivery going forward, while maintaining clear expectations for participation.

Year 2 (2022): In-Person PD with Strong Engagement

Dates: June 27-28, 2022 (in person, University of Alabama, CS PD week)
Sample Size: 18 counselors

By the summer of 2022, Alabama's C4C PD shifted fully back to in-person delivery. Eighteen counselors gathered as part of Alabama's CS PD Week, marking a new chapter for the program. Attendance was strong (though a few participants missed partial sessions), and participation soared. Counselors coded, shared reflections, and collaborated on implementation ideas. The in-person setting encouraged rich discussion and peer-to-peer learning. For several counselors, this was their second or even third time attending C4C, creating continuity and leadership within the group. Satisfaction was exceptionally high at 93%, and PD quality met every benchmark. Counselors reported feeling more knowledgeable about CS pathways and more confident in advising students. Several asked for additional time for hands-on programming and for networking with colleagues, sparking discussions about whether the two-day format should be extended to three days. This year marked a high point: counselors were not just learning about CS but were beginning to imagine themselves as champions for CS in their schools.

Year 3 (2023): A Smaller Cohort, But Strong Engagement

Dates: July 11-12, 2023 (in person, University of Alabama, CS PD week)
Sample Size: 11 counselors

In 2023, the counselor group was smaller, just eleven counselors, but their engagement was outstanding. The workshop followed a familiar structure, with counselors coding, experimenting with apps, and hearing from speakers about CS careers. Participation and satisfaction were 100%: every counselor attended fully, and all reported that the experience was valuable. Counselors described the PD as “motivating” and “eye-opening,” emphasizing that it gave them practical strategies for supporting students. Yet evaluators observed challenges. The room setup, with fixed seating, limited collaboration. The compressed two-day schedule felt rushed, leaving little time for reflection or for school-level planning. The content was strong, but the format constrained the experience. Even so, counselors left energized, with many planning to share resources immediately with students and colleagues. The smaller size allowed for more intimate discussions, and several participants noted the sense of camaraderie that developed.

Year 4 (2024): Consolidation and Continued Impact

Dates: June 25-26, 2024 (in person, University of Alabama)
Sample Size: 17 counselors (15 high school, 1 junior high, 1 middle schools)

Seventeen counselors participated in C4C in 2024. Attendance was excellent, with 94% meeting thresholds, and participation was equally high at 94%. Counselors praised the facilitators, the hands-on activities, and the relevance of the resources provided. Satisfaction was strong (94%), and PD quality met 91% of expectations, slightly below the perfect marks of earlier years but still solid. Counselors described the training as one of the best professional learning experiences they had attended. They particularly valued resources on credentialing, strategies for supporting underrepresented students, and opportunities to code and try out tools they could later share with students. As in prior years, time emerged as the greatest limitation. Counselors wanted more of it-- for coding, for collaboration, and for planning. Many recommended extending the workshop to three days and broadening participation to include administrators and teachers, creating full school-based teams who could strategize together.

Cross-Year Accomplishments

Over five years, the Counselors for Computing PD achieved important milestones:

1. **Broad Reach:** More than 130 Alabama counselors participated, representing diverse backgrounds and schools.
2. **High Satisfaction:** Across all years, satisfaction consistently met or exceeded thresholds, peaking at 100% in 2023.
3. **Transition to Face-to-Face:** After early struggles with virtual engagement, in-person delivery from 2022 onward stabilized fidelity and strengthened impact.
4. **Counselor Empowerment:** Counselors left with knowledge, tools, and confidence to guide students toward CS pathways.
5. **Equity Emphasis:** Workshops consistently emphasized supporting underrepresented groups, particularly girls and Black students.
6. **Sustainability:** Repeat participants and Alabama-based facilitation built a growing network of counselor champions for CS.

Conclusion

The Counselors for Computing PD strand of PACS evolved from a pandemic-constrained virtual pilot into a high-quality, in-person program that consistently met its goals of informing, equipping, and inspiring counselors. While participation fidelity was a challenge in virtual years, subsequent in-person sessions achieved high levels of engagement, satisfaction, and quality. By the end of 2024, counselors across Alabama were better prepared to serve as champions for CS pathways, leveraging their unique role to expand access and broaden participation. Recommendations for future iterations include extending workshops to three days, embedding more planning time, and engaging additional school team members. The C4C PD represents a vital contribution to the PACS mission, ensuring that counselors, critical decision-makers in student pathways, are empowered to advocate for, guide, and expand opportunities in computer science for all students.

4.9 Effectiveness of Cultivating Communities of Practice, 2020-2024

As the PACS initiative worked to expand equitable access to computer science across Alabama, it became increasingly clear that individual teacher training alone was not sufficient to drive sustainable, school-level change. From the outset, PACS prioritized the cultivation of school-level communities of practice (SCHOOL-LEVEL COPs)-- collaborative, multi-role teams that could collectively plan, implement, and support CS pathways. These SCHOOL-LEVEL COPs were envisioned as localized engines of change, drawing on the diverse strengths of teachers, administrators, counselors, and other stakeholders to embed CS in the broader academic fabric of their schools.

PACS Pathway schools were recruited to develop educator teams for the purpose of receiving PACS training, building SCHOOL-LEVEL COPs over multiple years, and participating in the PACS impact studies from 2021 through 2024. The impact studies require that 29 Treatment schools participate in PACS training sessions according to the following schedule:

Year 1 (starting summer 2021):	One teacher for PD in Exploring Computer Science One counselor for PD in Counselors for Computing
Year 2 (starting summer 2022):	At least one teacher for PD in Bootstrap Algebra
Year 3 (starting summer 2023):	One teacher for PD in AP CS Principles

Thus, a team of trained teachers and a counselor was available within each Pathway school. Teams were encouraged to include an administrator in the SCHOOL-LEVEL COP. Each academic year, activities and community engagement related to the SCHOOL-LEVEL COP or curriculum PD groups (ECS, Bootstrap Algebra, AP CSP, C4C) were tracked for quantity (i.e., time involved) and quality. To assess the quality of these communities, we tracked four distinct indicators over the course of the initiative:

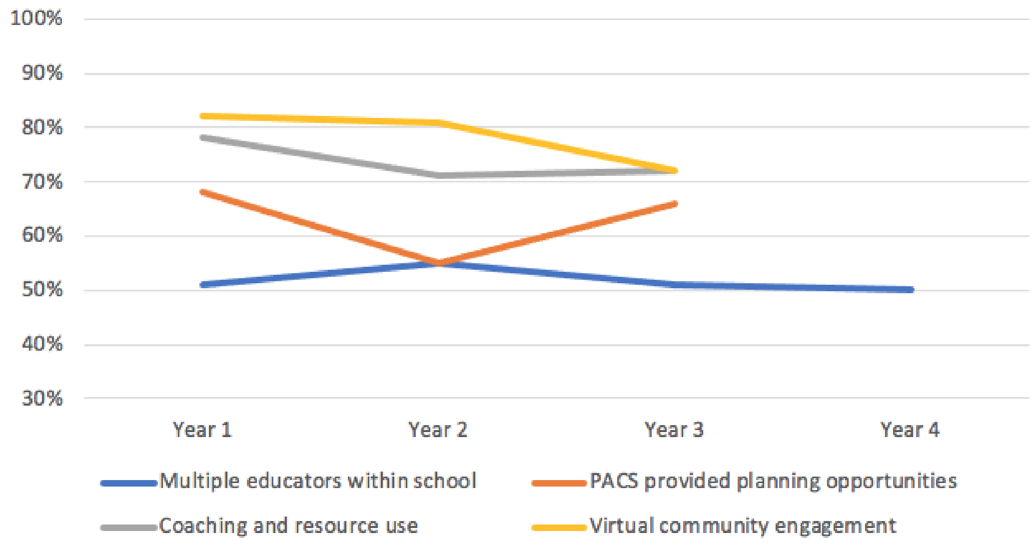
1. **Multi-educator participation per school** – Whether more than one educator from a school was active in the program following summer PD.
2. **PACS-provided planning structures** – Use of PACS-facilitated planning sessions, templates, and collaborative design tools during summer PD and throughout the AY.
3. **Coaching and resource use** – Utilization of regional coaches and program-provided supports during the academic year.
4. **Communities of practice** – Participation in training-based communities of practices and school-level communities of practice

Each indicator offers a lens into how school teams formed, evolved, and maintained momentum from one program year to the next. The following subsections provide detailed, year-by-year analyses of each indicator, weaving in both quantitative trends and qualitative insights. Together, they tell a nuanced story of how PACS supported the emergence of SCHOOL-LEVEL COPs and other supports for CS pathway, what factors contributed to success, and where continued investment may be needed to ensure long-term impact.

A note on reporting cycles. Each PACS implementation year began in June with the summer training and ended the following May. However, annual reporting cycles were from October to September. Therefore, the designation of combined years is used for reporting these results. For example, Y2/Y3 is the time period of 10/22-9/23.

Fidelity of implementation was evaluated (Figure 4.9.1) utilizing categories and thresholds defined in Year 0 of the project (Appendix F). What follows is the narrative of how the communities or practices strand evolved over the course of five years.

Figure 4.9.1 Fidelity Results for Communities of Practice, Years 1-4



Multiple Educators Within Schools (Year 1 – Year 4)

A foundational design principle of the PACS initiative was that the long-term success in computer science implementation would require broader school-based capacity, not just individual teacher leadership. From the beginning, PACS prioritized developing school-level capacity by supporting schools to train multiple educators -- teachers, counselors, administrators, and instructional leaders – who could collaborate to plan and implement CS pathways. Each summer, data were collected to determine how many participating schools sent multiple educators to PACS training. This measure, taken at the start of each academic year (typically August), served as an early indicator of distributed leadership and cross-role collaboration-- two key factors for overcoming the typical "single-champion" vulnerability common in new CS programs.

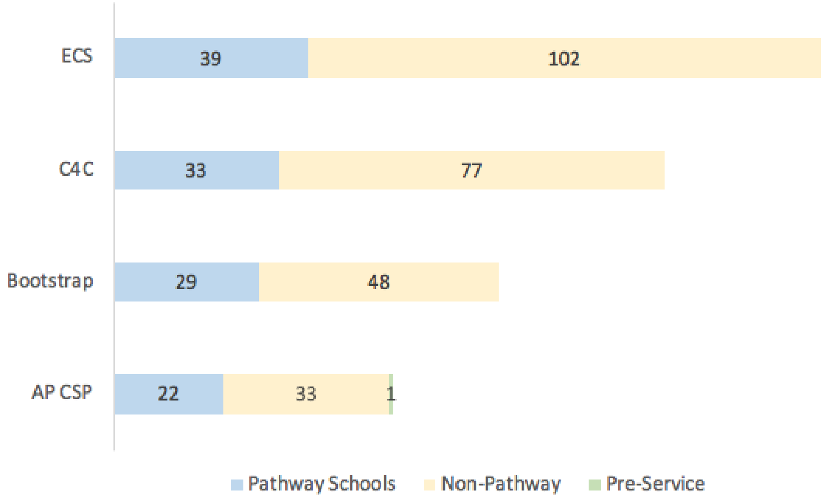
By the end of summer 2021, PACS had reached 113 schools. Among these, 58 schools (51%) had trained two or more educators. Within the 31 designated Pathway schools, most had both a trained ECS teacher and a C4C-trained counselor, forming the foundation of multi-role implementation teams. This early alignment between instruction and advising roles offered promise for coordinated student recruitment, course advising, and cross-grade CS planning. These early teams often served as hubs of momentum, building shared language and vision during initial implementation.

PACS expanded to 134 schools by the start of Year 2 (end of summer 2022). At that point, 73 schools (54%) had more than one trained educator, an increase of 15 schools from the prior year. In the 29 remaining Pathway schools (two schools having exited the study), team configurations became more diverse with the addition of Algebra I teachers trained in Bootstrap. This broadened the cross-role collaboration beyond the ECS-C4C pairs seen in Year 1. In both Pathway and non-Pathway schools, CS teams increasingly included math teachers, counselors, and introductory CS instructors, reflecting a growing capacity for school-level CS pathway development.

By summer 2023, the number of PACS-trained schools reached 164, and 84 of them (51%) had multiple trained educators – an addition of 11 schools over the previous year. The quality of team formation, particularly within Pathway schools, continued to strengthen. Among the Pathway schools, a notable 86% had three or more trained educators, suggesting maturation from small teams to robust CS communities. These teams were often composed of AP CSP instructors, Bootstrap teachers, ECS teachers, and C4C-trained counselors, giving schools greater capacity to align course progression, student advising, and recruitment strategies. Meanwhile, among non-Pathway schools, 41% had multiple educators, indicating steady but slower adoption of the team-based model outside the study cohort.

At the start of Year 4, PACS had trained educators in 190 schools. Half of these schools (95) had at least two trained educators, a gain of 11 schools over the previous year. In addition, fidelity thresholds (Appendix F) were fully met: 50% of all schools using PACS and 100% of Pathway schools had multiple PACS-trained staff, signaling widespread adherence to the team-based vision of implementation. Figure 4.9.2 illustrates this cumulative growth, capturing the network-wide shift toward shared leadership. Even as formal support for planning began to taper off in Year 4, the embedded presence of multi-role teams offered a durable structure for sustaining CS efforts.

Figure 4.9.2 Number of PACS-Trained Educators, Summers 2020-2024



Patterns and Implications

Across the four-year period, PACS made measurable progress in building a culture of collaborative CS implementation. From 51% participation in Y1 to 59% in Y3/Y4, schools gradually embraced the multi-educator team model. While growth was not linear, peaking in Y2/Y3 before dipping slightly, this pattern still reflects a marked departure from early-year reliance on individual teacher champions.

A few clear patterns emerged:

- **Pathway Schools Outperformed Peers:** As expected, Pathway schools for consistently posted higher team participation rates. By Y3/Y4, 100% of Pathway schools had at least two trained educators, and 86% had trained three or more. This suggests that the structured supports, accountability, and deeper engagement in the study context played a crucial role in fostering stronger internal teams.
- **Strategic Advantages of Teams:** Schools with multiple PACS-trained educators had observable implementation benefits. These included improved communication between advising and instruction, increased student recruitment through counselor advocacy, and more coordinated scheduling efforts. In schools experiencing staff turnover, the presence of a second or third trained educator frequently prevented implementation collapse.

The development of multi-educator teams represents one of PACS's clearest successes in building durable CS infrastructure across Alabama schools. The data show a meaningful shift from isolated champions to collaborative leadership structures, especially among Pathway schools. However, the flat trajectory in the final year and the persistent lag among under-resourced schools underscore the fragility of these gains. Moving forward, targeted supports, such as stipends, substitute coverage, or hybrid PD formats, may be necessary to increase team participation and reduce equity gaps in CS implementation capacity.

PACS-Provided Planning Support (Year 1 - Year 4)

One of the defining features of the PACS initiative was its focus on school-specific, hands-on planning support doe computer science pathway implementation. Rather than promoting a generic or one-size-fits all model, PACS emphasized differentiated planning processes that allowed educators to tailor CS expansion strategies to their school contexts. Planning tools included templates, scheduling frameworks, examples from peer schools, and structured prompts to help identify CS course offerings, student recruitment strategies, vertical alignment opportunities, and equity goals. Support was delivered both during summer PD week – when teams drafted plans – and during the academic year, when schools were encouraged to refine and operationalize them.

In the first year (summer 2021), planning support served as a scaffold to help schools transition from abstract goals to foundational action steps. Most Pathway schools were early in their CS implementation journeys, unfamiliar with the broader goals of PACS CS pathway model. PACS facilitators helped schools articulate a shared vision and identify achievable starting points for offering CS courses, training teachers, and involving school leadership. During the 2021 PD Week, school-based teams participated in a one-hour structured planning session using digital Jamboard templates with prompts like “We should teach CS because…” and “Our recruitment efforts should look like…”. Of the 31 Pathway schools, 68% participated as two- or three-person teams, surpassing the PACS fidelity threshold of 25%. While this early support generated enthusiasm and surfaced key barriers such as scheduling, student interest, and staffing limitations, the limited time—just one hour—proved inadequate for developing more detailed strategies. The session resulted in nearly every participating team identifying preliminary goals for expanding CS access, often focused on recruitment strategies and awareness-building among students and families. Teams recommended more consistent, structured opportunities for planning and goal-tracking throughout the academic year.

The following year (summer 2022), PACS continued planning support with a lightly structured activity during the 2022 PD Week. During a midweek lunch break, ECS and Bootstrap teachers from Pathway schools reflected on the importance of CS, identified implementation barriers, and discussed recruitment strategies and meeting commitments. Many teams recognized systemic challenges such as scheduling inflexibility, technology access gaps, and lack of student awareness. In response, they outlined strategies such as improved marketing, parent outreach, and establishing consistent planning meetings. While this approach built on the prior year’s foundation, the lack of formal facilitation or extended time continued to limit its depth. Still, the prompts helped foster cross-role dialogue between teachers and counselors and encouraged schools to commit to monthly planning check-ins.

By the third year (summer 2023), PACS placed greater emphasis on fostering collaborative, cross-role school-based planning, particularly among AP CSP teachers, C4C counselors, and other previously trained educators. During the 2023 PACS PD Week, the initiative encouraged AP teachers from Pathway schools to reconnect with their C4C-trained counselors and plan summer meetings to discuss upcoming implementation strategies. Nineteen AP CSP teachers indicated plans to meet with their counselors between late June and early August. Of those, six included their school’s Bootstrap teacher, and one included an ECS teacher – resulting in six 3-person teams (AP CSP, Bootstrap, and C4C), one with a CSP-ECS-C4C team, and twelve 2-person with CSP-C4C team.

Twelve of these teams submitted written reflections after their planning meetings. Common goals included building multi-year CS pathways, increasing student enrollment, broadening participation, and creating inclusive classrooms. Schools highlighted early exposure and equitable access as key priorities, with many expressing a desire to make CS exciting and approachable for all students. Reporting accomplishments ranged from launching new CS sequences and generating student interest, to creating a strongly, school-level identity around CS. However, persistent barrier emerged – particularly scheduling challenges, the cost of the AP exam, and teachers’ limited CS content knowledge. These challenges echoed those from earlier years and underscored the need for more structured and consistent support. Based on these reflections, three specific recommendations were communicated to the PACS leadership team**:** (1) Structure future planning time by formalizing both summer and academic-year planning sessions with facilitation, reflective prompts, and progress check-ins; (2) Promote full team participation, encouraging schools to assemble cross-role triads (e.g., AP CSP, Bootstrap or ECS, and C4C) for alignment across instruction, advising, and leadership; and (3) Address barriers to access by supporting schools with targeted resources—such as strategies for overcoming scheduling issues, offsetting AP exam costs, and providing refresher content training for teachers. These insights reinforced the growing understanding that sustainable CS implementation hinges not only on individual commitment but also on structured, school-level collaboration backed by responsive supports.

In the Year 4 (starting summer 2024), PACS did not offer formal planning support during summer 2024 Alabama CS PD week or the 2024-2025 school year. This represented a break from the previous years' efforts and removed a key scaffold at a time when sustaining momentum was critical. Though some schools may have continued internal planning, the absence of structured prompts, facilitation, and cross-team check-ins likely hindered widespread planning continuity across the PACS network.

Insights and Patterns

Over the four-year span of PACS implementation, several patterns emerged regarding school-level planning support. Most notably, cross-role collaboration, particularly when teachers, counselors, and administrators worked together, appeared to strengthen planning outcomes. Schools with multi-role teams often developed more actionable and ambitious CS plans, suggesting that shared responsibility may contribute to better alignment between vision and implementation. In contrast, schools where planning was left to individual educators sometimes struggled to influence broader scheduling, staffing, or policy decisions.

The depth of planning also seemed to depend on the structure and timing of the support provided. Facilitated planning sessions with guided prompts, especially when they extended beyond brief summer windows, were linked with more specific, actionable outcomes. Tools such as planning templates and reflection exercises appeared helpful in moving schools from early-stage conversations to practical implementation. However, these opportunities were not offered consistently each year. Years 1 and 2 provided only brief touchpoints, and Year 4 lacked planning time altogether, potentially limiting schools' ability to maintain or revise their plans.

Longitudinal engagement likely played a role in plan refinement. Teams returning for multiple years often articulated clearer recruitment strategies, equity goals, and sequencing decisions, possibly reflecting increased confidence or growing institutional support. Newer schools, meanwhile, typically needed more structured guidance and required time to move from general ideas to operational plans.

Finally, persistent structural barriers, most commonly related to scheduling, often limited schools' capacity to act on even well-formed plans. These constraints were especially pronounced in smaller and rural schools, where resource and staffing flexibility were limited. This suggests that even strong planning processes may benefit from paired investments in operational support and district- or state-level coordination to ensure follow-through.

PACS's investment in team-based, scaffolded planning support significantly shaped how schools approached CS pathway implementation. From initial visioning to more detailed strategic planning, schools increasingly embraced the idea of CS as a shared, school-level responsibility. The iterative and collaborative nature of the planning process helped deepen educators' understanding of their roles, surfaced systemic barriers, and laid the foundation for more sustainable CS programs. However, the lack of structured planning opportunities in the final year underscored the fragility of this progress. Going forward, programs like PACS will benefit from embedding sustained, facilitated planning cycles into both summer PD and academic year structures—ensuring that the momentum built during early implementation phases is not only preserved but strengthened.

Coaching and Resource Use (Year 1 – Year 3)

One of PACS's core strategies for supporting sustainable school-level implementation of computer science was the provision of coaching and instructional resources tailored to each CS course and professional role. These supports were designed not only to enhance individual teacher and counselor capacity, but also to serve as ongoing catalysts for community-building and implementation momentum throughout the academic year. Across the first through third years of PACS implementation (2021–2024), usage of coaching and resource support varied considerably across educator roles and training cohorts. Although PACS consistently aimed for 80% uptake and satisfaction, this benchmark was only partially met—highlighting both the promise and the fragility of these support systems.

Among the 72 educators trained in summer 2021 (start of Year 1), 56 (78%) reported utilizing coaching and PACS-provided resources—a near miss of the 80% implementation threshold. Disaggregated data showed high engagement among C4C counselors (83%) and AP CSP teachers (100%), both of whom accessed coaching, workshops, or summits and rated resources as both useful and sufficient. ECS teachers also demonstrated strong participation, with 72% meeting all coaching/resource use criteria, including high attendance at fall and spring PD and positive ratings for both utility and sufficiency of resources. Bootstrap teachers, however, lagged behind, with only 57% using coaching or instructional resources, and lower satisfaction ratings. This was likely influenced by the smaller cohort size and the novelty of Bootstrap implementation in Alabama. Still, teacher comments underscored the value of specific coaching on Codio and computational thinking strategies. As one teacher noted during this period:

"With the help of PACS this will be our 3rd year of teaching ECS, 2nd year for Bootstrap Algebra, and this year (23–24) we will offer AP CSP for the first time… It would be nice to eventually offer a more rigorous CS class like 'AP CS A' for students who plan to pursue CS degrees and careers."

This teacher leveraged coaching and resources to expand programming, envision next steps. Educators expressed appreciation for the responsiveness of PACS coaches and the relevance of instructional materials.

Following summer 2022 PD and during the 2022–2023 academic year (Year 2), coaching and resource use dipped slightly. Of the 69 educators trained in summer 2022, only 49 (71%) accessed coaching or PACS instructional resources. This marked a decline from the prior year and fell short of the 80% benchmark. The sharpest decline occurred among C4C counselors, only 44% of whom reported meeting with a coach or program leader. By contrast, ECS teachers remained highly engaged: 86% reported using ECS resources, and a majority attended both fall and spring PD. However, satisfaction with PD effectiveness dropped over time, rated highly in summer (79%) but falling to 47% by spring. Similarly, only 47% of ECS teachers rated the resources as sufficient, pointing to a growing mismatch between teacher needs and support provision as implementation matured. Bootstrap teacher support was more robust in 2022-2023. AMSTI coaches provided site-based assistance to 70% of Bootstrap teachers, and national experts conducted online sessions focused on Pyret coding and differentiated instruction. Still, only 60% of Bootstrap teachers rated resources as useful, and 45% as sufficient, again reflecting uneven impact despite expanded offerings. AP CSP teachers showed high engagement--100% used PACS resources and most rated them positively. However, coaching uptake was limited to informal sessions or external PD communities, suggesting missed opportunities for deeper instructional mentoring. One teacher summarized the value of these coaching and resources in creating an inclusive classroom culture:

"Our program encourages everyone to participate in the computer science program. We have an even number of female and male students… My classroom belongs to the students in it… They are free to express themselves in their projects and not be judged."

In Year 3 (2023-2024), coaching and resource usage data were collected only for AP CSP teachers - the focus of the impact study that year. Among the 21 educators trained in summer 2023, all used PACS-provided instructional resources and attended PD sessions in summer and fall. Spring 2024 attendance dipped to 71%, but satisfaction remained high across all sessions, with PD effectiveness rated at 93-100% and 75% rating the available resources as sufficient.

In Year 4 (2024-2025), coaching and resource usage data were collected for ECS teachers. Seventeen PACS-funded educators trained in summer 2024 were invited to attend two follow-up professional development sessions during the school year. The first session, held October 7-8, was attended by 12 teachers (71%) and the second, held January 31-February 1, was attended by 13 teachers (76%). Satisfaction remained high across both sessions, with 95% of participants agreeing that the PD was valuable and 86% indicating that the workshop provided useful instructional resources.

Patterns and Implications

Several patterns emerged across the three years:

- **Strongest Uptake in Early Implementation:** The highest levels of engagement occurred in 2022-2023 (Year 2), when the novelty of PACS and the recency of summer training likely contributed to high usage of coaching and resources. Satisfaction was also highest during this period, particularly among AP CSP and ECS teachers.
- **Decline in Counselor Participation:** After strong initial engagement, C4C counselors experienced a drop in support usage by 2023-2024. This may reflect role-based challenges, such as scheduling inflexibility or less frequent integration with instructional planning cycles. It may also signal a need for more structured follow-up after initial training.
- **Bootstrap Support Gaps:** Despite efforts to expand Bootstrap coaching in 2023-2024 (Year 3), uptake and satisfaction remained lower than other roles. Smaller cohort sizes and variation in local implementation likely affected the impact of available support. This suggests a need for more individualized, high-frequency coaching in emerging CS courses.
- **Positive Impact of AP CSP Structure:** AP CSP teachers consistently reported high engagement and satisfaction, especially when supports were coordinated. The alignment between PD content (e.g., Create Task preparation), real-time needs, and yearlong community interaction likely contributed to this success.

Ultimately, coaching and resource supports were among PACS's most valued features, when used. The data highlight that timely, role-specific, and high-quality supports not only improve educator satisfaction but also contribute to deeper implementation. To sustain progress, PACS or future initiatives should prioritize structured coaching cycles, ensure data collection across all roles, and adapt support delivery based on evolving needs.

Training-Based Communities of Practice (Year 1 – Year 3)

A key strategy of the PACS initiative was to foster professional communities of practice (CoPs) around each of its core curricular programs. These training-based CoPs served as platforms for teachers and counselors to engage with peers, deepen their pedagogical knowledge, and access implementation supports. Centered on Exploring Computer Science, Bootstrap Algebra, AP CS Principles, and Counselors for Computing, these communities were designed to provide discipline-specific collaboration, facilitate cross-school exchange, and offer scaffolding aligned to each program's demands.

ECS teachers exhibited consistently high rates of participation in professional communities of practice. In Year 1 (2021–2022), the PACS Impact Study 2 focused on ECS teacher training and classroom implementation. During that year, 90% of ECS teachers (26 of 29) reported engaging with fellow ECS educators- 52% through formal learning communities and 69% via school-based CoP teams. By Year 2, ECS teacher engagement increased to 96% (28 of 29), indicating not only sustained participation but also the strengthening of the ECS network over time. In Year 3, 83% of trained ECS teachers implemented the course and had community interactions around CS pathways by attending fall 2023 (83%) and/or spring 2024 (48%) PD workshops. The success of the ECS CoP suggests that the program's foundational placement in 9th or 10th grade and its sequence-setting role in the CS pathway contributed to a strong sense of shared purpose among its educators.

Bootstrap teachers showed a more fluctuating pattern of participation. Engagement in CoPs, including teaching observations with an AMSTI coach, rose from 43% (3 of 7) in Year 1 to 65% (13 of 20) in Year 2, a period during which PACS Impact Study 2 supported Bootstrap training and implementation. However, this upward trend did not persist. In Year 3, participation dropped sharply to just 15% (4 of 27), with minimal evidence of AMSTI coaching or broader professional interaction. These fluctuations suggest that while structured coaching during a focused implementation year can boost engagement, but sustaining connections afterward requires a stronger school culture of valuing AMSTI support and professional collaboration. Given that Bootstrap is often taught by math teachers with varying levels of CS experience, the data point to the need for more targeted scaffolds, such as cohort-building, computational thinking support, and scheduled collaboration time, to deepen integration into the school-level CS effort.

AP CSP teachers, meanwhile, demonstrated increasing engagement in structured CoPs, particularly in Year 3 when PACS Impact Study 2 focused on AP CSP training and classroom rollout. All 21 AP CSP teachers participated in CSPdWeek in the summer of Year 3 and continued to engage through academic-year PD sessions, ongoing communications, and structured supports around key curricular elements, such as the College Board's Create Task. The high participation rate underscores the importance of combining content-specific training with sustained opportunities for collaboration and resource sharing. Teachers benefited from a sustained rhythm of engagement--summer preparation, fall and spring PD, and informal peer exchanges throughout the school year. The momentum built through this model highlights how discipline-specific needs can drive ongoing community involvement. As one AP CSP teacher explained, “My classroom belongs to the students in it... They are free to express themselves in their projects and not be judged,” reflecting the program’s emphasis on inclusive culture and student empowerment. Sustaining this strong CoP will likely require continued facilitation, timely resource dissemination, and opportunities for shared problem-solving linked to AP expectations.

Counselors participating in the C4C program also showed strong initial engagement. In Year 1, 83% of counselors engaged in peer or team-based CoPs, followed by 78% in Year 2. These early figures suggest the C4C model resonated--particularly when counselors collaborated closely with classroom teachers to support student recruitment, scheduling, and long-term pathway planning. Participation data were not available in Year 3, limiting the ability to analyze longer-term trends. Nonetheless, qualitative evidence suggests that counselor-teacher coordination continued to influence course access and enrollment equity. One participant described their school’s approach: “Our CS teacher does a great job of personally recruiting students to the program... We strive to keep our classes with a well-balanced male to female ratio. With our diverse student population, recruiting minorities is not a problem.” This underscores the crucial role of counselors in equity-driven CS expansion.

Together, these training-based CoPs underscore a broader insight: structured, role-aligned professional learning communities can effectively engage educators when they are paired with appropriate supports and clearly defined curricular goals. However, long-term sustainability of these communities requires consistent scaffolding, opportunities for collaboration, and models that reflect the unique responsibilities and content demands of each educator group.

School-Based Communities of Practice (Year 1–Year 3)

In addition to training-based professional networks, PACS also emphasized the importance of local, school-based communities of practice (CoPs) composed of interdisciplinary teams working collaboratively to advance CS pathway implementation at the local level. These teams typically included two or more educators—most often a CS teacher, a math or science colleague, a counselor, and, where possible, an administrator. Their work focused on vision-setting, course sequencing, scheduling, student recruitment, and program sustainability tailored to each school's context.

During Years 1 and 2, PACS supported the formation of these school-based teams through summer planning sessions, team templates, and structured goal-setting processes. By the end of Year 2, 62% of participating schools included both a PACS-trained teacher and a counselor on their CS team. Team size varied from 0 to 5 members, and vision + goal enactment scores ranged from 0 to 9, reflecting wide variability in maturity. Some teams were in the early stages of CS planning, while others had already articulated and begun implementing multi-year course sequences. The process of writing and submitting annual planning documents helped these teams build a shared vision and begin aligning supports around common goals.

In Year 3, planning documents remained a required component, and many pathway schools engaged the school counselor to meet with the AP CSP teacher during CSPdWeek, enabling additional face-to-face planning of school CS pathways. Many school-level teams submitted written reflections detailing their goals, priorities, and progress over the year. Focus group data revealed that the most effective teams shared a foundation of relational trust, frequent communication, and shared ownership of the CS program's success. Teachers in smaller or rural schools often described highly personalized coordination with counselors: "I can just meet with her [the counselor]... She's flexible and always works with me to find students for CS." Leadership support proved critical. One teacher shared, "Our principal called the shots and got me into CS," while another noted the impact of a new administrator with CS experience: "Our new principal had a CS background—it made a big difference."

Focus group lunch sessions were held during Summer 2023 CS PD Week with experienced team leaders to reflect on accomplishments and ongoing challenges. Participants described expanded course offerings—e.g., progressing from ECS to Bootstrap and AP CSP—and increased efforts to build continuity across years. Many highlighted the benefits of working alongside colleagues who shared responsibility for recruitment, curriculum alignment, and equity goals. Yet participants raised concerns about long-term sustainability. In several cases, schools remained dependent on a single teacher to drive the CS program forward. One veteran warned, "if I retire, it might dwindle," highlighting the vulnerability of singly-teacher-led programs.

Across these years, effective school-level CoPs shared several common traits: cross-role collaboration, alignment on pathway vision, shared commitment to equitable student participation, and a sense of distributed leadership. When supported by PACS structures and training, these interdisciplinary teams became instrumental in implementing and sustaining the school's CS offerings. Schools that paired strong school-based teams with robust training-based CoPs made the greatest strides toward building inclusive and sustainable CS pathways.

5. Program Measures

Program measures were articulated in the project proposal and are meant to be lasting, objective measures of program performance. The evaluation team and the program team collaborate on measuring and reporting results for these measures. Performance findings based on project objectives are reported where possible for October 2024–September 2025 and cumulatively.

For each, a check √ indicates the target was reached, a ~ indicates it was nearly reached, and an X indicates it was not reached.

<u>Project Objective 1</u>: Expand local partnerships to develop CS pathways

√ 1b. 29 schools participated in the 3-year pathways as treatment schools. 30=goal
√ 1c. Coaching was made available to all Bootstrap teachers in Years 1-3. AMSTI did not provide coaching to Bootstrap teachers in year 4. Goal was all teachers in years 1-3.
√ 1d. 6 ECS teacher-leaders were active through summer 2024, with an additional 4 facilitators trained in summer 2025. 6=goal by year 3
√ 1e. 5 AP CSP teacher-leaders serving PACS training needs. 4=goal by year 3.
√ 1f. All schools that participated in PACS training in summers 2020-2025 have access to an AMSTI specialist within a regional in-service center[6]. Goal=100%.

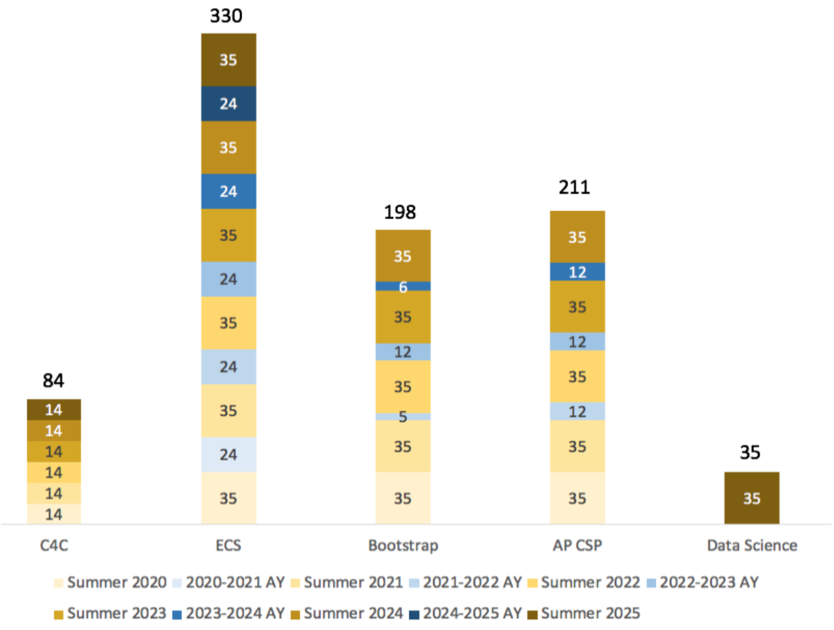
<u>Project Objective 2</u>: Implement PD program to improve instructor competencies

√ 2. 858 hours of PD (124%) through end of summer 2025. Goal= 692 by end of project.

Summer 2025 PD hours (summer 2025) are: 14 C4C, 35 ECS, Bootstrap & AP CSP), and 35 Bootstrap Data Science.

Year 4 (2024-2025) Academic Year PD hours were 24 for ECS.

The total number of PD hours through summer 2025 exceeds the original goal by 24%.



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[6] Since this grant targeted rural schools, criteria 1a was not helpful in evaluating the quality of the program implementation. Therefore, criteria 1f was added, "100% of schools within districts have access to an AMSTI specialist within a regional in-service center".

Project Objective 3: Proving coaching support for classroom implementations - *90% of Bootstrap teachers utilize coaching which they rate as "effective" in years 0, 1, 2, 3*

X 3. This objective was not met in Year 4 for any of the 11 trained Bootstrap teachers.
Goal = 90%

Project Objective 4: Increase teacher effectiveness in CS - *75% of teachers make gains in CS efficacy, pedagogical confidence, preparedness, outcome expectancies, and attitudes towards 21st century learning in years 0, 1, 2, 3. Measured Pre-PD and Post-AY.*

This objective was not measured quantitatively for Years 3 or 4. Qualitative results for Year 3 are provided here. Data are drawn from AP CSP teacher focus groups during summer PD (July 11-12, 2023), surveys and open-ended responses (July 14, 2023 for AP CSP teachers – post-PD).

CS Teaching Efficacy. Across focus groups surveys, and open-ended responses, teachers consistently reported increasing efficacy in teaching computer science, particularly as they moved through the PACS-supported PD sequence (ECS → Bootstrap → AP CSP). Many began with no formal CS background, and several described early doubts or anxiety ("I didn't think I could do this"), but this sentiment gradually shifted toward ownership and competence. By Year 3, teachers were describing their role in CS instruction with assurance: "By your third year, you actually know what you're doing." Efficacy was also closely linked to curriculum design—teachers credited ECS and Bootstrap with supporting student success and enabling them to feel like competent facilitators of meaningful learning. Teachers felt they could reach all types of learners, including students who would not have self-selected into CS classes.

Pedagogical Confidence. PACS teachers demonstrated growing pedagogical confidence, particularly around student-centered, project-based instruction. Focus group participants described shifting from "teaching syntax" to "building thinkers," illustrating how their understanding of what it means to teach CS had evolved. They spoke confidently about modifying lessons, using storytelling, scaffolding projects, and differentiating instruction.

Survey data echoed this trend: teachers cited enjoyment in curriculum delivery and noted satisfaction with their instructional approach. One post-PD respondent referenced the strength of their school's momentum in CS ("We have added ECS, Bootstraps, and now AP"), a reflection of sustained confidence in pedagogy and curricular continuity. Even Bootstrap teachers, who were often newer to PACS, generally expressed openness and effort in navigating CS-infused instruction—even if they hadn't yet reached full fluency.

Preparedness. Preparedness was an area of notable growth. Teachers credited multi-year, layered PD with equipping them for each successive course. Resources like pacing guides, hands-on training, and peer collaboration were frequently cited as effective. Teachers felt prepared not just to deliver content, but to integrate the courses into their school culture and schedule. In the AP CSP post-PD survey, teachers expressed confidence in implementation logistics; some were already planning for expanded enrollment and continued rollout. Preparedness appeared highest when teachers had participated in more than one year of PD and course delivery.

Outcome Expectancies. Teachers' expectations for student success were cautious but hopeful. Across all sources, they expressed belief in students' ability to succeed with proper exposure and support. They often cited surprise at how students "lit up" after succeeding in CS, especially those who had been placed into the course rather than self-selecting. Teachers viewed early exposure—such as ECS or Bootstrap—as essential to helping students build confidence and motivation. While some noted challenges related to scheduling or institutional buy-in, many believed that with the right supports, students could thrive. Recruitment and retention were also top of mind. Several teachers described building a pathway where students were beginning to take multiple CS courses and even considering CS careers. These anecdotes revealed longitudinal vision, even if immediate gains were modest.

Attitudes Toward 21st Century Learning. Teachers strongly embraced the broader goals of 21st-century education—especially problem-solving, collaboration, creativity, and career relevance. Many explicitly framed CS as a tool for empowerment and economic opportunity, particularly in rural communities. One teacher noted, "It's a good time to be in computer science," capturing the forward-looking tone of many participants. They described efforts to align instruction with real-world applications, such as agriculture technology or robotics, and saw value in students learning transferable skills, not just coding syntax. The focus group and AP CSP survey responses suggested that teachers further along the PACS pathway had internalized these values. They spoke not just about skills but about student empowerment and social mobility.

Conclusion. Across all sources, PACS teachers demonstrated a clear trajectory of professional growth. Their reflections showed that sustained, scaffolded PD and curricular support enabled them to evolve from tentative adopters to confident CS educators. The cumulative effect of PACS training was evident in increased confidence, preparedness, and alignment with modern teaching values. Teachers see themselves as key drivers of equity and innovation, especially in rural schools. Their investment in students' CS success is both personal and pedagogical, underscoring the importance of continued support, community building, and strategic sustainability planning.

Project Objective 5: Foster professional learning community - *90% of teachers participate in learning communities with 20+ measured interactions within community in years 0, 1, 2, 3*

Previously, this objective was met for AP CSP teachers in Year 3, although it was not met for ECS teachers or Bootstrap teachers. It was undetermined for C4C counselors.

In Year 4, the objective was not rigorously implemented, and results include:

> Of the 17 ECS PACS teachers trained in summer 2024, 13 (76%) implemented the course and had community interactions around CS pathways by attending fall 2024 (71%) and/or spring 2025 (76%) PD workshops.

For 11 Bootstrap teachers trained in summer 2024, unit completion was not documented and no AMSTI coaching was provided in 2024-2025.

All four of the AP CSP teachers trained in summer 2024 implemented the course and had access to A+ College Ready preparation sessions.

Of the 17 C4C counselors trained in summer 2024, there were no documented professional community interactions during 2024-2025.

Project Objective 6: Teacher Retention - *75% of trained teachers are retained (teaching courses received PD) at project's end*

Not measured in Year 4. Previous results (Haynie, Blankenship, & Gorham 2024) are:

X 48% of teachers taught the PACS course in 2023-2024 for which they were trained in summers 2021, 2022, and 2023. Rate for the ECS course is 38% (n=113), for the Bootstrap unit is 73% (n=60), and for AP CSP course is 44% (n=52). 75%=goal by Year 3

Project Objective 7: Prepare Counselors for providing Career and Workforce Readiness activities
After C4C, 95% of counselors report having better understanding of computing and greater confidence in guiding students in years 0, 1, 2, 3

√ 7a. This objective was met in Years 0, 1, 2, 3, 4 and Summer 2025 combined. C4C Counselors were surveyed after their summer training and 98% (148/151) agreed that their understanding was moderately or greatly impacted in a number of key areas. In gaining confidence and resources for guiding students, 97% (146/151) agreed that they gained in this, or that the training moderately or greatly contributed to this. 95%=goal

100% of C4C schools provide information to all students about: (1) ***available CS courses****, (2)* ***internships and co-op opportunities****, (3)* ***credentials for in-demand career pathways*** *for years 0, 1; (90% previously for years 0, 1) (7b)*

√X 7b. This objective was assessed and partially met in Years 3 and 4 immediately following the C4C summer PD, focusing on counselors' intended actions.

1. **CS Course Information:** 100% of surveyed counselors (11 in Year 3 and 16 in Year 4) reported motivation to inform students about available computer science courses.
2. **Internships and Co-ops:** Providing information about internship and co-op opportunities was **not measured** during these years.
3. **Career Pathways and Credentials:** 100% of surveyed counselors (11 in Year 3 and 16 in Year 4) reported that the workshop increased their awareness of the breadth and depth of computing careers, the availability of technical jobs, and their understanding of how comprehensive school counseling programs can support students' access to CS-related career pathways.

> Results indicate that the C4C PD effectively strengthened counselors' motivation and awareness related to CS course promotion and computing career pathways. However, systematic data on internship and co-op information sharing are still needed to fully assess progress toward the complete objective.

<u>Project Objective 8</u>: Develop and deliver AP CSP Student Workshops and academic year sessions for rural/town students - *80% of AP CSP students attending Summer Institute attend both fall and spring regional sessions (Saturday sessions) in years 1, 2, 3*

This objective was partially accomplished in Years 1-3.

Results for Year 4 and Summer 2025 include:

> √ Five-day AP CSP Student Workshops were delivered in Summer 2025 at University of Alabama for AP CSP students enrolled in an AP CSP course. In summer 2025, Thirty-five students attended from 24 high schools. These students can expect study sessions offered online through A+ College Ready during the 2025-2026 academic year.

<u>Project Objective 9</u>: Deliver evidence-based CS: Bootstrap, ECS, and AP CSP in rural/town high schools - *ECS and AP CSP curricula cover 100% of DLCS standards <u>strands and topics</u> in years 1, 2, 3 based on curriculum analysis and teacher self-report (i.e., end of year survey). Bootstrap unit (about 5 weeks to implement) covers 25% of DLCS standards strands and topics in years 1, 2, 3 based on curriculum analysis and teacher self-report (i.e., end of year survey)*

This objective has been clarified to indicate that standards coverage is defined as meeting at least <u>one</u> standard within each DLCS <u>strand</u> and <u>topic</u>, not all standards within a topic. That would require a breadth and depth of every PACS course that is not feasible or optimal. This objective is measured in terms of <u>intended</u> curriculum based on curricular analyses and <u>enacted</u> curriculum, based on teacher report.

This objective was partially met in Years 3 and 4:

> √ ECS <u>intended</u> curriculum (six units) covers 100% of the DLCS standards.
>
> X For ECS enacted curriculum, an estimated 24 of 30 (80%) of Year 3 teachers completed or partially completed units 1-5 or 1-6 units, and 21 of 28 (75%) of Year 4 teachers completed or partially completed units 1-5 or 1-6 units.
>
> √ The Bootstrap <u>intended</u> curriculum in Algebra I covers DLCS Standards 3-6, 9, 10, 25-28, 31, 32, 38, and 40. In total, 14 of the 40 standards (35%) are strongly embedded in the BS Algebra curriculum.
>
> X For Bootstrap <u>enacted curriculum</u>, there is evidence that only 5 of 27 teachers (19%) implemented the Bootstrap unit in Year 3. There is no implementation evidence for the 11 teachers who received PD in Summer 2024.

√ AP CSP UTeach intended curriculum units 1-6 cover 22 topics, 100% of DLCS Standards.

√ For the AP CSP UTeach enacted curriculum, 21 of 21 Year 3 teachers (100%) reported completing or partially completing units 1-6 and Create, covering 100% of the DLCS standards. In addition, 17 of 21 (81%) Year 3 teachers had students complete the Create task and take the examination. There is no implementation evidence for the 4 teachers trained in Summer of Year 4.

Project Objective 10 *80% of observed Bootstrap Units (rural/town schools) reached level 3 of 4 quality levels in years 1, 2, 3; measure is MCOP^2 (Gleason, Livers, & Zelkowski, 2017, 2018)*

No Bootstrap Algebra class observations were carried out between October 2024 and September 2025 (Year 4-5). Previous results (Haynie, Blankenship, & Gorham 2024) were:

√ *For the seven observed Bootstrap class sessions, ratings for 86% reached or exceeded an average level "2" (scale = 0 to 3) across all MCOP^2 qualities.*

Project Objective 11 60% of rural/town selected student sample exceeds the previous groups' mean algebra scores in years 1, 2, 3; measure is algebra problem-solving (e.g., Zelkowski, 2021)

Not measured in Year 4. Year 2 results provided by Haynie, Blankenship & Gorham, 2023.

Project Objective 12 80% of selected and observed ECS classes (rural/town schools) reach level "2" (= sometimes or over half of students) on 75% of the CSCHOOL-LEVEL COP1[7] qualities.

No ECS class observations were carried out between October 2024 and September 2025 (Year 4-5). Previous results (Haynie, Blankenship, & Gorham 2024) are:

√ *For the six observed and recorded ECS class sessions, five sessions (83%) reached a level "2" on 75% or more of the ECS COP qualities.*

Project Objective 13: Year 3 outcome scores exceed Year 1 outcomes scores for 60% of students in Treatment schools; measure is High School Computational Thinking Assessment (Haynie & Ravitz, 2021)

Not measured in Year 4. Previous results (Haynie, Blankenship, & Gorham 2024) are:

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[7] Please note the development and validation of the ECS Classroom Observation Protocol, aka Computer Science Classroom Observation Protocol 1, was documented in a previous evaluation report (Haynie and Blankenship, 2022).

> *√ Year 3 outcome scores exceed Year 1 outcomes scores on the High School Computational Thinking Assessment for 65% of students in Treatment schools, n=406*

<u>Project Objective 14</u> 80% of selected and observed AP CSP classes (rural/town schools) reach level “2” (= sometimes or over half of students) on 75% of the AP CSP COP qualities.

> No AP CS Principles class observations were carried out between October 2024 and September 2025 (Year 4-5). Previous results (Haynie, Blankenship, & Gorham 2024) were:
>
> *X For seventeen observed AP CSP class sessions, ten (59%) reached a level “2” on 75% or more of the AP CSP COP qualities.*

<u>Project Objective 15</u>: Increase student content knowledge and computational thinking practices in AP CS Principles

15.a. 80% of rural/town students in AP CSP courses take the AP exam

> Not measured in Year 4. Previous results (Haynie, Blankenship, & Gorham 2024) are:
>
> X 15a. 66% of students of PACS-trained teachers took the AP exam in May 2024. Goal=80%

15.b. Increase AP CSP qualifying scores for rural/town districts over Alabama statewide May 2020 baseline (54% qualifying, n=1782): year 0 rate matches baseline, year 1 rate is baseline + 2%, year 2 rate is baseline + 4%, year 3 rate is baseline + 6%.

> Not measured in Year 4. Previous results (Haynie, Blankenship, & Gorham 2024) are:
>
> X 15b. 31% of students of PACS-trained AP CSP teachers (52 of 218 students in 16 schools) received qualifying scores on the exam in May 2024. Goal=60%

15.c. 60% of students with supplemental AP CSP experiences (Summer Institute, Academic Year work) score higher than comparison group mean in years 1, 2, 3

> Not measured in Year 4. Previous results (Haynie, Blankenship, & Gorham 2024) are:
>
> √ 15c. Fourteen of 24 students who attended the AP CSP camp in summer 2023 took the AP CSP exam. Of these, nine students (64%) received a qualifying score. Goal=60%

Project Objective 16: Increase students' CS attitudes, 21st century skills, intent to persist, and CS/STEM career interest through CS Pathway

16b. 75% of students make gains on every scale (CS Belonging, Encouragement, Interest, Confidence, and Career Interest) for years 1 and 3 over baseline; measure is Student Computer Science Attitude Survey (Haynie 2017) and CS Career Interest Survey (Haynie & Counts, 2022)

X 16b. The 75% threshold was not reached for any of the measures in Year 1 or Year 3.

Analysis across the five attitude scales indicates that while some gains were observed, the 75% threshold was not met on any scale in either Year 1 or Year 3.

- Belonging: Scores remained flat, with 45% of students in both Year 1 and Year 3 scoring above the baseline average (Table 3.2.15).
- Encouragement: Slight improvements were seen, with 56% of students scoring above baseline in both Year 1 and Year 3 (Table 3.2.16).
- Interest: Modest gains were observed, with 53% in Year 1 and 51% in Year 3 exceeding the baseline average (Table 3.2.17).
- Confidence: Scores remained stable, with 53% of students above baseline in Year 1 and 54% in Year 3 (Table 3.2.18).
- Career Interest**:** Scores declined slightly, from 53% above baseline in Year 1 to 50% in Year 3 (Table 3.2.20).

These results suggest that while a moderate share of students experienced growth, overall movement across all five attitude measures was insufficient to meet the defined program objective. Gains were typically modest and variable across constructs, pointing to areas for targeted reinforcement in future implementation cycles.

16.c. 100% of pathways course enrollments for rural/town female students match school demographics: within <15% of school demographics in year 0, <10% in year 1, <5% in year 2, equal in year 3

X 16c. 40% of schools had sufficient female enrollment in ECS and AP CSP combined. Goal=100% of schools equal to or exceeding school demographics in year 3

These data were not analyzed for October 2024 through September 2025 (Year 4-Summer 2025). Previous results are provided by (Haynie, Blankenship, & Gorham 2024).

16.d. 100% of pathways course enrollments for rural/town students from under-represented ethnic/racial groups match school demographics: within <15% of school demographics in year 0, <10% in year 1, <5% in year 2, equal in year 3

X 16d. 29% of schools have sufficient numbers of URG students enrolled in ECS and AP CSP. Goal=100% of schools equal to or exceeding school demographics in year 3

These data were not analyzed for October 2024 through September 2025 (Year 4-Summer 2025). Previous results are provided by (Haynie, Blankenship, & Gorham 2024).

16.e. 100% of pathways course enrollments for rural/town low SES students match school demographics: within <15% of school demographics in year 0, <10% in year 1, <5% in year 2, equal in year 3

X 16e. 57% of schools have sufficient low SES student enrollment in ECS and AP CSP. Goal=100% of schools equal to or exceeding school demographics in year 3

These data were not analyzed for October 2024 through September 2025 (Year 4-Summer 2025). Previous results are provided by (Haynie, Blankenship, & Gorham 2024).

Project Objective 17: Increase career and workforce readiness of students, with particular focus on rural, underrepresented, and low-income students.

17) 80% of selected student sample in years 1and 3 participate in at least one CS-related career and workforce readiness activity/workshop.

This was not measured in Year 4. Previous results (Haynie, Blankenship, & Gorham 2024) are:

✓ *87% of 11th grade students (n=819) in Pathway schools (i.e., schools with a counselor trained in C4C), surveyed in spring 2023, indicated participating in at least one career or workforce readiness activities/workshop (42% indicated 2 or more activities).*

6. Impact and Recommendations for Scale-Up

Synthesis of Impacts: Deepening Computational Thinking in Rural Contexts

Across five years of implementation and two rigorous impact studies, the Pathways for Alabama Computer Science initiative demonstrated clear and meaningful benefits for students, educators, and school systems in Alabama's rural and high-need communities. At the student level, PACS achieved measurable gains in computational thinking, algebra proficiency, and AP CSP exam participation—key indicators of readiness for both higher-level coursework and future STEM careers. These findings are especially significant given the rural context, where systemic barriers and resource gaps have long limited access to advanced STEM education.

Students in PACS schools not only outperformed comparison peers on targeted assessments (with moderate effect sizes across multiple domains), but also showed a higher likelihood of attempting rigorous coursework such as AP Computer Science Principles—an important behavioral marker of academic self-efficacy and aspiration. While broad attitudinal and career interest measures remained stable, these performance and participation gains underscore the tangible academic benefits of PACS's sustained, schoolwide computer science pathways.

At the systems level, PACS fostered school-based teams, cross-role professional networks, and a statewide infrastructure for equity-driven CS instruction. These capacity-building efforts—especially the integration with Alabama's AMSTI system and the development of teacher-leaders—have laid a durable foundation for long-term implementation, even as some program components (e.g., coaching or Bootstrap fidelity) experienced end-of-grant variation. PACS succeeded not only as a professional development initiative, but as a model for rural systems change: building structures, skills, and cultures that enable equitable CS access at scale.

Sustainability and Policy Context

PACS's achievements must be interpreted within a rapidly evolving policy landscape. At the start of the initiative, PACS Pathway schools were among the first in Alabama to offer CS coursework, making the comparison to "business as usual" both valid and impactful. However, this context shifted dramatically with the passage of Alabama's Computer Science Act (2019-389)**,** which mandated that all high schools offer at least one CS course by 2020–21. The result was a statewide surge in CS activity—led largely by A+ College Ready—which accelerated implementation timelines and blurred the distinction between treatment and comparison schools.

This newer landscape presents both a challenge and a validation. On one hand, PACS schools were no longer compared to non-CS schools but to peers also moving aggressively to expand computing. On the other, PACS schools remained competitive—and in many cases led the field—even against this rising tide. That is a testament to the program's quality, reach, and relevance.

Nevertheless, this same context complicates vertical scale-up (institutionalization) within Alabama. Given the substantial influence and infrastructure of A+ College Ready in the state's current CS rollout, opportunities for embedding PACS as a distinct statewide model are likely limited. Any future scale-up within Alabama would require thoughtful coordination with existing efforts, or potential specialization in underserved niches (e.g., counselor PD, Bootstrap Data Science, rural systems alignment).

Recommendations for Scale-Up Planning

Given the strength of its implementation and the barriers to institutionalization within Alabama, PACS is well-positioned to pursue horizontal scale-up (expansion and replication)—particularly in similar rural and high-need contexts in the Southeast or other under-resourced regions. The core model of schoolwide teams, sequenced PD, and integrated academic pathways offers a replicable approach that could be tailored for other rural states.

The following strategies are recommended:

1. Advance Horizontal Scaling Beyond Alabama

- Target rural districts in neighboring southern states (e.g., Mississippi, Georgia, Louisiana, Arkansas) that share similar demographics, access gaps, and teacher shortages
- Prioritize early engagement with state education departments, rural collaboratives, and land-grant universities
- Emphasize Bootstrap Algebra and Data Science as scalable entry points that integrate with existing math curricula

2. Explore Diversification Strategies

- Consider applications in urban high-need settings**,** where counselor supports, team-based implementation, and culturally responsive curriculum may offer added value
- Tailor professional learning communities and advising strategies for more diverse teaching environments

3. **Convene a Leadership Strategy Session**

- Bring together PACS leadership, AMSTI, regional in-service centers, and potential external partners to:
    - Review scaling-readiness dimensions such as credibility, observability, relevance, compatibility, and testability
    - Identify which components are most “ready to travel” and where adaptations are needed
    - Discuss potential alignment or differentiation from other CS initiatives (e.g., A+ College Ready)

4. Refine the Innovation Package for Transferability

- Develop a PACS “implementation toolkit” including PD structures, community of practice guides, counselor resources, and assessment instruments
- Create short-form evidence briefs tailored for external stakeholders and funders (e.g., for IES mid-phase applications)
- Add in AI components to the resource package

5. Position for a Mid-Phase EIR Grant

- Leverage impact evidence, implementation fidelity, and strong rural outcomes to pursue Mid-Phase EIR funding
- Emphasize PACS’s theory of action, cross-role teams, and rural equity impacts in the grant narrative
- Build a multi-state or regional partnership that centers rural systems transformation

Conclusion

The PACS initiative has demonstrated impact, and built the infrastructure, evidence, and collaborative capacity needed to go further. With Alabama’s policy context reaching maturity, the most promising next chapter lies in thoughtful expansion and contextual adaptation. PACS can now serve as a national model for how to build sustainable, equity-oriented CS pathways in rural and under-resourced systems. Scale-up will require coordination, adaptation, and continued attention to educator and student needs—but the core ingredients are already in place. A focused next phase, supported by EIR mid-phase funding and strategic partnerships, would extend the reach and promise of PACS to communities beyond Alabama’s borders.

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Appendix A: Evaluation Activities and Responsibilities

Evaluation Activities and Responsibilities	
Activity	**May the activity be a 'shared' responsibility or only the responsibility of the 'independent evaluator'**
Study Design	
Articulating the logic model	Shared
Specification of research questions	Shared
Development of the evaluation plan and schedule of evaluation activities	Shared
Recruitment and Assignment	
Introduction of the study, and presentation of the program	Shared
Recruiting subjects and obtaining informed consent	Shared
Assignment of participants to treatment or comparison groups (For RCTs only)	Independent Evaluator
Tracking of the sample	Shared
Data Collection	
Collection of data to score fidelity of implementation	Independent Evaluator or Shared*
Collection of other descriptive data on implementation of the intervention	Independent Evaluator or Shared*
Collection of any data that will be used to describe the contrast created between treatment and comparison conditions (including student outcomes and other outcomes (e.g., teacher or parent behavior) that are used in impact analyses)	Independent Evaluator
Analysis and Reporting	
Descriptive analyses of implementation	Shared
Analyses of data to estimate the treatment/comparison contrast	Independent Evaluator
Confirmatory and exploratory impact analyses of outcomes (student, teacher, classroom, school)	Independent Evaluator
Other exploratory analyses (relationship of implementation and outcomes, etc.)	Independent Evaluator or Shared
Participating in Evaluation TA	
Regular communication with Evaluation TA Liaison	Independent Evaluator (Grantee and Developer may join calls as needed)

Appendix B: Fidelity Indicator for Implementation of ECS PD

PARTICIPATION	Definition	Unit of Implementation	Data Source(s)	Data Collection (who, when)	Score for levels of implementation at unit level	Threshold for adequate implementation at unit level		sample level (score and threshold for adequate implementation at sample level)	fidelity measure (n=# units in which the intervention is being implemented)	Expected years of fidelity measurement
1. PD attendance	Number of AM & PM sessions attended by a participant	Participant	Observations of PD sessions	Evaluator collects participation data during PD	5= present at 9-10 sessions; 4=present at 7-8 sessions; 3=present at 5-6 sessions; 2=present at 3-4 sessions; 1=present at 1-2 sessions; 0= present at no sessions	**1= participant score is 5.0;** **0=score less than 5**			All ECS teachers in schools implementing PACS	2020-2021 (year 0=pilot year of implementation) 2021-2022 (year 1 of implementation) 2022-2023 (year 2 of implementation) 2023-2024 (year 3 of implementation)
2a. PD participation: video or in person	Observed video participation or in person	Participant	Observations of PD sessions	Evaluator collects participation data during PD	2= observed participating live or on video for 5+ sessions; 1=observed participating for 1-4 sessions;	**1= participant score is 5.0 out of 6, with a score of "2" in at least two of the three subscores;** **0=score less than 5**			All ECS teachers in schools implementing PACS	
2b. Small Group Participation (in person, hybrid, online, and via online forum)	Presented/posted group projects (lessons and lesson revisions) and individual comments (in person or forum)		Small group discussion/presentation and/or forum discussion board entries		2=part of groups with 4 projects + 2 comments; 1=part of groups with 2 projects + 1 comment OR or all 4 group projects posted with no comments 0= participant did not participate in group work					
2c. PD participation: speaking	Observed speaking participation		Observations of PD sessions		2= observed speaking about content/questions for more than a sentence; 1=observed speaking for one sentence; 0=not observed speaking					
3. Participant Satisfaction	Participant satisfaction with quality of training	Participant	Participant post-PD survey	Evaluator collects survey data end of last PD day	On each of 20 items, score of 4/5=agree w/statement of quality; 3=neutral about statement; 1/2=disagree w/statement	**1= participant average score (across items) is 4.0;** **0=doesn't meet threshold**			All ECS teachers in schools implementing PACS	
4. Session Quality	Rubric of session observation qualities: planning/preparation, counselor kits, logistics, content/skill delivery, information/resources,	Program	Observations of PD sessions by 2 evaluators	Evaluators' adjudicated ratings	adjudicated score: 4=exceeds expectations; 3=meets expectations; 2=partially met; 1=not met	**Year 0 score of 1 = 90% of scores on items are 3&4; Year 1 score of 1 = 95% of scores are 3&4; Years 2-3 score of 1 = 100% of scores are 3&4**	1 = meets threshold; 0 = doesn't meet threshold			
Components (across all indicators)						Participant score on all three components ranges from 0 - 3.	Participant threshold for full PARTICIPATION = score of 3	**1=At least 80% of participants received scores of 3 AND program receives score of 1 on quality**		

Appendix C: Fidelity Indicator for Implementation of Bootstrap Algebra PD

PARTICIPATION	Definition	Unit of Implementation	Data Source(s)	Data Collection (who, when)	Score for levels of implementation at unit level	Threshold for adequate implementation at unit level	Next higher level if needed (score and threshold): indicate level	sample level (score and threshold for adequate implementation at sample level)	fidelity measure (n=# units in which the intervention is being implemented)	Expected years of fidelity measurement
1. PD attendance	Number of AM or PM sessions attended by a participant	Participant	Observations of PD sessions	Evaluator collects participation data during PD	5= present at 9-10 sessions; 4=present at 7-8 sessions; 3=present at 5-6 sessions; 2=present at 3-4 sessions; 1=present at 1-2 sessions; 0= present at no sessions	Score of 5	1= participant score is 5.0; 0=doesn't meet threshold		All Bootstrap teachers in schools implementing PACS	2020-2021 (year 0=pilot year of implementation) 2021-2022 (year 1 of implementation) 2022-2023 (year 2 of implementation) 2023-2024 (year 3 of implementation)
2a. PD participation: video	Observed video participation	Participant	Observations of PD sessions	Evaluator collects participation data during PD	2= observed on video for 5+ sessions; 1=observed on video for 1-4 sessions; 0=not observed on video	**1= participant score is 5.0 out of 6, with a score of "2" in at least two of the three subscores;** **0=score less than 5**			All Bootstrap teachers in schools implementing PACS	
2b. Online Forum Participation (or chat)	Registered/introduced on online forum through July 24/Chat participation				2=forum and/or chat participation and/or shared project, 2 entries; 1=forum or chat participation or shared project, 1 entries; 0= participant did not use online					
2c. PD participation: speaking	Observed speaking participation				2= observed speaking about content/questions for more than a sentence; 1=observed speaking for one sentence; 0=not observed speaking					
3. Participant Satisfaction	Participant satisfaction with quality of training	Participant	Participant post-PD survey	Evaluator collects survey data end of last PD day	On each of XX items, 3=agree w/statement of quality; 2=neutral about statement of quality; 1=disagree w/statement of quality	**1= participant average score (across items) is 3.0;** **0=doesn't meet threshold**			All Bootstrap teachers in schools implementing PACS	
4. Session Quality	Rubric of session observation qualities: planning/preparation, counselor kits, logistics, content/skill delivery, information/resources, facilitation of learning and planning, participant learning and planning	Whole PD Session	Observations of PD sessions by 2 evaluators	Evaluators' adjudicated ratings	adjudicated score: 4=exceeds expectations; 3=meets expectations; 2=partially met; 1=not met	**Year 0 score of 1 = 90% of scores on items are 3&4;** **Year 1 score of 1 = 95% of scores are 3&4;** **Years 2-3 score of 1 = 100% of scores are 3&4**	1 = meets threshold; 0 = doesn't meet threshold			
Components (across all indicators)						Participant score on all three components ranges from 0 - 3.	Participant threshold for full PARTICIPATION = score of 3	**1=At least 80% of participants received scores of 3 AND program receives score of 1 on quality**		

Appendix D: Fidelity Indicator for Implementation of AP CSP PD

PARTICIPATION	Definition	Unit of Implementation	Data Source(s)	Data Collection (who, when)	Score for levels of implementation at unit level	**Threshold for adequate implementation at unit level**	Next higher level if needed (score and threshold): indicate level	sample level (score and threshold for adequate implementation at sample level)	fidelity measure (n=# units in which the intervention is being implemented)	Expected years of fidelity measurement
1. PD attendance	Number of sessions attended	Participant	Observations of PD sessions	Evaluator collects participation data during PD	5=present all five days, 4=present four days, 3=present three days, 2=present two days, 1=present one day, 0=present no days	**1= participant score is 5.0; 0=score less than 5**			All UTeach teachers in schools implementing PACS	2020-2021 (year 0=pilot year of implementation) 2021-2022 (year 1 of implementation) 2022-2023 (year 2 of implementation) 2023-2024 (year 3 of implementation)
2a. PD participation: video or in person	Observed video participation (or in person 2021-2024)	Participant	Observations of PD sessions	Evaluator collects participation data during PD	3= observed on video all five days; 2=observed on video for three-four days; 1=observed on video for one-two days 0=not observed on video	**1= participant score is 5.0 out of 6, with a score of "3" in at least one of the two subscores; 0=score less than 5**			All UTeach teachers in schools implementing PACS	
2b. PD participation: canvas discussion board	Observed discussion board entries		Read Canvas Discussion Board entries		3=one chat entry all five days 2=one chat entry three-four days 1=one chat entry one-two days 0=no chat entries recorded					
3. PD Assignments	Assignments completed and submitted on Canvas platform	Participant	Canvas gradebook	Evaluator collects one week after PD	24=all 24 asssignments completed 23=23 assignments completed 22=22 assignments completed 21=21 assignments completed 20=20 or fewer assignments completed	**1= participant score is 21 out of 24; 0=score less than 21**			All UTeach teachers in schools implementing PACS	
4. Participant Satisfaction	Participant satisfaction with quality of training	Participant	Teacher participant post-PD survey.	Provider collects survey data end of last PD day	On each of 8 items, score of 4/5=agree w/statement of quality; 3=neutral about statement; 1/2=disagree w/statement	**1= participant average score (across items) is 4.0; 0=doesn't meet threshold**			All UTeach teachers in schools implementing PACS	
5. Session Quality	Rubric of session observation qualities: planning/preparation, logistics, content/skill delivery, facilitation of learning and planning, participant learning and planning	Program	Observations of PD sessions by 2 evaluators	Evaluators' adjudicated ratings	adjudicated score: 4=exceeds expectations; 3=meets expectations; 2=partially met; 1=not met	**Year 0 score of 1 = 90% of scores on items are 3&4; Year 1 score of 1 = 95% of scores are 3&4; Years 2-3 score of 1 = 100% of scores are 3&4**	1 = meets threshold; 0 = doesn't meet threshold			
Components (across all indicators)						Participant score on all four components ranges from 0 - 4.	Participant threshold for full PARTICIPATION = score of 4	**1=At least 80% of participants received scores of 4 AND program receives score of 1 on quality**		

Appendix E: Fidelity Indicator for Implementation of Counselors for Computing PD

PARTICIPATION	Definition	Unit of Implementation	Data Source(s)	Data Collection (who, when)	Score for levels of implementation at unit level	Threshold for adequate implementation at unit level	Next higher level if needed (score and threshold): indicate level	sample level (score and threshold for adequate implementation at sample level)	fidelity measure (n=# units in which the intervention is being implemented)	Expected years of fidelity measurement
1. PD attendance	Number of AM or PM sessions attended by a counselor-participant	Participant	Observations of PD sessions	Evaluator collects participation data during PD	4= present at 4 sessions; 3=present at 3 sessions; 2=present at 2 session; 1=present at 1 session; 0=present at no sessions	**1= participant score is 4.0; 0=score less than 4**			All counselors from schools implementing PACS	2020-2021 (year 0=pilot year of implementation) 2021-2022 (year 1 of implementation) 2022-2023 (year 2 of implementation) 2023-2024 (year 3 of implementation)
2a. PD participation: video	Observed video participation	Participant	Observations of PD sessions	Evaluator collects participation data during PD	2= observed on video for 2+ sessions; 1=observed on video for 1 session; 0=not observed on video	**1= participant score is 5.0 out of 6, with a score of "2" in at least two of the three subscores; 0=score less than 5**			All counselors from schools implementing PACS	
2b. PD participation: chat comments	Observed chat participation				2= 2+ chat entries (substantive, more than just a simple response); 1=1 chat entries					
2c. PD participation: speaking	Observed speaking participation				2= observed speaking about content/questions for more than a sentence; 1=observed speaking for one sentence; 0=not observed speaking					
3. Participant Satisfaction	Participant satisfaction with quality of training	Participant	Participant post-PD survey	Evaluator collects survey data end of last PD day	On each of XX items, 3=agree w/statement of quality; 2=neutral about statement of quality; 1=disagree w/statement of quality	**1= participant average score (across items) is 3.0; 0=doesn't meet threshold**			All counselor participants who registered for the PD	
4. Session Quality	Rubric of session observation qualities: planning/preparation, counselor kits, logistics, content/skill delivery, information/resources, facilitation of learning and planning, participant learning and planning	Program	Observations of PD sessions by 2 evaluators	Evaluators' adjudicated ratings	adjudicated score: 4=exceeds expectations; 3=meets expectations; 2=partially met; 1=not met	**Year 0 score of 1 = 90% of scores on items are 3&4; Year 1 score of 1 = 95% of scores are 3&4; Years 2-3 score of 1 = 100% of scores are 3&4**	1 = meets threshold; 0 = doesn't meet threshold			
Components (across all indicators)						Participant score on all three components ranges from 0 - 3.	Participant threshold for full PARTICIPATION = score of 3	**1=At least 80% of participants received scores of 3 AND program receives score of 1 on quality**		

Appendix F: Fidelity Indicator for Implementation of School-Level Community of Practice

	Definition	Unit of Implementation	Data Source(s)	Data Collection (who, when)	Score for levels of implementation at unit level	Threshold for adequate implementation at unit level	Next higher level if needed (score and threshold): indicate level	Next higher level if needed (score and threshold): indicate level	fidelity measure (n=# units in which the	Expected years of fidelity measurement
1a. Teachers utilize coaching	PACS-trained teachers utilize coaching from Bootstrap coaches or ECS or UTeach teacher-leaders	PACS-trained teacher	Record of teachers' uses of coaching sessions	Program administrator collects participation data about coaching	3= 90%+ of trained teachers 2=80%+ of training teachers 1=<80% of trained teachers	**1= participant score is 10 out of 12, with a score of "2" in at least two of the three subscores; 0=score less than 10**				2020-2021 (year 0=pilot year of implementation) 2021-2022 (year 1 of implementation) 2022-2023 (year 2 of implementation) 2023-2024 (year 3 of implementation)
1b. Teachers rate coaching as effective	PACS-trained teachers rate coaching as effective	PACS-trained teacher	Teacher participant post-AY survey	Evaluator collects survey data last month of AY	On each of XX items, 3=agree w/statement of effectiveness; 2=neutral about statement of effectiveness; 1=disagree w/statement of effectiveness					
1c. Teachers/counselors utilize resources	PACS-trained teachers/counselors utilize resources from PACS PD	PACS-trained teacher or counselor	Teacher and counselor participant post-AY surveys	Evaluator collects survey data last month of AY	3= 90%+ of trained teachers/counselors indicate using these resources; 2=80%+ of trained teachers/counselors indicate using these resources; 1=<80% of trained teachers/counselors indicate using these resources;					
1d. Teachers/counselors rate resources as useful and sufficient	PACS-trained teachers/counselors rate PACS-provided resources as useful and sufficient	PACS-trained teacher or counselor	Teacher and counselor participant post-AY surveys	Evaluator collects survey data last month of AY	On each of XX items, 3=agree w/statement of usefulness/sufficiency; 2=neutral about statement of					
2a. Teachers/counselors attend virtual PD support/learning community sessions	Teachers/counselors attend virtual learning community synchronous sessions	PACS-trained teacher or counselor	Observations of virtual learning community sessions and discussion boards	Evaluator observes virtual learning community sessions, reviews discussion board data	3= 90%+ of trained teachers/counselors attend 1 or more sessions; 2=80%+ of training teachers/counselors attend 1 or more sessions 1=<80% of trained teachers/counselors attend 1 or more sessions	**1= participant score is 5 out of 6; 0=score less than 5**				
2b. Teachers/counselors interact within virtual learning community (VLC)	Teachers/counselors interact sychronously and asynchronously on VLC sessions and discussion boards									
3. Multiple teachers/ counselors within a school participate in PACS	Cumulative number of PACS-trained teachers and counselors in Years 0, 1, 2, 3, parsed by school	School-level CoP teams	PACS Administration's participation data	Program administrator collects participation data about PACS program	4=4 or more PACS-trained teachers and counselors within a school; 3=3 PACS-trained teachers and counselors within a school; 2=2 PACS-trained teachers and counselors within a school; 1=1 PACS-trained teachers and counselors within a school	**Year 1 score of 1 = 25% level 2 participants; 0=do not reach threshold; Year 2 score of 1 = 25% level 3 and 50% level 2; 0=do not reach threshold; Year 3 score of 1 = 25% level 4 participants and 50% level 3 and 75% level 2; 0=do not reach threshold**				
4. Multiple teachers/ counselors engage in PACS-provided initial structured opportunities for school-wide planning	PACS-trained school-level groups participate in planning sessions	School-level CoP teams	PACS Administration's participation data	Program administrator collects participation data about PACS program	4=4 or more PACS-trained teachers and counselors within a school; 3=3 PACS-trained teachers and counselors within a school; 2=2 PACS-trained teachers and counselors within a school; 1=1 PACS-trained teachers and counselors within a school	**Year 1 score of 1 = 25% of PACS schools have participating team; 0=do not reach threshold; Year 2 score of 1 = 50% of PACS schools have participating team; 0=do not reach threshold; Year 3 score of 1 = 75% of PACS schools have**				
Components (across all indicators)						Participant score on two components ranges from 0 - 2. SCoP score on two components ranges from 0 - 2.	Participant threshold for full PARTICIPATION = score of 2. SCoP threshold for full PARTICIPATION = score of 2.	**1=At least 80% of participants received scores of 2 AND 90% of SCoPs received scores of 2.**		

Appendix G: Comparative Short Interrupted Time Series Impact Study Design

G.1. Introduction to Impact Study 1

The Impact Study uses a Comparative short Interrupted Time-Series design (CITS) to examine the effect of PACS intervention on students' state assessment scores in mathematics. The impact study compared the ACT achievement of students in grade 11 attending treatment schools with ACT achievement of students in grade 11 attending schools that share similar demographic characteristics, but are non-treatment schools. Selection of treatment schools was carried out in January-February 2021. Selection of comparison schools was carried out in winter 2024, before the final Spring 2024 ACT administration. The ACT Mathematics achievement data used in the study was aggregate data measured and reported at the school level, obtained from publicly available data provided on the state's education agency website.

The treatment group of 29 schools participated in PACS programs beginning in summer 2021 and began implementing their computer pathways starting in fall 2021. A comparison group of 82 schools shared similar characteristics and had not participated in any PACS programs before summer of 2023. School-level ACT averages from the larger sample of 82 comparison schools were compared to those of the treatment schools. The research question, outcome, baseline measure, samples, and contrast relevant to the study being described in this section is listed in "Early 19 Contrast Tool 050122.xlsm."

This Impact Study investigates one confirmatory research question and one exploratory research question.

G.2. Research Questions

Confirmatory Research Question

(RQ4) What is the effect on average ACT Math scores for 11th grade students in schools receiving PACS compared to the average ACT Math scores of 11th grade students in schools in the business-as-usual comparison condition? (Treatment students may or may not have taken ECS, will have taken Algebra with Bootstrap, and may or may not have taken AP CSP; comparison students may or may not have taken ECS, will have taken Algebra I without Bootstrap, and may or may not have taken AP CSP)

Exploratory Research Question

(EQ10) What is the effect on average ACT Science scores for 11th grade students in schools receiving PACS compared to the average ACT Science scores of 11th grade students in schools in the business-as-usual comparison condition? (Treatment students may or may not have taken ECS, will have taken Algebra with Bootstrap, and may or may not have taken AP CSP; comparison students may or may not have taken ECS, will have taken Algebra I without Bootstrap, and may or may not have taken AP CSP).

G.3. Comparison Conditions

School-level comparisons. The comparison condition involves "business as usual" (BAU) at schools that did not participate in PACS Alabama CS PD week in summer 2020, 2021, or 2022. To be eligible, these schools had a maximum of one teacher trained in computer science.

The comparison is between: the 9th grade students who entered treatment schools in fall 2021, where the schools offer the pathway of Exploring Computer Science as an elective in 9th grade, Algebra with Bootstrap as part of the algebra requirement in 10th grade, and AP CS Principles as an elective course in 11th grade, in conjunction with school counselors trained in the Counselors for Computing program, versus the 9th grade students who entered comparison schools in fall 2021 that may or may not have offered 9th grade Exploring Computer Science, did not offer integrated computer science with Algebra in 10th grade (i.e., Algebra without Bootstrap), and may or may not have offered AP CS Principles as an elective course in 11th grade, in conjunction with school counselors following a BAU model. It should be noted that the state-level mandate for every high school to offer one computer science course means that BAU is offering Exploring Computer Science or AP CS Principles or a different approved computer science course.

The evaluation data is school-level average ACT scores in Math and Science from 2019-2024. These scores represent a trend line for 2019-2023. The ACT Math and Science scores in 2024 represent 9th grade students who entered treatment schools in fall 2021 and 9th grade students from comparison schools following a BAU model.

G.4. Sample Identification, Selection and Assignment

The goal of the school sample identification and selection process was 29 treatment group schools and 60 comparison schools. In winter 2021, all high schools in Alabama that met the following criteria were invited to participate in the impact study as treatment schools:

- Rural (NCES codes of 31-33) or Town (NCES codes of 41-43; Geverdt, 2015)
- No computer science courses prior to fall 2020
- A maximum of one teacher trained for AP CS Principles by A+ CR in summer 2020
- A regular public high school, not a career tech center

The evaluation team recruited the efficacy study sample from a pool of 144 Alabama high schools that met these criteria. Of these, 29 treatment schools were selected, trained through PACS and implementing the course sequences or some subset thereof.

Of the remaining 113 schools that meet these criteria, a sample of about 82 schools was selected as a comparison group in winter 2024. Reasons for exclusion from the comparison group included:

- Participation as a PACS treatment school
- Participation in PACS training, not as a treatment school
- Currently offering more than one approved computer science course

School level scores are the outcome measure; there is no selection of teachers or students.

G.5. Key Measures and Plan for Collecting Data

This section provides a description of the key outcome and baseline measures and other covariates and the plan for collecting data. Additional details about these measures are found in the PACS contrast tool[8].

Outcome Measures

The study's only outcome measures are ACT math and science outcomes which are measured at the grade-within-school level before and after implementation of the program in PACS schools, and at the same time points in comparison schools.

Outcome measure	**Domain**	**Grade/Timing of Outcome Measurement**	**Baseline measure(s)**	**Timing/Grade of Baseline Measurement**
ACT Mathematics Test	Mathematics Achievement	End of 11th grade (spring 2024)—school level	i. ACT Mathematics Test	Five years up to year before intervention Spring 2019, 2020, 2021, 2022, 2023
ACT Science Test	Science Achievement	End of 11th grade (spring 2024)—school level	i. ACT Science Test	Five years up to year before intervention Spring 2019, 2020, 2021, 2022, 2023

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[8] The Contrast Tool is a resource to assist with describing the measures. The tool includes a tab for providing details about the outcome measures and a tab for baseline measures.

The ACT Mathematics Test

- Is a well-validated assessment of 60 questions with an allowance of 60 minutes to complete
- Content includes preparing for higher math (57-60%):
    - number and quantity, algebra, functions, geometry, statistics and probability
- Integrating essential skills (40-43%): rates, percentages, area, volume, basic statistics
- Modeling (>25%): producing, interpreting, understanding, evaluating, improving models

The ACT Science Test

- Is a well-validated assessment of 40 questions with an allowance of 35 minutes to complete
- Content includes interpretation of data (40-50%):
    - manipulate and analyze scientific data presented in scientific tables, graphs, and diagrams
- Scientific investigation (20-30%): experimental tools, procedures, and design, compare, extend, and modify experiments
- Evaluation of models, inferences, and experimental results (25-35%): validity of scientific information, formulate conclusions and predictions based on scientific information

G.6. Statistical Analysis of Impacts – Comparative Interrupted Time Series

Impact study 1 used a Comparative short Interrupted Time-Series design (CITS) to examine the effect of PACS intervention on students' state assessment scores in mathematics (Figure G.1). This impact study compares the ACT Mathematics achievement of students in grade 11 attending treatment schools with ACT Mathematics achievement of students in grade 11 attending non-treatment schools that share similar demographic characteristics. The ACT Mathematics achievement data used in the study are aggregate data measured and reported at the school level, and obtained from publicly available data provided by the Alabama State Department of Education. The PACS intervention was implemented in 29 high schools across three years, 2021-2022, 2022-2023, and 2023-2024.

For treatment schools, the intervention began in SY 2021-2022; however, the intervention is geared towards 9th graders in SY 2021-2022, 10th graders in SY 2022-2023, and 11th graders in SY 2023-2024. Full intervention impacts were not expected to be observable in 11th graders until spring 2024. For treatment schools, SY 2023-2024 is the first year of full treatment. Outcomes are from state assessments that are administered in the spring of each academic year.

The impact model is a two-level model with repeated observations over years (level-1) nested in schools (level-2). The model is fit to the data from 11th grade only. See Haynie 2022 for more details about the statistical model.

Figure G.1: Treatment and Pre-treatment Years for Treatment and Comparison Schools

Type of School (Treatment or Comparison)	Spring 2019	Spring 2020	Spring 2021	Spring 2022	Spring 2023	Spring 2024	Number of Schools
Treatment	x	x	x	x	x	T	30
Comparison	x	x	x	x	x	t	60
Time coded as:	-4	-3	-2	-1	0	+1	
Tyr coded as:	0	0	0	0	0	1	

The research questions, outcomes, baseline measures, sample, and contrasts relevant to the study being described in this section are listed in “contrast_tool_PACS_050122.xlsm.” See confirmatory and exploratory contrasts listed in the Contrast Table.

G.7. Baseline Equivalence Testing

Baseline equivalence of schools was assessed using the last pre-intervention year of data. That year is identified in Exhibit G.6 as the year corresponding to “Time=0” or the last pre-intervention year before the year marked with “T” or “t”. The last pre-intervention year is SY 2022-23. The baseline difference between treatment and control schools will be estimated using a modified form of the impact model. Only data from the last pre-intervention year is included in the baseline equivalence model, and the sample of schools utilized in the baseline equivalence model is the same sample of schools that is used in the corresponding impact mod

Appendix H: Quasi-Experimental Impact Study Design

H.1. Introduction to Impact Study 2

Impact Study 2 is a three-year quasi-experimental design, involving 38 schools selected in winter through fall 2021. To have been eligible, the high schools were in a rural or town locale(s) and either no CS course or only in AP CS Principles by summer of 2020. The treatment group of 29 schools began participating in PACS programs in summer 2021 and implementing the computer pathway starting in fall 2021; the control group of 9 schools was not eligible for PACS programs until summer of 2023. The study followed for three years a single cohort of 9th grade students who enrolled in the study high schools in fall 2021. The outcomes of interest are students' computational thinking, algebraic problem-solving, AP CS Principles exam score, and CS attitudes. The research questions, outcomes, baseline measures, sample, and contrasts relevant to the study being described in this section are listed in "Early 19 Contrast Tool 050122.xlsm."

H.2. Research Questions

The Impact Study investigated three confirmatory research questions and five exploratory research questions.

Confirmatory Research Questions

RQ1-2 What is the effect on computational thinking of students in PACS schools compared to the computational thinking of students in schools in the business-as-usual comparison schools?

- For all students at the end of 9th grade? (Treatment students may or may not have taken ECS; comparison students will not have been offered ECS)
- For the same 9th grade students at the end of 11th grade, (Treatment students may or may not have taken ECS, will have taken Algebra with Bootstrap, and may or may not have taken AP CSP; comparison students will not have taken ECS, will have taken Algebra I without Bootstrap, and may or may not have taken AP CSP)

RQ3 What is the effect on algebra skills of 10th grade students in schools receiving PACS compared to the algebra skills of 10th grade students in schools in the business-as-usual comparison condition? (Treatment students will be the same 9th grade students and may or may not have taken ECS but will have received Bootstrap as part of their algebra course; comparison students will not have been offered ECS and will not have been offered Bootstrap)

Exploratory Research Questions

EQ5-6 What is the effect on CS attitudes of students in schools receiving PACS compared to the CS attitudes of students in schools in the business-as-usual comparison condition?

- For all students at the end of 9th grade? (Treatment students may or may not have taken ECS; comparison students will not have been offered ECS)
- For the same 9th grade students at the end of 11th grade? (Treatment students may or may not have taken ECS, will have taken Algebra with Bootstrap, and may or may not have taken AP CSP; comparison students will not have been offered ECS, will not have been offered Bootstrap, and may or may not have taken AP CSP)

EQ7-8 What is the effect on CS career interest of students in schools receiving PACS compared to CS career interest of students in schools in the business-as-usual comparison condition?

- For all students at the end of 9th grade? (Treatment students may or may not have taken ECS; comparison students will not have been offered ECS)
- For the same 9th grade students at the end of 11th grade? (Treatment students may or may not have taken ECS, will have taken Algebra with Bootstrap, and may or may not have taken AP CSP; comparison students will not have been offered ECS, will not have been offered Bootstrap, and may or may not have taken AP CSP)

EQ9 What is the effect on AP CSP qualifying exam score rates for 11th grade students in schools receiving PACS compared to the AP CSP qualifying exam score rates of 11th grade students in schools in the business-as-usual comparison condition? (Treatment students may or may not have taken ECS, will have taken Algebra with Bootstrap, and will have taken AP CSP; comparison students will not have taken ECS, will have taken Algebra I without Bootstrap, and will have taken AP CSP).

H.3. Control or Comparison Conditions

Student-level comparisons. The control condition involved business-as-usual (BAU) at schools that did not participate in PACS Alabama CS PD week in summers 2020, 2021, or 2022. To be eligible, these schools were limited to only a maximum of one teacher trained in computer science, for example, one teacher trained through the state-initiated A+ College Ready summer training in 2020 to implement AP CS Principles starting in fall 2020. The evaluation sample is the 9th grade students in the comparison schools entering in fall 2021. These students may have had access to a computer science course in 2021-2022, but not Exploring Computer Science. In 2022-2023, 10th grade students in the comparison condition took a BAU algebra course that did not include a Bootstrap Algebra unit. In 11th grade, students in the comparison condition in 2023-2024 may have had access to the AP CS Principles course based on the summer training through A+ College Ready. Counselors in the comparison condition were not trained in Counselors for Computing.

The comparison is between: the 9th grade students who entered treatment schools in fall 2021, where the schools offered Exploring Computer Science as an elective in 9th grade (2021-2022), offered Algebra with Bootstrap as part of the algebra requirement in 10th grade (2022-2023), and offered AP CS Principles as an elective course in 11th grade (2023-2024), in conjunction with school counselors trained in the Counselors for Computing program, versus the 9th grade students who entered comparison schools in fall 2021 that offered no 9th grade Exploring Computer Science (2021-2022), offered no integrated computer science with Algebra in 10th grade (i.e., Algebra without Bootstrap in 2022-2023), and possibly offered AP CS Principles as an elective course in 11th grade (2023-2024), in conjunction with school counselors following a BAU model.

H.4. Sample Identification, Selection and Assignment

Identification/Selection of Study Schools

The school sample identification and selection process identified 30 treatment group schools and 30 comparison group schools; however, only 29 treatment schools and 9 comparison schools were recruited and sustained. In winter 2021, all high schools in Alabama that met the following criteria were invited to participate in the Impact Study:

- Rural (NCES codes of 31-33) or Town (NCES codes of 41-43; Geverdt, 2015)
- No computer science courses prior to fall 2020
- A maximum of one teacher trained for AP CS Principles by A+ CR in summer 2020
- A regular public high school, not a career tech center

The evaluation team recruited from 144 Alabama high schools that met these criteria (note the efficacy study sample is a subset of the implementing sample - schools that participate in PACS Alabama CS PD Week in summers 2021, 2022, 2023, and 2024.) The study procedures, expectations, and professional learning opportunities were described to the school administrators, and a Memorandum of Understanding (MOU) was completed with each treatment school.

Identification/Selection of Study Teachers

Teachers were recruited through their schools for participation in PACS Alabama CSPdWeek. In other words, when treatment schools agreed to participate in the impact study, they agreed to the following:

- One teacher trained in Exploring Computer Science, summer of 2021 (with subsequent sessions in fall 2021, spring 2022, and summer 2022)
- One counselor trained in Counselors for Computing, summer of 2021
- One or more teachers trained in Bootstrap Algebra, summer of 2022
- One teacher trained in AP CS Principles, summer of 2023

It was at each school's discretion which teachers and counselors were selected, and whether one teacher was trained for multiple courses, or a unique teacher was trained for each course. Therefore, the number of counselors expected in the treatment condition was 29, and the number of teachers expected in the treatment condition was a minimum of 29 (i.e., every school has one teacher trained in all three courses) and a maximum of 87 (every school has a unique teacher trained in each course). In addition, multiple teachers were invited for training in Bootstrap Algebra, summer 2022, since every student is required to take algebra.

Identification/Selection of Students

Following assignment, for each study high school, rosters of rising 9th grade students were identified to form the study sample. All of the students who actually enrolled in a study high school in fall 2021 were invited to be part of the study and sample. Student consent is required and was obtained during fall of the 2021-2022 academic year. Students who did not consent, either through actively declining or not returning consent, are not included in the sample.

Within the T condition of 29 schools, 1346 students (51% of 2650 total enrollment) consented and 1096 students (42%) received positive parental consent. Within the C condition of 9 schools, 438 students (42% of 1035) consented and 383 students (37%) received positive parental consent. Note: There were 28 student withdrawals (3%) for consented students at T schools and 28 student withdrawals (7%) for consented students at C schools.

Baseline Math ACAP scores were received for a total of 1266 students (T and C, Table H.1). The sample characteristics for underrepresented group status, SES status, and baseline math ACAP scores are significantly different for the two groups.

Table H.1: Treatment and Comparison Group Baseline Statistics for Impact Study 2

	Treatment Group	Comparison Group	Total Group	Significance
Number of students	940	326	1266	
Number of schools	29	9	38	
% Female	49.0%	47.2%	48.6%	N.S.
% Students from Historically Underrepresented Groups[9]	31.7%	44.0%	34.9%	X^2, p <.001
% Higher [10] SES Students	48.4%	21.8%	41.5%	X^2, p <.001
8th Grade Math ACAP Scores	Mean=489.3, SD=58.3	Mean=468.9 SD=61.4	Mean=484.0 SD=59.7	t-test, p<.001

A word of explanation on the group differences. The original intention for the PACS efficacy study was to randomly assign schools to treatment or comparison groups. It quickly become apparent that random assignment would be impossible, particularly in spring 2020 during the height of COVID-19. Many schools were reticent to commit resources to participating in a study and PACS training, and they were simply unwilling to agree to random assignment by condition.

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[9] Students who indicated their race as American Indian, Black, Native Hawaiian or Other Pacific Islander, or Multi-racial, or their ethnicity as Hispanic/Latinx were coded '1', other students (i.e., White or Asian) were coded '0'.

[10] Students who are not eligible for free or reduced-price lunch were coded '1', other students were coded '0'.

The recruitment process was arduous. Most of the successful recruitment for Pathway and Associate schools were conducted by phone calls to the school administrator, counselor, or appropriate district administrator. There were clearly differences in motivation for schools that agreed to be Pathway schools and those that agreed to be Associate schools.

Incentives for Pathway schools included Computer Science PD for teachers and counselors, support in establishing a pathway of CS courses for students, and modest stipends as compensation for data collection efforts. Many schools joined PACS as Pathway schools because they wanted to offer desirable content for students and understood the importance of adding Computer Science to their current schedule. Many Pathway schools were motivated by the state-level requirement beginning in the 2020-2021 school year, Alabama Code Section 16-46B-2 states that each Alabama public high school is required to offer at least one authentic computer science course from a department-approved list. Associate schools were recruited with a future incentive of PD in the PACS coursework as well as financial incentives for data collection. A number of Associate schools (i.e., Comparison) wished to be involved, but were not prepared to engage with adding a computer science pathway. Their decisions about level of involvement were made during a very difficult time when schools were overwhelmed with COVID (spring-summer 2020). Therefore, the schools that stepped forward to participate as Pathway schools had greater readiness to take on the resources and training activities that the PACS program provided.

H.5. Key Measures and Plan for Collecting Data

This section provides a description of the key outcome and baseline measures, other covariates and data collection procedures. Additional details are found in the PACS contrast tool[11].

Outcome Measures

For Impact Study 2, program effects are evaluated for five outcomes: computational thinking, algebra skills, CS attitudes, CS career interest, and the AP CS Principles examination. To ensure validity and reliability, computational thinking was measured for all 9th and 11th grade students using the Computational Thinking Assessment for High School (Haynie, Ravitz, & Zelkowski, 2021). Mathematical skills were measured for all 10th grade students in spring 2023 using an algebra skills assessment (Zelkowski, 2020). The CS attitudes survey (Haynie 2017) was given to all students in 9th and 11th grades. CS career interest data was drawn from the 2019 measure (Haynie & Counts 2022) of CS career interest items. For Impact Study 1, program effects are evaluated for two outcomes: ACT Math and ACT Science. Mathematics and science achievement were assessed for all 11th grade students using the ACT Math (spring 2024) and ACT Science (spring 2024). The evaluation team established data sharing agreements in 2021 with the ALSDE for covariates (e.g., SES, gender, race/ethnicity, course-taking).

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[11] The **Contrast Tool** is a resource to assist with describing the measures. The tool includes a tab for providing details about the outcome measures and a tab for baseline measures.

Table H.2: Outcome Measures for PACS Impact Study 2

Outcome measure	Domain	Grade/Timing of Outcome Measurement	Baseline measure(s)	Timing/Grade of Baseline Measurement
Computational Thinking Assessment for High School (Haynie, Ravitz, & Zelkowski, 2021)	Technology and Engineering Literacy	End of 9th, 11th grades (spring 2022, 24)	i. Alabama State math test ii. Measure of student SES	End of 8th grade (spring 2021)
Algebra Assessment (Zelkowski, 2020)	Math Achievement	End of 10th grade (spring 2023)	i. Alabama State math test ii. Measure of student SES	End of 8th grade (spring 2021)
CS Attitudes Survey (Haynie 2017): CS confidence, belongingness, encouragement	Interpersonal Competencies [a]	End of 9th and 11th grades (spring 2022, 24)	CS Attitudes (Haynie 2017)	Fall of 9th grade (fall 2021)
Career Interest Survey: interest in CS job responsibilities	Interpersonal Competencies	End of 9th and 11th grades (spring 2022, 24)	Career Interest Survey (Haynie & Counts 2022)	Fall of 9th grade (fall 2021)
Percent Qualifying in AP CS Principles	Technology and Engineering Literacy	End of 11th grade (spring 24)	i. Alabama State math test ii. Measure of student SES	End of 8th grade (spring 2021)

The Computational Thinking Assessment for High School (Haynie, Ravitz & Zelkowski, 2021):

- Assesses general computational thinking ability is not tied to a specific computer language or course experience
- Assess CT concepts and processes

  Concepts: abstraction, algorithms / algorithmic skills and teaching, logic and logical thinking, pattern recognition

  Practices: problem decomposition, problem solving, testing and debugging, loops

- Includes items from the well-validated sources such as the Computational Thinking Test (Román-González, Pérez-González, & Jiménez-Fernández, 2017) and Bebras Tasks (Blokhuis et al., 2016)
- Requires no more than 40 minutes to complete
- Has 8 item blocks of 6-10 items each and Cronbach's alpha reliability levels (Cronbach 1951) ranging from 0.56 to 0.83 (baseline data obtained in spring 2021)
- Was given to all students in the study at the end of years 2022 and 2024

The Algebra Skills Assessment:

- Is a well-validated measure requiring less than 40 minutes to complete
- The algebra skills assessment is not tied to a specific algebraic learning experience (such as Bootstrap Algebra)
- The algebra skills assessment will be number right scored (i.e., summing items) or scored using item response theory (i.e., based on estimated ability levels)
- The reliability of the newly-developed measure will be established on the baseline data obtained in fall 2021
- Was given to all 10th grade students in the study at the end of the 2023 academic year

The CS Attitudes Survey

- Includes items from the validated Computer Science Attitude Survey (Haynie 2017)
    - 15 Likert-style items pertaining to confidence (5 items, Cronbach's α =.890), belongingness (5 items, α=.850), and encouragement (5 items, α = .858)
- Has Likert-style items and require no more than 10 minutes to complete
- Will be analyzed to determine whether separate constructs exist; if so, subtests will be analyzed and scored separately
- The reliability of the overall score and any subtests to be analyzed was established on the baseline data collected in fall 2021 and compared to previously established reliability levels, such as subscores on the Computer Science Attitude Survey (see section 3.2.7)
- Was given to all students in the study at the end of years 2022 and 2024

CS Career Interest

- Includes 10 items from the Alabama LEGACY project (Haynie & Counts 2022)
    - 10 Likert-style items pertaining to interest in various Computer Science work responsibilities ranging from very important (I would not consider a job without it) to not important at all (not a factor in job selection)
- Has Likert-style items and require no more than 10 minutes to complete
- Will be analyzed to determine whether separate constructs exist; if so, subtests will be analyzed and scored separately
- Was given to all students in the study as baseline (at the beginning of 9th grade) and in 9th grade (spring 2022) and 11th grade (spring 2024)

Baseline and outcome measures are shown in Figure 4.0.

H.6. Multi-year Intervention

This section describes the way the sampling design followed schools and students over multiple years. The PACS-EIR Impact Study design is provided in Figure 3.2.1.

- Students were tracked across outcome measures given in May of 2022 (for 9th graders), May of 2023 (for 10th graders) and May of 2024 (for 11th graders).
- Students in the T group were in "treatment" schools and many had the option of taking the Exploring Computer Science class; students in the C group did not have access to this class.
- Students in the T group were most likely placed in an Algebra I with Bootstrap class in 10th grade; students in the C group were most likely placed in an Algebra I class in 10th grade and no 10th grade Algebra I classes have Bootstrap in the C schools.
- Students in the T group had the option of being part of the "treatment" in 11th grade by taking the AP CS Principles class with a newly trained teacher; students in the C group may or may not have had access to an AP CS Principles class.
- Students in the T group had access to a counselor trained through the Counselors for Computing (C4C) program for three years (9th-11th grade); students in the C group have access to counselors without C4C training.

Figure 3.2.1 shows the timing of measurement and the relationship of the sample over time to the research questions. Study year 1 outcomes for 9th graders were collected in May of 2022 and provide evidence for research and exploratory questions:

RQ1 What is the effect on computational thinking of 9th grade students in PACS schools compared to the computational thinking of 9th grade students in schools in the business-as-usual comparison schools?

EQ5 What is the effect on CS attitudes of 9th students in schools receiving PACS compared to the CS attitudes of 9th grade students in schools in the business-as-usual comparison condition?

EQ7 What is the effect on CS career interest of 9th students in schools receiving PACS Alabama compared to CS career interest of 9th students in schools in the business-as-usual control condition?

Study year 2 outcomes for 10th graders were collected in May of 2023 and provide evidence for the research question:

RQ3 What is the effect on algebra skills of 10th grade students in schools receiving PACS compared to the algebra skills of 10th grade students in schools in the business-as-usual control condition?

Study Year 3 outcomes for 11th graders were collected in May of 2024 and provide evidence for research and exploratory questions:

RQ2 What is the effect on computational thinking of 11th grade students in PACS schools compared to the computational thinking of 11th grade students in schools in the business-as-usual comparison schools?

EQ6 What is the effect on CS attitudes of 11th students in schools receiving PACS compared to the CS attitudes of 11th grade students in schools in the business-as-usual comparison condition?

EQ8 What is the effect on CS career interest of 11th students in schools receiving PACS Alabama compared to CS career interest of 11th students in schools in the business-as-usual control condition?

EQ9 What is the effect on AP CSP qualifying exam score rates for 11th grade students in schools receiving PACS compared to the AP CSP qualifying exam score rates of 11th grade students in schools in the business-as-usual control condition?