ARCS External Evaluation
Year 5 Annual Report

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November 30, 2024

Contents

Introduction

Advancing Rural Computer Science (ARCS) is a professional development program developed and implemented by Old Dominion University with partners at CODE VA and the Virginia Department of Education. The purpose of ARCS is to improve elementary students' computer science content knowledge and affect toward computer science by improving teacher computer science content and pedagogical knowledge, self-efficacy, and instructional skills for teaching computer science through an interdisciplinary lens, with a specific focus on students from rural areas of Virginia.

Specifically, the goals of ARCS related to teacher outcomes are to improve K-5 teachers' knowledge of computer science (CS) concepts, improve K-5 teachers' pedagogy for integrating CS into instruction, improve K-5 teachers' self-efficacy for teaching CS and increase the frequency of K-5 teachers' CS-integrated lessons in the classroom. Goals of ARCS related to student outcomes include improving K-5 students' content knowledge related to and interest in CS (Figure 1).

The project intends to serve 18,000 K-5 students and 440 K-5 teachers over 5 years and the goal is that most students that will be served by the project are members of subgroups who are traditionally underrepresented in STEM and Computer Science education, including Black, Hispanic, and mixed-race students, students from economically disadvantaged families, and students living in rural communities.

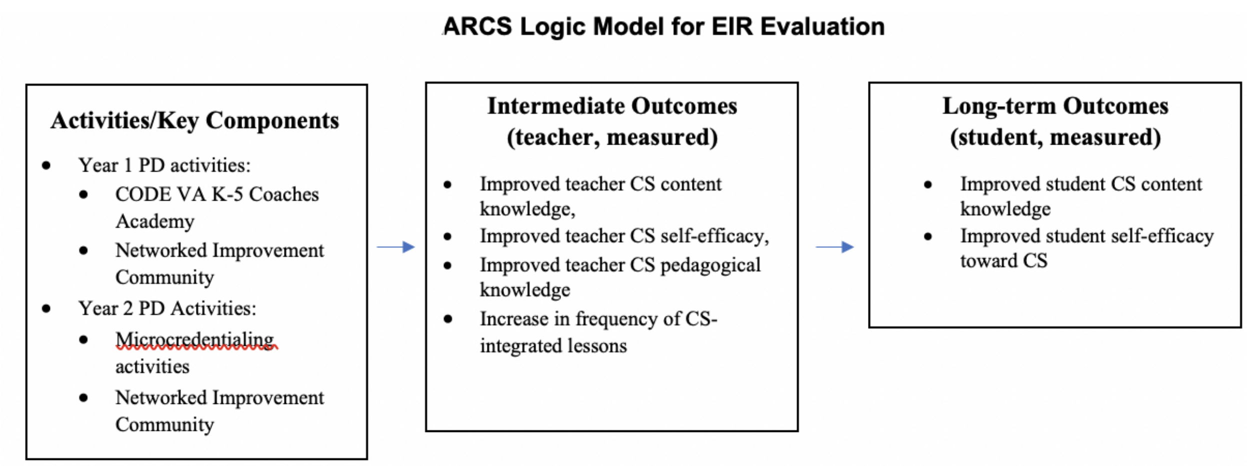

Figure 1. ARCS Logic Model

Activities include teachers completing Year 1 PD Summer Academy and follow-up activities, teachers completing the Year 2 Microcredentialing process, and teachers participating in the Networked Improvement Community (via CodeVA NING PLC - pilot year 1, Learning Bytes- all other cohorts) during both years of the intervention. Intermediate (measured) outcomes include improved teacher content knowledge, self-efficacy, and pedagogical knowledge, and increased frequency of CS-integrated lessons. Long-term (measured) outcomes include improved student attitudes toward CS and improved student CS content knowledge. Long Term (not measured) outcomes include increased student interest in pursuing CS careers, especially among traditionally underrepresented groups and increased integration of CS into K-5 instruction statewide.

For each cohort and condition, the timing of key PD elements and data collection administration is indicated below. ARCS employed a staggered implementation design where schools assigned to the control condition in year one of their cohort are offered the treatment in year two, so we use the descriptors “Immediate treatment” and “Control/Delayed treatment,” with the control descriptor used during the control year and “Delayed treatment” used once treatment began for these participants. Pilot and Immediate treatment teachers participate for 2 years and Control/ Delayed treatment teachers participate for 3 years (an initial year of data collection as control followed by 2 years of PD).

Table 1. Key PD and Data Collection Elements by Cohort/Condition

PD Element/Data Collection	Pilot Cohort (2020-2022)	RCT Cohort 1 Immediate treatment (2021-2023)	RCT Cohort 1 Control/Delayed treatment) (2021-2024)	RCT Cohort 2 Immediate treatment (2023-2025)	RCT Cohort 2 Control/Delayed treatment) (2023-2026)
Year 1 Pre	Summer 2020	Summer 2021	Summer 2021	Summer 2023	Summer 2023
CodeVA Coaches Academy	Summer 2020	Summer 2021	Summer 2022	Summer 2023	Summer 2024
Year 1 Post (pilot and immediate treatment)/ Year 2 Post (control)	Summer 2020	Summer 2021	Summer 2022	Summer 2023	Summer 2024
Year 1 Student Preassessment	Fall 2020	Fall 2021	Fall 2021	Fall 2023	Fall 2023
Mid-Year 1 Implementation Frequency	Winter 2020	Winter 2021	Winter 2021	Winter 2023	Winter 2023
Year 1 Student Post Assessment	Spring 2021	Spring 2022	Spring 2022	Spring 2024	Spring 2024
Year 1 End (pilot and immediate treatment)/ Year 2 Pre (control)	Spring 2021	Spring 2022	Spring 2022	Spring 2024	Spring 2024
Microcredentials	Summer 2021 – September 30, 2022	Summer 2022-Summer 2023	Summer 2023-Summer 2024	Summer 2024-Summer 2025	Summer 2025- Summer 2026
Year 2 Student Preassessment	Fall 2021	Fall 2022	Fall 2022	Fall 2024	Fall 2024
Mid-Year 2 Implementation Frequency	Winter 2021	Winter 2022	Winter 2022	Winter 2024	Winter 2024
Year 2 Student Post Assessment	Spring 2022	Spring 2023	Spring 2023	Spring 2025	Spring 2025
Year 2 End	Spring 2022	Spring 2023	Spring 2023	Spring 2025	Spring 2025
Year 3 Student Preassessment	N/A	N/A	Fall 2023	N/A	Fall 2025
Mid-Year 3 Implementation Frequency	N/A	N/A	Winter 2023	N/A	Winter 2025
Year 3 Student Post Assessment	N/A	N/A	Spring 2024	N/A	Spring 2026
Year 3 End	N/A	N/A	Spring 2024	N/A	Spring 2026

Evaluation Questions

The external evaluation related to ARCS implementation is conducted by UVa. The UVa evaluation team collects and analyzes data focused on the implementation and outcomes of the stated project goals. This annual report addresses progress in evaluation activities including recruitment, instrument development, data collection and analysis, and other evaluation activities and conclusions. These are primarily drawn from the October 1, 2023 to September 30, 2024 grant year.

The ARCS evaluation consists of two components, assessing the outcomes of a randomized controlled trial designed to answer the following confirmatory and exploratory research questions, and documenting fidelity of implementation of the ARCS PD. Confirmatory research questions are:

(1) What is the effect of ARCS PD on the mean school-level student CS interest of K-5 students compared to the mean school-level student CS interest of K-5 students in the business-as-usual condition?
(2) What is the effect of ARCS PD on the mean school-level CS content knowledge of grade 3, 4, and 5 students compared to the mean school-level CS content knowledge of grade 3, 4, and 5 students in the business-as-usual condition?

Exploratory research questions include:

(1) What is the effect of ARCS PD on K-5 teacher CS content knowledge compared to teachers in the business-as-usual condition?
(2) What is the effect of ARCS PD on K-5 teacher CS pedagogical knowledge compared to teachers in the business-as-usual condition?
(3) What is the effect of ARCS PD on K-5 teacher CS self-efficacy compared to teachers in the business-as-usual condition?
(4) How does CS-integrated instruction among K-5 teachers change over the course of participation in ARCS?
(5) How many participating teachers earn microcredentials through ARCS?

Implementation questions include:

(1) Were the key components of the ARCS PD implemented as planned (with fidelity)?
    a. How much variation in implementation fidelity was there across the two cohorts of ARCS PD?
    b. Did the participants attend the ARCS PD consistently and regularly?
    c. Did the participants have the opportunity to practice intended instructional approaches?
    d. What were the barriers to and facilitators of implementation of the ARCS PD as planned?
(2) What were teachers' perceptions of the ARCS PD?
(3) What were participating teachers' perceptions of the microcredentialing process?

Year 5 Evaluation Activities

1. Documented implementation of microcredentials for the RCT Cohort 1 delayed treatment (June 2023 through July 2024) teachers.
2. Administered and analyzed end-of-year assessments for RCT Cohort 1 delayed treatment teachers.
3. Administered pre-/post-CKACS to students in RCT Cohort 1 delayed treatment teacher classrooms in Fall 2023 and Spring 2024.
4. Analyzed RCT Cohort 2 Year 1 immediate treatment and control student pre-/post-assessment data from Fall 2023 and Spring 2024.
5. Documented implementation of microcredentials for the RCT Cohort 2 immediate treatment (June 2024 through September 2024) teachers.
6. Documented 2024 summer PD attendance of RCT Cohort 2 delayed treatment teachers.
7. Administered and analyzed post-summer PD assessments to RCT Cohort 2 delayed treatment teachers.
8. Administered pre-CKACS to students in RCT Cohort 2 teacher classrooms in August/September/October 2024.

Acknowledgments and Recommended Citation

We would like to acknowledge our postdoctoral research associate, Ruohan Liu, and undergraduate research assistants, Theodore LengKong, Chiamaka Ahaghotu, and Angel Lin for their assistance in data analysis. This work was funded under US Department of Education Grant # U411C190032.

Recommended citation: Maeng, J. L. & Singh, K. (2024). *ARCS External Evaluation Year 5 Report.* Charlottesville, VA: School of Education and Human Development, University of Virginia.

Overview of the Intervention

The ARCS intervention includes summer professional development (PD) sessions and web-assisted school-year PD across two years.

Year 1 – Code VA Summer Institute

During the 5-day summer institute, teachers learn fundamental principles of computer science and are introduced to the six threads of the Virginia Computer Science Standards of Learning: (1) Algorithms and Programming, (2) Computing Systems, (3) Cybersecurity, (4) Data and Analysis, (5), Impacts of Computing, and (6) Networking and the Internet through the online ARCS CODE VA K-5 Coaches Academy.

The Covid-19 pandemic led to the decision to move the PD to an online format for the remainder of the project. Whereas the pilot cohort Coaches Academy consisted of 6 days of synchronous and asynchronous components as described in the Year 1 Annual Report. This structure has been consistently used for all subsequent Code VA Summer Institutes.

Participants were assigned by school to attend one of two five 3.5-hour synchronous sessions: Session 1 or Session 2 with asynchronous meetings individually or in groups as well as office hours in the afternoon (Table 2).

	Day 1	Day 2	Day 3	Day 4	Day 5
10:00 – 12:30 Synchronous	Live facilitator-led workshop	Live facilitator-led workshop	Live facilitator-led workshop	Live facilitator-led workshop	Live facilitator-led workshop
1:30 – 3:00 Asynchronous	Collaborative work with other participants	Collaborative work with other participants	Collaborative work with other participants	Collaborative work with other participants	Collaborative work with other participants
3:00 – 4:00	Live facilitator-led daily close-out	Live facilitator-led daily close-out	Live facilitator-led daily close-out	Live facilitator-led daily close-out	Live facilitator-led daily close-out

Table 2. ARCS K-5 Coaches Academy Daily Schedule

The overarching goal of the ARCS CODE VA K-5 Coaches Academy is to prepare division employees to lead professional development in computer science. Learning objectives included that participants would develop:

1. Knowledge of VA Computer Science SOLs
2. Coding skills using SCRATCH programming language
3. An understanding of how to design and teach integrated lessons
4. An ability to plan and implement local CS professional learning activities
5. Awareness of resources and tools to support teacher and student learning in in-person and online classrooms
6. Confidence in coaching others in CS education.

During the 5-day Academy, teachers learn instructional strategies for integrating these threads into elementary instruction in reading, writing, science, mathematics, and social studies. They develop pedagogical knowledge and assessment literacy designed to enable them to teach and assess students' understanding and acquisition of computer science concepts and skills. ARCS also integrated a culturally responsive teaching component to building participating teachers' capacity to incorporate students' interests and experiences into lesson content, particularly when new content (computer science, in this case) is introduced. Making new content culturally and contextually relevant can promote students' sense of social belonging, self-efficacy, and academic achievement.

Year 2 - Microcredentialing

In year 2, teachers have the opportunity to earn five microcredentials over the course of the program, one for each of the following areas: (1) Introduction to Computer Science Principles, Digital Impact, and Digital Citizenship; (2) Computing Systems, Networks and the Internet, and Cybersecurity; (3) Algorithms and Programming, (4) Data and Analysis; and (5) Lesson Integration.

A description of each microcredential is provided below:
Introduction to Computer Science, Digital Impact, and Digital Citizenship. In this microcredential course, participants will acquire an introduction to computer science principles and will develop pedagogical content knowledge aligned with the Impacts of Computing strand of the Virginia Computer Science *Standards of Learning*. Course participants will demonstrate competence in the Impacts of Computing subject matter and will develop a lesson plan for teaching an Impacts of Computing topic within an elementary grade level of their choosing.

Computing Systems, Networks and the Internet, and Cybersecurity. Through completion of this microcredential course, participants will develop pedagogical content knowledge for the Computing Systems, Networking and the Internet, and Cybersecurity strands of the Virginia Computer Science *Standards of Learning*. Course participants will demonstrate competence in the subject matter for these strands and will develop a lesson plan for teaching these content topics within an elementary grade level of their choosing.

Algorithms and Programming. This microcredential course will provide participants with pedagogical content knowledge for the Algorithms and Programming strand of the Virginia Computer Science *Standards of Learning*. Participants will gain skills through hands-on use of the Scratch programming language. Course participants will demonstrate competence in the Algorithms and Programming subject matter and will develop a lesson plan for teaching an Algorithms and Programming topic within an elementary grade level of their choosing.

Data and Analysis. The Data and Analysis microcredential course is designed to develop participants' pedagogical content knowledge aligned with the Data and Analysis strand of the Virginia Computer Science *Standards of Learning.* Course participants will demonstrate competence in the Data and Analysis subject matter and will develop a lesson plan for teaching a Data and Analysis topic within an elementary grade level of their choosing.

Elementary Computer Science and Lesson Integration. This microcredential course is designed to provide participants with an understanding of how to design and teach lessons that integrate Virginia Computer Science *Standards of Learning* into elementary instruction in reading, writing, science, mathematics, and social studies. This course is the culmination of the ARCS professional development series and will allow participants to develop lesson plans that demonstrate K-5 Computer Science *SOL* teaching competencies and the ability to integrate this content into one or more core curriculum areas.

Networked Improvement Community

Both years of the ARCS PD, school year PD takes the form of a Networked Improvement Community (NIC; McKay, 2017). NICs are professional learning groups that possess four key characteristics: they focus on a well-specified aim; they are guided by a deep understanding of a problem and develop a theory of change to solve it; they deliberately attend to improvement metrics to demonstrate movement toward an intended solution; they are coordinated such that educational interventions can be implemented in varying contexts (LeMahieu, 2015). In the pilot year of the program, this was referred to as the CodeVA NING PLC. In the first year of the RCT, the CodeVA NING PLC was replaced with CodeVA Connect (online resources provided by CodeVA) and Learning Bytes. The goal was that Cohort 1 and 2 teachers completed four "learning byte" modules; two in the fall and two in the spring during their first treatment year.

Data Sources and Analysis

Data Sources

Teacher Instrument (Appendix A)

This instrument consists of measures to assess participants' content knowledge, pedagogical knowledge, self-efficacy, and culturally responsive teaching. Items also assess CS confidence and experience and confidence and experience for teaching CS. This instrument is administered at four timepoints: prior to the ARCS PD, after the CODE VA K-5 Coaches Academy (treatment year only), at the end of year 1, at the end of year 2, and at the end of year 3 (control only).

Measures were piloted and revised in year 1 and the resulting instrument implemented with both RCT cohorts. Support for face and content validity was established through a review of the assessment by a panel of experts whose feedback on the items was incorporated into the assessment that was administered to pilot year participants. Reliability (Cronbach's α) for key scales within the measures was calculated and is reported in the results.

Self-efficacy Scale

This measure consists of 9 Likert scale items adapted from the Teachers' Self-efficacy in Computational Thinking (Bean et al., 2015; α = .935) instrument. Modifications that were pilot-tested included using a 6-point scale instead of a 5-point scale, and replacing items 9 and 10, which relate to the Common Core and NGSS, with a single item about the Virginia Standards of Learning. Cronbach's α for the revised instrument was calculated using pilot data and determined to be .92 at pre-test and .92 at post-test, indicating good reliability.

Content knowledge index

This measure consists of 5 open-ended response items developed by the external evaluator with support for face validity established through expert review. Teacher responses were coded as "I don't know", did not meet expectations, partially met expectations, and met expectations using a rubric developed by the external evaluator.

Culturally responsive teaching scales

This measure consisted of 12 Likert scale items adapted from the Culturally Responsive Teaching Survey (Rhodes, 2016) and the Culturally Responsive Teaching Self-Efficacy Scale (Siwatu, 2007). A team of experts selected items from the existing instruments. Eight items related to confidence with culturally responsive teaching (Cronbach's α = .97 for pilot cohort) and four items related to the frequency of culturally responsive teaching (Cronbach's α = .74 for pilot cohort).

Post- and Year-End Items

The post- and year-end PD survey included 13 Likert scale items designed to understand participants' perceptions of the PD, 14 items to assess topics for additional PD, 2 open-ended items to better understand usefulness and recommendations. Five items on the post-survey about the participants' anticipated classroom environment during the 2020-21 school year and were not included on subsequent iterations of the survey. Another 6 questions asked only on the year-end survey asked about experiences participating in the Networked Improvement Community.

PD Observations
The ARCS CODE VA K-5 Coaches Academy Summer PD was digitally recorded and the chat was saved for each of the 5 sessions. The purpose of these observations was to characterize the implementation of the ARCS PD. An observation protocol ensured observers focused their observations and field notes on key aspects of the professional development. These included: the nature of teacher/teacher and teachers/facilitator interactions, signs of engagement, fatigue, understanding, discontent, questions among participants, implementation as planned (e.g., administrative, structural issues), and the nature of instruction.

Artifacts
Planning materials were collected. These artifacts allowed for detailed characterization of the ARCS components and triangulated with survey and observation data. Daily attendance for participants was recorded by the CODE VA facilitators and sent to the external evaluator.

Student Instrument - CKACS (Appendix C)
Grade three, four, and five students of in treatment and control teacher classrooms complete the Content Knowledge and Affective Instrument for Computer Science (CKACS) at the beginning and end of each school year that their teacher participates. Assessments are completed online and a read-aloud version is available.

The content knowledge component of the assessment (Cronbach's $\alpha = .79$) has three performance-based tasks and measures students' knowledge and understanding of computer science across 3 subscales: systems and impacts of computing (Cronbach's $\alpha = .72$), data and analysis (Cronbach's $\alpha = .60$), and cybersecurity. The 15- item affective component of the instrument (Cronbach's $\alpha = .89$) included 3 subscales: confidence (Cronbach's = .80), interest (Cronbach's $\alpha = .85$), and utility (Cronbach's $\alpha = .76$) scales.

Data Analysis
For Likert items (e.g., self-efficacy, confidence, experience), frequency of teacher endorsement for each item and descriptive statistics (*M*, *SD*) were calculated. Paired t-tests compared changes in participants' pre- to post- and pre- to year-end mean scores on scales.

Teacher pre- and post- open-ended CS Content Knowledge responses are analyzed using systematic data analysis (Miles & Huberman, 1994) using a rubric validated by an expert panel. An overall score (1 = I don't know/did not meet expectations, 2 = partially met expectations, 3 = met expectations (ranging from 5 to 15) was calculated for content knowledge. Participants' responses are assessed for changes in their understanding of these constructs and alignment of their responses to these constructs as taught during the professional development. Paired t-tests compared changes in participants' pre- to post- and pre- to year-end mean scores.

For the student Content Knowledge and Affective Instrument for Computer Science (CKACS) a detailed three-point (1- did not meet expectations, 2- partially met expectations, and 3- met expectations) rubric was designed to score the content knowledge component of the instrument. Rubric development was informed by the state CS Standards. To obtain interrater reliability for scoring the open-ended content knowledge items, two rounds of coding were conducted by three coders, with discussion and clarification of the rubric between rounds. This process resulted in interrater reliability of 80% across 25% percent of the data. Then, two raters used the rubric to code student responses. An overall content knowledge score and an overall interest score are calculated for each student and these scores.

Analytic induction, as described by Bogdan and Biklen (1992), was used to analyze the open-ended survey responses, observations, and artifacts. In this approach, the entire data set of responses was read. For open-ended survey responses, initial categories were developed and then each response was coded into one or more categories. Two coders independently coded approximately 20% of the data set and the intercoder agreement was calculated to be 100%. Categories were added and collapsed throughout the coding process. For observations and artifacts, the inductive process involved identifying patterns in the data set with the goal of characterizing participants' PD experiences. From these patterns, preliminary categories were developed, which were refined through comparison with the original data set.

RCT Cohort 1 Delayed Treatment Teacher Outcomes

The documentation and evaluation of activities in this section represent a synthesis of the implementation data for ARCS that have been analyzed to date. These data were obtained through observations, document analysis, and surveys of participants.

Recruitment, Attrition, and Analytic Sample

Elementary teachers were recruited, started applications, and agreed to the informed consent for the ARCS program (n = 91). The ARCS program was advertised primarily via communication with division superintendents and central office staff as well as via Virginia Department of Education announcements. Of these 91 teachers from 34 schools who applied, 11 schools did not meet the criteria for participation in the RCT (did not have a 3rd, 4th, or 5th-grade teacher apply) and therefore all teachers from these schools were placed into a "non-RCT" group that received the PD. These teachers are excluded in subsequent sections of this report. Of the remaining 77 teachers from 23 schools, 11 schools (n = 33 teachers) were randomized into the treatment condition and 12 schools (n = 44 teachers) were randomized into the control condition (Table 3).

As of June 22, 2021, the first day of the ARCS Academy, 33 teachers from 11 schools began the CODE VA K-5 Coaches Academy and 29 completed it (88%). 17 treatment teachers have enrolled in the micro-credentials as of October 1, 2022. In the control group, 39 teachers from 12 schools completed the pre-assessment. Of these 39 control teachers 20 participated in the ARCS Academy Summer PD after their control year (Summer 2022).

Table 3. Elementary RCT Cohort 1 Randomization and Retention Data

	Randomized		Completed Year 1			Completed Micro-credentials	
	Immediate Treatment	Control/Delayed Treatment	Immediate Treatment	Control/Delayed Treatment	Non-RCT	Immediate Treatment	Control/Delayed Treatment
Schools	11	12	10	10	7 (11 applied)	n/a	n/a
Teachers	33	44	29	39	9 (14 applied)	10	9

Rural teacher participation

Seventy-eight school divisions in Virginia meet the classification as "rural, distant," "rural, fringe," or "rural, remote" as identified by the Virginia Department of Education. Of the 10 divisions represented by ARCS participants in the RCT Cohort, 7 meet the "rural, distant," "rural, fringe," or "rural, remote" designations. A total of 27/77 (35%) teachers from rural designation districts are in the RCT Cohort (i.e., treatment, control/delayed treatment, or non-RCT condition).

Sample Demographics

Table 4 describes the demographic characteristics of the 77 elementary teachers participating in ARCS Year 2 (n = 29 immediate treatment, n = 39 control, n = 9 non-RCT). Table 25 describes their CS background. The mean years of teaching experience was: treatment *M* = 15.5 (*SD* = 8.8), control *M* = 15.3 (*SD* = 6.7), non-RCT *M* = 8.1 (*SD* = 5.7). Four immediate treatment teachers did not self-report demographic information. These data are self-reported.

Table 4. Cohort 1 Demographics

	Immediate Treatment (n =25)[1] n (%)	Control/Delayed Treatment (n =39) n (%)
Gender		
Male	3 (12.0%)	4 (10.3%)
Female	22 (88.0%)	35 (89.7%)
Race/Ethnicity		
White	23 (92.0%)	30 (76.9%)
Black	1 (4.0%)	8 (20.5%)
Asian	1 (4.0%)	0 (0%)
Other	0 (0%)	1 (2.6%)
Hispanic	0 (0%)	0 (0%)

Note. [1]4 teachers in the immediate treatment group did not provide demographic data.

Table 5. Educational Background

	Immediate Treatment (n = 25)[1] n (%)	Control/Delayed Treatment (n = 39) n (%)
Has Ed Degree	25 (100%)	25 (100%)
Elementary	22 (88%)	31 (79.5%)
Secondary	1 (4%)	0 (0%)
SPED	2 (8%)	2 (5.1%)
Ed Tech	2 (8%)	0 (0%)
Other2	2 (8%)	3 (7.7%)
Has STEM Degree	1 (4%)	3 (7.7%)

Note. [1] 4 teachers in the immediate treatment group did not provide demographic data. [2] Other degree includes childhood education, music education, education leadership, ESOL, and library science.

RCT Cohort 1 Implementation Results

Microcredentials

As of October 2023, 20 teachers in the RCT Cohort 1 delayed treatment group were eligible and had access to complete the microcredentials. As of October 2024, 9 teachers in the RCT Cohort 1 delayed treatment group completed the microcredentials (Table 6).

Table 6. Microcredential completion by course

	Cohort 1 Delayed Treatment*
Introduction to Computers, Digital Impact, and Digital Citizenship	10
Computing Systems, Networks and the Internet, and Cybersecurity	10
Algorithms and Programming	10
Data and Analysis	10
Elementary Computer Science and Lesson Integration	10

*These numbers represent unique participants for each course; although 10 participants completed each of the five courses, only nine completed the entire stack.

Teachers who completed the year-end survey questions about the microcredentials (n = 6) were overwhelmingly positive. One teacher noted, *"All of the micro credentials were informative, engaging & provided an opportunity to further my CS integration lesson integration skills!"* and another indicated, "*I learned new information doing this course, and my integrated lessons created will help me be more effective in teaching CS standards*..."

Regarding format, all strongly agreed that they liked the self-paced nature of the microcredentials, and all somewhat to strongly agreed that they liked the staggered opening dates for the microcredentials. All teachers indicated that completing the microcredentials helped them build knowledge of the VA CS Standards and that completing the microcredentials will help them better integrate the VA CS Standards into their instruction (somewhat agreed to strongly agreed), and indicated that they can effectively teach the VA CS Standards for their grade after completing the microcredentials. Notably, none of the teachers reported using the office hours and one teacher indicated that the self-reflection sheet was difficult to find.

Implementation

Teacher self-report data indicated that of 7 teachers (delayed treatment) who completed the frequency of integration survey in June 2024, 6 (85.7%) reported teaching at least one lesson that explicitly targeted CS SOLs between Thanksgiving break and the end of the 2024 school year. Table 7 indicates the number of lessons teachers reported teaching for this strand.

Table 7. Standards and Number of Lessons taught by Teachers

CS SOL Strand	Number of Lessons	Year End N (%)
Algorithm and Programming	None	0 (0%)
	1-2 lessons	2 (4.7%)
	3-4 lessons	2 (4.7%)
	5 or more lessons	2 (4.7%)
Computing Systems	None	2 (4.7%)
	1-2 lessons	4 (9.3%)
	3-4 lessons	0 (0%)
	5 or more lessons	0 (0%)
Cybersecurity	None	1 (2.3%)
	1-2 lessons	3 (7.0%)
	3-4 lessons	1 (2.3%)
	5 or more lessons	1 (2.3%)
Data and Analysis	None	0 (0%)
	1-2 lessons	5 (14%)
	3-4 lessons	0 (0%)
	5 or more lessons	0 (0%)
Networking and the Internet	None	4 (9.3%)
	1-2 lessons	2 (4.7%)
	3-4 lessons	0 (0%)
	5 or more lessons	0 (0%)

The data from table 7 indicates that teachers focused most on teaching lessons within the Algorithms and Programming and Data and Analysis strands. Networking and the Internet received the least attention, with most teachers (n = 4) either not including lessons that integrating it or teaching only 1-2 lessons. In summary, the emphasis was on Algorithms and Programming and Data and Analysis.

Most teachers, 83% at mid-year and 75% at year end, somewhat to strongly agreed their students were more engaged in CS than at the beginning of the year; mid-year *M* = 4.8 (*SD* = 1.1), year-end *M* = 4.4 (*SD* = 1.2), scale strongly disagree = 1 to strongly agree = 6. Only 1 teacher indicated they did not cover any CS SOL content during this period.

Table 8. Level of Engagement During CS SOL

Student Engagement	Not at all Engaged (1)	Slightly Engaged (2)	Moderately Engaged (3)	Highly Engaged (4)
Algorithms and Programming (n = 6)	0	1	1	4
Computing Systems (n = 4)	0	1	0	3
Cybersecurity (n = 5)	0	2	2	1
Impacts of Computing (n= 4)	0	1	2	1
Networking and the Internet (n = 2)	0	1	1	0

Based on the reports from teachers, students found the Algorithms and Programming and Computing Systems lessons the most engaging (*M* = 3.5, *SD* = 0.84 and M = 3.5, SD = 1.0), followed by Impacts of Computing (*M* = 3.0, *SD* = .82), and Cybersecurity (*M* = 2.8, *SD* = 0.84). Teachers indicated that students were only slightly to moderately engaged in Networking & the Internet lessons (*M* = 2.5, *SD* = 0.71).

Teachers implemented a variety of CS-related activities that they perceived to be engaging and effective for students. For Algorithms and Sequencing, they used unplugged activities to help students understand sequencing by completing tasks in a logical order, reinforced through video creation projects. In Cybersecurity, lessons emphasized responsible digital citizenship, supported by IT-led training sessions and role-playing scenarios. Through Historical Perspectives on Communication, students examined and creatively envisioned the evolution of communication devices, integrating historical understanding. Robotics and Programming activities, such as working with Indi, Sphero, and Ozobot robots, encouraged hands-on exploration of programming and problem-solving, especially popular among younger students. A robotics team using LEGO Spike Prime deepened students' teamwork skills. With Coding Platforms like CODE Virginia, Scratch, and Raspberry Pi, students enjoyed seeing their code come to life in real-time, fostering enthusiasm for coding. Finally, lessons on Real-World Online Behavior resonated deeply with students, addressing practical issues like information sharing and online bullying, which connected directly to their daily digital experiences.

The 7 delayed treatment teachers indicated varied degrees of student engagement by the of the year with 3 teachers strongly disagreeing that their students were more engaged, M = 3, SD = 1.9.

RCT Cohort 1 Teacher Results

Participant Outcomes. Of participants, 25 immediate treatment participants completed both the pre- and post-assessment and were included in the analytic sample, 39 control participants completed the pre-assessment and were included in the analytic sample, and 9 non-RCT participants completed the pre- and post-assessment. Their results are included below. Due to the small number of teachers who completed the year 2 assessment (immediate treatment = 4, control/delayed treatment = 12), inferential statistics were not conducted to compare pre- to year-2-end outcomes for immediate treatment or control/delayed treatment teachers.

CS Content Knowledge

Results indicated no significant improvement in immediate treatment teacher CS knowledge following participation in the Code VA K-5 Coaches Academy (pre/post PD), t (21) = .8, p = .4 (Table 9). In addition, there was no significant difference in immediate treatment teacher CS knowledge from pre to year-1-end, t (12) = .4, p = .7. For the control/delayed treatment group, there was no significant difference in teacher CS knowledge from pre to post, t (13) = .4, p = .7. There was a significant decline in teacher CS knowledge from pre to year-1-end, t (13) = -4.0, p = <.001, and there was no significant difference in control/delayed treatment teacher CS knowledge from pre to year-2-end, t (9) = -1.5, p = .2.

Results of ANCOVA indicated that at the end of the first year of ARCS (spring 2022), immediate treatment teacher CS content knowledge was significantly greater than control teachers, p = .05; R^2 = .3, after controlling for prescore, race, gender, prior CS PD experience.

Table 9. Teacher Content Knowledge Outcomes

	Immediate Treatment				Control/Delayed Treatment				
Item	[1] Pre-Year 1 M (*SD*)	[1] Post PD M (*SD*)	[2] Year 1 End M (SD)	[3]Year 2 End M (SD)	[4]Pre Year 1 M (*SD*)	[5]Year 1 End M (SD)	[6]Post PD M (SD)	[7]Year 2 End M (SD)	[8]Year 3 End M (SD)
1. What is computer science?	2.0 (0.8)	2.1 (0.5)	2.1 (0.5)	1.6 (0.5)	2.2 (0.7)	2.0 (0.8)	2.2 (0.8)	2 (0.5)	1.6 (0.7)
2. Describe what a computer programmer does.	2.3 (0.4)	2.2 (0.4)	2.1 (0.5)	1.6 (0.5)	2.1 (0.4)	2.1 (0.7)	2.2 (0.6)	2.1 (0.6)	1.6 (0.7)
3. What makes a device a computer?	1.2 (0.6)	1.4 (0.5)	1.4 (0.6)	1.2 (0.4)	1.5 (0.5)	1.3 (0.7)	1.5 (0.5)	1.4 (0.5)	2 (0.9)
4. What is an algorithm?	2.3 (0.7)	2.3 (0.6)	2.5 (0.7)	2.8 (0.4)	2.3 (0.7)	1.7 (0.9)	2.1 (1.0)	2.3 (0.7)	1.7 (0.7)
5. In what ways is the term “variable” used differently in computer science than in math and science?	1.6 (1.2)	1.5 (0.8)	1.4 (0.8)	1 (1.0)	1.8 (.07)	0.9 (0.9)	1.5 (1.1)	1.4 (0.7)	1.2 (0.4)

Note. Each item scored 1-3. [1] Immediate Treatment Pre and Post: Summer 2021, [2]Immediate treatment Year 1 End: Spring 2022, [3]Immediate treatment Year 2 End: Spring 2023, [4]Control Pre-Year 1: Summer 2021, [5]Control Year 1 End: Spring 2022, [6]Delayed treatment Post PD: Summer 2022, [7]Delayed treatment Year 2 End: Spring 2023, [8]Delayed treatment Year 3 End: Spring 2024. Immediate treatment group (pre n = 25, post n = 25, year 1 end n = 15, year 2 end = 4), control/delayed treatment group (pre n = 39, post n = 23, year 1 end n = 14, year 2 end = 12, year 3 end = 7).

CS Pedagogical Knowledge

Pedagogical knowledge was measured through several scales with high reliability (Cronbach's α > .8). Results indicated significant improvement in immediate treatment teacher experience programming, participant experience teaching programming, and experience integrating CS SOLs from pre- to post-PD, and pre to year 1 end (p's < .05).

Table 10. Experience Programming

	Immediate Treatment				Control/Delayed Treatment)				
Rate your experience:	[1]Pre M (*SD*)	[2]Post M (*SD*)	[3]Year 1 End M (SD)	[4]Year 2 End M (SD)	[1]Pre M (*SD*)	[5]Year 1 End M (SD)	[2]Post M (SD)	[3]Year 2 End M (SD)	[3]Year 3 End M (SD)
1. Programming (any language)	2.1 (1.2)	2.9 (1.0)	3.6 (1.1)	3 (1.6)	2.4 (1.4)	2.3 (1.5)	2.5 (1.3)	3.3 (1.2)	3.7 (1.2)
2. Coding in a block language	2.5 (1.6)	3.4 (1.4)	3.6 (1.2)	3.6 (2.1)	2.8 (1.7)	2.9 (1.6)	2.9 (1.5)	4 (1.4)	4.3 (1.0)
3. Coding in a text-based language	1.9 (1.2)	2.6 (1.1)	2.9 (1.3)	1.2 (0.4)	1.9 (1.1)	1.9 (1.2)	2.1 (1.4)	2.6 (1.3)	2.3 (1.0)
4. Running an "Hour of Code" event	2.6 (1.8)	3.4 (1.6)	3.2 (1.7)	2.4 (2.1)	3.1 (1.8)	3.3 (1.8)	3.5 (1.9)	4.1 (1.6)	4.3 (1.6)

Note. Immediate treatment group (pre n = 25, post n = 25, year 1 end n = 15, year 2 end = 4), control group (pre n = 39, post n = 23, year 1 end n = 14, year 2 end = 12, year 3 end= 8). Each item scored 1-6. Cronbach's α pre = .91, Cronbach's α post = .83. Cronbach's α Year 1 End = .90. Scale: very inexperienced = 1, Very experienced = 6. Administration timepoints: [1]Pre: spring after randomization. [2]Post: after CodeVA Coaches academy. [3]Year 1 End (immediate treatment) and [3]Year 2 end (delayed treatment): end of academic year after coaches academy. [4]Year 2 End: end of year after microcredentials. [5]Year 1 end: end of control year for control/delayed treatment teachers.

Table 11. Experience Integrating CS SOLs

	Immediate Treatment				Control/Delayed Treatment)				
Rate your experience with the following:	[1]Pre M (*SD*)	[2]Post M (*SD*)	[3]Year 1 End M (SD)	[4]Year 2 End M (SD)	[1]Pre M (*SD*)	[5]Year 1 End M (SD)	[2]Post M (SD)	[3]Year 2 End M (SD)	[3]Year 3 End M (SD)
1. The Virginia Computer Science Standards	2.4 (1.4)	4.1 (1.0)	4.0 (0.9)	3.0 (1.8)	2.9 (1.4)	3.5 (1.4)	3.6 (1.2)	4.3 (0.8)	4.5 (0.9)
2. Algorithms and programming	2.0 (1.2)	4.1 (1.0)	3.8 (1.2)	2.8 (1.7)	2.3 (1.4)	3.0 (1.5)	3.7 (1.4)	4.3 (1.0)	4.1 (0.8)
3. Information about computer systems	2.6 (1.1)	4.0 (0.8)	3.6 (1.2)	2.8 (1.7)	2.8 (1.4)	3.5 (1.4)	3.8 (1.4)	4.3 (0.8)	4.0 (1.0)
4. Information about cybersecurity	2.5 (1.2)	4.0 (0.8)	4.0 (1.2)	3.0 (2.2)	2.8 (1.5)	3.6 (1.5)	4.1 (1.4)	4.3 (0.8)	3.8 (0.9)
5. Data and analysis	2.5 (1.4)	4.2 (0.9)	3.9 (1.0)	3.0 (1.8)	3.0 (1.5)	3.5 (1.4)	3.9 (1.3)	4.3 (0.9)	4.0 (1.0)
6. Information about the impacts of computing	2.4 (1.3)	4.2 (0.9)	3.7 (1.0)	3.0 (1.8)	2.9 (1.5)	3.3 (1.5)	4.0 (1.2)	4.2 (0.8)	4.0 (1.0)

Note. Immediate treatment group (pre n = 25, post n = 25, year 1 end n = 15, year 2 end = 4), control group (pre n = 39, post n = 23, year 1 end n = 14, year 2 end = 12, year 3 end= 8). Each item scored 1-6. Cronbach's α pre = .91, Cronbach's α post = .83. Cronbach's α Year 1 End = .90. Scale: very inexperienced = 1, Very experienced = 6. Administration timepoints: [1]Pre: spring after randomization. [2]Post: after CodeVA Coaches academy. [3]Year 1 End (immediate treatment) and [3]Year 2 end (delayed treatment): end of academic year after coaches academy. [4]Year 2 End: end of year after microcredentials. [5]Year 1 end: end of control year for control/delayed treatment teachers.

Table 12. Experience Teaching Programming

	Immediate Treatment				Control/Delayed Treatment)				
Rate your experience:	[1]Pre M (*SD*)	[2]Post M (*SD*)	[3]Year 1 End M (SD)	[4]Year 2 End M (SD)	[1]Pre M (*SD*)	[5]Year 1 End M (SD)	[2]Post M (SD)	[3]Year 2 End M (SD)	[3]Year 3 End M (SD)
1. Teaching Programming (any language)	2.0 (1.2)	2.8 (1.1)	3.4 (1.1)	3.2 (1.6)	2.2 (1.4)	2.1 (1.4)	2.6 (1.5)	3.6 (1.2)	3.7 (1.2)
2. Teaching coding in a block language	2.4 (1.5)	3.4 (1.3)	3.5 (1.2)	3.6 (2.0)	2.7 (1.7)	2.7 (1.6)	2.8 (1.6)	4.2 (1.4)	4.2 (1.3)
3. Teaching coding in a text-based language	1.8 (1.1)	2.5 (1.0)	2.7 (1.1)	1.4 (0.5)	1.7 (1.0)	1.8 (1.0)	2.1 (1.4)	2.7 (1.4)	2.1 (1.1)

Note. Immediate treatment group (pre n = 25, post n = 25, year 1 end n = 15, year 2 end = 4), control group (pre n = 39, post n = 23, year 1 end n = 14, year 2 end = 12, year 3 end= 8). Each item scored 1-6. Cronbach's α pre = .91, Cronbach's α post = .83. Cronbach's α Year 1 End = .90. Scale: very inexperienced = 1, Very experienced = 6. Administration timepoints: [1]Pre: spring after randomization. [2]Post: after CodeVA Coaches academy. [3]Year 1 End (immediate treatment) and [3]Year 2 end (delayed treatment): end of academic year after coaches academy. [4]Year 2 End: end of year after microcredentials. [5]Year 1 end: end of control year for control/delayed treatment teachers.

Table 13. Other Items Related to Pedagogical Knowledge

	Immediate Treatment				Control/Delayed Treatment)				
How strongly do you agree or disagree with the following statements?	[1]Pre M (*SD*)	[2]Post M (*SD*)	[3]Year 1 End M (SD)	[4]Year 2 End M (SD)	[1]Pre M (*SD*)	[5]Year 1 End M (SD)	[2]Post M (SD)	[3]Year 2 End M (SD)	[3]Year 3 End M (SD)
1. I understand what computer science is.	4.3 (0.9)	5.2 (0.6)	5.0 (0.5)	5.4 (0.5)	4.4 (1.0)	4.3 (1.2)	4.8 (0.9)	5.0 (0.9)	5.2 (0.7)
2. I am familiar with my school division's plan for computer science education at the K-5 level.	3.6 (1.2)	4.3 (1.1)	4.5 (0.8)	4.2 (1.5)	3.7 (1.3)	3.7 (1.5)	3.9 (1.6)	4.6 (0.9)	4.5 (1.1)
3. I can engage students from rural areas in computer science.	4.3 (1.1)	5.0 (0.8)	4.8 (0.7)	4.0 (2.1)	4.3 (1.1)	4.2 (1.2)	4.6 (0.9)	4.9 (0.9)	4.8 (1.0)
4. I can engage students from low socioeconomic backgrounds in computer science.	4.4 (1.2)	5.1 (0.7)	4.9 (0.6)	5.0 (1.0)	4.4 (1.1)	4.4 (1.0)	4.6 (0.8)	4.9 (0.9)	5.0 (0.9)
5. I can engage students who are traditionally underrepresented in STEM in computer science	4.4 (1.2)	5.2 (0.7)	4.8 (0.7)	5.2 (0.8)	4.4 (1.2)	4.5 (1.0)	4.6 (1.0)	5.0 (0.9)	5.0 (1.1)
6. I can address issues of access to computer technologies for students in my school.	4.0 (1.2)	4.7 (0.9)	4.6 (1.1)	5.0 (1.0)	4.5 (1.0)	4.2 (1.2)	4.7 (0.8)	4.8 (1.0)	4.5 (0.7)

Note. Immediate treatment group (pre n = 25, post n = 25, year 1 end n = 15, year 2 end = 4), control group (pre n = 39, post n = 23, year 1 end n = 14, year 2 end = 12, year 3 end= 7). Each item scored 1-6. Cronbach's α pre = .91, Cronbach's α post = .83. Cronbach's α Year 1 End = .90. Scale: strongly disagree = 1, strongly agree = 6. Administration timepoints: [1]Pre: spring after randomization. [2]Post: after CodeVA Coaches academy. [3]Year 1 End (immediate treatment) and [3]Year 2 end (delayed treatment): end of academic year after coaches academy. [4]Year 2 End: end of year after microcredentials. [5]Year 1 end: end of control year for control/delayed treatment teachers.

CS Self-efficacy and Confidence

CS self-efficacy and confidence were measured through several scales with high reliability (Cronbach's α > .8). Results of ANCOVA indicated that at the end of the first year of ARCS, immediate treatment teacher self-efficacy for teaching CS was significantly greater than that of control teachers, $p = .001$; $R^2 = .6$. Immediate treatment teacher confidence in programming, $p = .002$; $R^2=.5$, confidence in teaching programming, $p = .003$; $R^2=.5$, and confidence in integrating CS SOLs, $p < .001$; $R^2=.4$, were also significantly greater than that of control teachers after controlling for prescore, race, gender, prior CS PD experience. These results indicate a both statistically and practically meaningful improvement in immediate treatment teachers' self-efficacy, confidence in programming, confidence in teaching programming, and confidence in integrating CS SOLs compared to control teachers at the end of the first year of ARCS. Results indicated significant improvement in immediate treatment teacher self-efficacy for teaching CS, confidence programming, confidence teaching programming, and confidence integrating CS SOLs from pre- to post- and pre- to year-end (all *p*'s < .05).

Table 14. Self-Efficacy Scale

	Immediate Treatment				Control/Delayed Treatment)				
How strongly do you agree or disagree with the following statements	[1]Pre M (*SD*)	[2]Post M (*SD*)	[3]Year 1 End M (SD)	[4]Year 2 End M (SD)	[1]Pre M (*SD*)	[5]Year 1 End M (SD)	[2]Post M (SD)	[3]Year 2 End M (SD)	[3]Year 3 End M (SD)
1. I feel confident using computer technology.	5.0 (0.7)	5.3 (0.6)	5.3 (0.8)	4.8 (0.8)	4.9 (0.9)	4.9 (0.8)	4.9 (0.9)	5.1 (0.8)	5.4 (0.9)
2. I know how to teach programming concepts effectively.	3.1 (1.3)	4.2 (1.0)	4.3 (0.8)	3.4 (2.0)	3.1 (1.4)	3.2 (1.5)	3.4 (1.5)	4.4 (1.3)	4.4 (1.6)
3. I feel confident writing simple programs for the computer.	2.5 (1.3)	3.6 (1.3)	4.1 (1.2)	3.0 (1.2)	3.0 (1.5)	2.8 (1.5)	3.1 (1.6)	4.3 (1.4)	4.4 (1.7)
4. I can promote a positive attitude toward programming in my students.	5.0 (0.8)	5.2 (1.1)	4.9 (0.8)	4.6 (2.2)	5.0 (1.0)	4.7 (0.8)	4.7 (1.3)	4.8 (0.9)	4.8 (1.8)
5. I can guide students in using programming as a tool while we explore other topics.	4.0 (1.5)	4.7 (1.2)	4.6 (0.9)	4.2 (1.9)	3.8 (1.5)	3.7 (1.5)	4.1 (1.4)	4.6 (0.8)	4.7 (1.7)
6. I feel confident using programming as an instructional tool within my classroom.	3.6 (1.4)	4.5 (1.3)	4.3 (1.2)	3.8 (1.9)	3.7 (1.6)	3.5 (1.5)	3.7 (1.5)	4.4 (1.1)	4.7 (1.7)
7. I can adapt lesson plans incorporating programming as an instructional tool.	4.0 (1.3)	4.8 (1.1)	4.6 (0.7)	4.0 (1.9)	4.1 (1.4)	3.7 (1.5)	4.1 (1.5)	4.5 (0.9)	4.5 (1.3)
8. I can create original lesson plans incorporating programming as an instructional tool.	3.8 (1.4)	4.7 (1.0)	4.4 (0.7)	4.0 (1.9)	3.7 (1.4)	3.4 (1.5)	3.6 (1.6)	4.3 (1.2)	4.5 (1.3)
9. I can identify how programming concepts relate to the Virginia Standards of Learning.	3.8 (1.2)	4.8 (1.1)	4.4 (1.0)	4.2 (2.0)	4.0 (1.3)	3.9 (1.2)	4.2 (1.5)	4.7 (0.9)	5.0 (1.5)

Note. Immediate treatment group (pre n = 25, post n = 25, year 1 end n = 15, year 2 end = 4), Control group (pre n = 39, post n = 23, year 1 end n = 14, year 2 end = 12, year 3 end = 7). Each item scored 1-6. Cronbach's α pre = .91, Cronbach's α post = .83. Cronbach's α Year 1 End = .90. Scale: strongly disagree = 1, strongly agree = 6. Administration timepoints: [1]Pre: spring after randomization. [2]Post: after CodeVA Coaches academy. [3]Year 1 End (immediate treatment) and [3]Year 2 end (delayed treatment): end of academic year after coaches academy. [4]Year 2 End: end of year after microcredentials. [5]Year 1 end: end of control year.

Table 15. Confidence Programming

	Immediate Treatment				Control/Delayed Treatment)				
Rate your confidence with the following:	[1]Pre M (*SD*)	[2]Post M (*SD*)	[3]Year 1 End M (SD)	[4]Year 2 End M (SD)	[1]Pre M (*SD*)	[5]Year 1 End M (SD)	[2]Post M (SD)	[3]Year 2 End M (SD)	[3]Year 3 End M (SD)
1. Programming (any language)	2.3 (1.2)	3.5 (1.2)	3.9 (0.7)	3.4 (1.3)	2.5 (1.4)	2.7 (1.5)	3.1 (1.5)	4.1 (1.3)	3.8 (1.1)
2. Coding in a block language	2.8 (1.5)	3.8 (1.2)	4.3 (1.3)	3.6 (2.0)	3.1 (1.7)	3.3 (1.6)	3.4 (1.8)	4.5 (1.3)	4.5 (1.0)
3. Coding in a text-based language	2.1 (1.2)	2.9 (1.1)	3.1 (1.2)	1.6 (0.5)	2.0 (1.1)	2.2 (1.4)	2.6 (1.7)	2.8 (1.2)	2.5 (1.3)
4. Running an “Hour of Code” event	2.8 (1.8)	4.1 (1.2)	4.1 (1.2)	3.0 (2.0)	3.5 (1.8)	3.6 (1.8)	3.9 (1.8)	4.7 (1.6)	4.7 (1.6)

Note. Immediate treatment group (pre n = 25, post n = 25, year 1 end n = 15, year 2 end = 4), control group (pre n = 39, post n = 23, year 1 end n = 14, year 2 end = 12, year 3 end = 8). Each item scored 1-6. Max possible mean scale score is 24, min possible mean score is 4. Cronbach’s α pre = .89, Cronbach’s α post = .80. Scale: 1 = not at all confident, 6 = very confident. Administration timepoints: [1]Pre: spring after randomization. [2]Post: after CodeVA Coaches academy. [3]Year 1 End (immediate treatment) and [3]Year 2 end (delayed treatment): end of academic year after coaches academy. [4]Year 2 End: end of year after microcredentials. [5]Year 1 end: end of control year.

Table 16. Confidence Teaching Programming

	Immediate Treatment				Control/Delayed Treatment)				
Rate your confidence with the following:	[1]Pre M (*SD*)	[2]Post M (*SD*)	[3]Year 1 End M (SD)	[4]Year 2 End M (SD)	[1]Pre M (*SD*)	[5]Year 1 End M (SD)	[2]Post M (SD)	[3]Year 2 End M (SD)	[3]Year 3 End M (SD
1. Teaching Programming (any language)	2.3 (1.4)	3.2 (1.2)	3.8 (0.8)	3.0 (1.6)	2.4 (1.6)	2.6 (1.5)	2.9 (1.4)	3.8 (1.4)	4.0 (0.7)
2. Teaching coding in a block language	2.6 (1.6)	3.7 (1.2)	4.1 (1.3)	3.6 (2.1)	3.1 (1.7)	3.0 (1.6)	3.4 (1.5)	4.6 (1.4)	4.6 (0.7)
3. Teaching coding in a text-based language	2.0 (1.4)	2.6 (1.2)	2.8 (1.2)	1.4 (0.5)	1.9 (1.1)	2.0 (1.3)	2.6 (1.4)	2.9 (1.4)	2.2 (1.2)

Note. Immediate treatment group (pre n = 25, post n = 25, year 1 end n = 15, year 2 end = 4), control group (pre n = 39, post n = 23, year 1 end n = 14, year 2 end = 12, year 3 end = 8) Each item scored 1-6. Cronbach’s α pre = .89, Cronbach’s α post = .81. Scale: 1 = not at all confident, 6 = very confident. Administration timepoints: [1]Pre: spring after randomization. [2]Post: after CodeVA Coaches academy. [3]Year 1 End (immediate treatment) and [3]Year 2 end (delayed treatment): end of academic year after coaches academy. [4]Year 2 End: end of year after microcredentials. [5]Year 1 end: end of control year.

Table 17. Confidence Integrating CS SOLs

	Immediate Treatment				Control/Delayed Treatment)				
Rate your confidence integrating the following into your K-12 instruction:	[1]Pre M (*SD*)	[2]Post M (*SD*)	[3]Year 1 End M (SD)	[4]Year 2 End M (SD)	[1]Pre M (*SD*)	[5]Year 1 End M (SD)	[2]Post M (SD)	[3]Year 2 End M (SD)	[3]Year 3 End M (SD)
1. The Virginia Computer Science Standards	2.9 (1.5)	5.0 (.8)	4.6 (0.7)	4.0 (1.7)	3.8 (1.2)	3.5 (1.4)	4.8 (1.1)	4.8 (0.7)	4.4 (1.2)
2. Algorithms and programming	2.4 (1.6)	4.5 (1.1)	4.3 (1.0)	3.8 (1.9)	2.9 (1.3)	3.0 (1.4)	4.5 (1.2)	4.8 (0.8)	4.0 (1.3)
3. Information about computer systems	3.0 (1.4)	4.6 (1.0)	4.4 (1.0)	3.6 (1.7)	3.2 (1.4)	3.5 (1.4)	4.6 (1.2)	4.7 (0.8)	3.9 (1.4)
4. Information about cybersecurity	3.0 (1.4)	4.7 (0.9)	4.5 (1.0)	4.4 (2.1)	3.3 (1.5)	3.6 (1.5)	5.0 (0.8)	4.8 (0.8)	4.5 (1.3)
5. Data and analysis	3.2 (1.5)	4.8 (0.9)	4.3 (0.8)	4.0 (1.9)	3.6 (1.5)	3.5 (1.4)	4.6 (1.2)	4.7 (1.0)	4.1 (1.5)
6. Information about the impacts of computing	3.1 (1.4)	4.8 (0.8)	4.3 (1.0)	3.8 (1.9)	3.5 (1.4)	3.3 (1.5)	4.9 (0.7)	4.5 (0.9)	4.2 (1.5)

Note. Immediate treatment group (pre n = 25, post n = 25, year 1 end n = 15, year 2 end = 4), control group (pre n = 39, post n = 23, year 1 end n = 14, year 2 end = 12, year 3 end=13). Each item scored 1-6. Cronbach's α pre = .94, Cronbach's α post = .93. Scale: 1 = not at all confident, 6 = very confident. Administration timepoints: [1]Pre: spring after randomization. [2]Post: after CodeVA Coaches academy. [3]Year 1 End (immediate treatment) and [3]Year 2 end (delayed treatment): end of academic year after coaches academy. [4]Year 2 End: end of year after microcredentials. [5]Year 1 end: end of control year.

Culturally Responsive Teaching

Culturally responsive teaching confidence and frequency were measured with high reliability (Cronbach's a > .8). Results indicated no change in immediate treatment teacher confidence for culturally responsive teaching from pre- to post-PD, t (24) = 2.7, p = .63. Results of ANCOVA at the end of the first year of the ARCS PD indicated that there was no significant difference in immediate treatment teacher confidence for implementing culturally responsive teaching group compared to the control group, p = .3; R^2=.4, after controlling for prescore, race, gender, and prior CS PD experience.

Table 18. Culturally Responsive Teaching Confidence

	Immediate Treatment				Control/Delayed Treatment)				
Please indicate how confident you are that you can:	[1]Pre M (*SD*)	[2]Post M (*SD*)	[3]Year 1 End M (SD)	[4]Year 2 End M (SD)	[1]Pre M (*SD*)	[5]Year 1 End M (SD)	[2]Post M (SD)	[3]Year 2 End M (SD)	[3]Year 3 End M (SD)
1. Identify ways that the school culture is different from my students' home culture.	4.4 (1.0)	4.5 (0.9)	4.7 (0.7)	4.6 (1.1)	4.4 (1.0)	4.0 (1.1)	4.9 (0.9)	4.5 (0.9)	4.8 (0.6)
2. Implement strategies to minimize the effects of any mismatch between my students' home culture and the school culture.	4.2 (1.0)	4.3 (1.0)	4.1 (1.0)	5.0 (1.0)	4.1 (1.0)	4.0 (1.0)	4.7 (0.8)	4.5 (0.9)	4.7 (0.7)
3. Develop a community of learners when my class consists of students from diverse backgrounds.	4.6 (1.0)	4.8 (0.9)	4.6 (1.0)	5.2 (1.1)	4.8 (0.9)	4.6 (1.1)	5.1 (0.7)	4.7 (1.1)	5.2 (0.9)
4. Use my students' cultural background to help make learning meaningful.	4.6 (0.8)	4.7 (0.8)	4.7 (0.9)	5.2 (0.8)	4.7 (0.9)	4.4 (0.9)	5.0 (0.8)	4.7 (1.1)	5.2 (0.9
5. Use my students' prior knowledge to help them make sense of new information.	4.7 (0.9)	4.7 (0.8)	4.7 (0.9)	5.2 (0.8)	4.8 (0.9)	4.5 (0.9)	5.1 (0.8)	4.7 (1.1)	5.2 (0.9)
6. Revise instructional material to include a better representation of cultural groups.	4.6 (0.9)	4.6 (0.8)	4.5 (1.1)	5.4 (0.9)	4.6 (1.0)	4.5 (1.1)	5.1 (0.9)	4.4 (1.1)	5.0 (0.8)
7. Critically examine the curriculum to determine whether it reinforces negative cultural stereotypes.	4.4 (0.9)	4.5 (0.9)	4.6 (1.1)	5.4 (0.9)	4.3 (1.0)	4.3 (1.0)	4.6 (1.0)	4.5 (1.2)	5.0 (1.0)
8. Use examples that are familiar to students from diverse cultural backgrounds.	4.6 (0.9)	4.6 (0.8)	4.6 (1.1)	5.2 (0.8)	4.5 (1.0)	4.5 (1.1)	4.8 (1.1)	4.6 (1.1)	5.0 (0.8)

Note. Immediate treatment group (pre n = 25, post n = 25, year 1 end n = 15, year 2 end = 4, year 3 end=3), control group (pre n = 39, post n = 23, year 1 end n = 14, year 2 end = 12). Each item scored 1-6. Cronbach's α pre = .96, Cronbach's α post = .96. Scale: 1= not at all confident, 6 = completely confident. Administration timepoints: [1]Pre: spring after randomization. [2]Post: after CodeVA Coaches academy. [3]Year 1 End (immediate treatment) and [3]Year 2 end (delayed treatment): end of academic year after coaches academy. [4]Year 2 End: end of year after microcredentials. [5]Year 1 end: end of control year.

Table 19. Culturally Responsive Teaching Frequency

	Immediate Treatment				Control/Delayed Treatment)				
Please indicate how often you do the following:	[1]Pre M (*SD*)	[2]Post M (*SD*)	[3]Year 1 End M (SD)	[4]Year 2 End M (SD)	[1]Pre M (*SD*)	[5]Year 1 End M (SD)	[2]Post M (SD)	[3]Year 2 End M (SD)	[3]Year 3 End M (SD)
1. Spend time outside of class learning about the cultures and languages of my students.	4.1 (0.6)	4.4 (0.6)	4.4 (0.6)	4.6 (0.9)	4.3 (0.9)	4.1 (0.9)	4.7 (0.9)	4.6 (0.8)	4.8 (0.6)
2. Make an effort to get to know my students' families and backgrounds.	5.1 (0.7)	5.0 (0.7)	5.1 (0.9)	5.0 (0.7)	5.1 (0.8)	5.2 (0.8)	5.5 (0.7)	5.0 (0.6)	5.5 (0.5)
3. Examine class materials for culturally appropriate images and themes.	5.0 (0.6)	4.8 (0.7)	5.1 (0.7)	4.8 (1.1)	4.9 (0.8)	4.9 (0.7)	5.1 (0.6)	4.9 (0.5)	5.1 (0.6)
4. Encourage students to use cross-cultural comparisons when analyzing material	4.6 (1.0)	4.5 (0.8)	4.5 (0.8)	4.8 (0.8)	4.5 (0.9)	4.5 (1.0)	5.0 (0.8)	4.5 (0.7)	5.0 (0.8)

Note. Immediate treatment group (pre n = 25, post n = 25, year 1 end n = 15, year 2 end = 4, year 3 end=7), control group (pre n = 39, post n = 23, year 1 end n = 14, year 2 end = 12). Cronbach's α pre = .76, Cronbach's α post = 77. Scale: 1 = never, 6 = always. Administration timepoints: [1]Pre: spring after randomization. [2]Post: after CodeVA Coaches academy. [3]Year 1 End (immediate treatment) and [3]Year 2 end (delayed treatment): end of academic year after coaches academy. [4]Year 2 End: end of year after microcredentials. [5]Year 1 end: end of control year.

RCT Cohort 2 Teacher Results

The documentation and evaluation of activities in this section represent a synthesis of the implementation data for ARCS that have been analyzed to date. These data were obtained through observations, document analysis, and surveys of participants.

Recruitment, Attrition, and Analytic Sample

Elementary teachers were recruited, started applications, and agreed to the informed consent for the ARCS program (n = 136). The ARCS program was advertised primarily via communication with division superintendents and central office staff as well as via Virginia Department of Education announcements. Of the 136 teachers from 54 schools who applied, 15 were from 6 schools that did not meet the criteria for participation in the RCT (did not have a 3rd, 4th, or 5th-grade teacher apply). Teachers from these schools were placed into a "non-RCT" group that began the PD during the summer of 2023 but were not randomized and are not included in the analytic sample. These teachers are excluded in subsequent sections of this report. Of the remaining 121 teachers from 48 schools, 24 schools (n = 60 teachers) were randomized into the immediate treatment condition and 23 schools (n = 61 teachers) were randomized into the control/delayed treatment condition (Table 20).

Table 20. Elementary RCT Cohort 2 Randomization and Retention Data

	Randomized		Completed Pre-Assessment		Completed Summer Institute			[1]Completed Microcredentials	
	Immediate treatment	Control/delayed treatment	Immediate treatment	Control/delayed treatment	Immediate treatment	Control/delayed treatment	Non-RCT	Immediate treatment	Control/delayed treatment
Schools	24	23	20	21	20	N/A	4 (6 applied)	N/A	N/A
Teachers	60	61	48	48	48	42	9 (15 applied)	2	--

Note. [1] 41 teachers are still enrolled in and working on the microcredentials during the 2024-25 school year (out of 43 who registered).

Rural teacher participation

Seventy-eight school divisions in Virginia meet the classification as "rural, distant," "rural, fringe," or "rural, remote" as identified by the Virginia Department of Education. Of the 25 divisions represented by ARCS participants in the RCT Cohort, 14 meet the "rural, distant," "rural, fringe," or "rural, remote" designations. A total of 40/106 (38%) teachers from rural designation districts are in the RCT Cohort (i.e., immediate treatment = 20, control/delayed treatment = 20).

Sample Demographics

Table 21 describes the demographic characteristics of the 96 elementary teachers included in the analtytic sample participating in ARCS Cohort 2 group (n = 48 immediate treatment, n = 48 control/delayed treatment). Table 22 describes their CS background. The mean years of teaching experience was: immediate treatment *M* = 15.2 (*SD* = 9.2), control/delayed treatment *M* = 15.5 (*SD* = 7.2), non-RCT *M* = 18.2 (*SD* = 7.4). These data are self-reported.

Table 21. Cohort 2 Demographics

	[1]Immediate treatment (n =48) n (%)	Control/delayed treatment (n =48) n (%)
Gender		
Male	1 (2.1%)	2 (4.2%)
Female	47 (97.9%)	44 (91.7%)
Race/Ethnicity		
White	39 (81.3%)	36 (78.3%)
Black	8 (16.7%)	9 (19.6%)
Asian	1 (2.1%)	0
Other	0	1 (2.1%)
Hispanic	0	1 (2.1%)

Note. [1]2 teachers in the control/delayed treatment group did not provide demographic data.

Table 22. Educational Background

	[1]Immediate treatment (n =48) n (%)	[2]Control/delayed treatment (n =48) n (%)
Has Ed Degree	48 (100%)	48 (100%)
Elementary	31 (72.1%)	31 (73.8%)
Secondary	1 (2.3%)	1 (2.4%)
[3]Other	11 (25.6%)	10 (23.8)
Has STEM Degree	7 (14.6)	5 (10.4%)

Note. [1] 5 teachers in the immediate treatment group, [2]6 teachers in the control/delayed treatment group did not provide information about their educational background. [3] Other degree includes education leadership, online learning, instructional technology, special education, and library science.

RCT Cohort 2 Implementation Results

This section describes implementation outcomes for year 5 of the ARCS 2024 CodeVA K-5 Coaches Academy for teachers in the RCT analytic sample randomized into the control/delayed treatment condition. This begins their delayed treatment period of the program.

Attendance

Table 23. ARCS K-5 Coaches Academy Daily Attendance

	Day 1 N	Day 2 n	Day 3 n	Day 4 N	Day 5 n
Summer 2024 (n = 42)	41	41	40	41	41

Implementation

Overall, the ARCS CODE VA K-5 Coaches Academy Summer PD appeared to be implemented as planned for the 2024 Summer (Cohort 2 delayed treatment) teachers. In addition, it appeared that in general, the 2024 ARCS CODE VA K-5 Coaches Academy Summer PD was consistent with prior Coaches Academies. For details of the ARCS Code VA K-5 Coaches Academy Summer PD, please see Maeng & McCoy, 2021. Consistent with prior years, teachers' perceptions of the PD were positive.

PD Perceptions

Table 24. Perceptions of the PD (Cohort 2 delayed treatment, n = 42)

How strongly do you agree or disagree with the following statements?	Strongly disagree (%)	Disagree (%)	Somewhat disagree (%)	Somewhat agree (%)	Agree (%)	Strongly Agree (%)
1. Communications regarding the ARCS/Code VA K-5 Coaches Academy were received in a timely manner	0	0	0	0	24	18
2. The ARCS/Code VA K-5 Coaches Academy objectives were clear to me.	0	1	0	4	19	18
3. The ARCS/Code VA K-5 Coaches Academy provided me with lesson plans that fit state standards.	1	2	9	0	14	16
4. The facilitators had adequate knowledge of the subject.	1	1	0	1	19	20
5. The facilitators created an atmosphere of trust and open communication.	0	0	0	1	18	23
6. I am satisfied with my interactions with the facilitators	0	1	0	1	18	22
7. As needed, the facilitators were available to answer questions and provide direction.	1	0	0	2	19	20

Table 24 con't. Perceptions of the PD (Cohort 2 delayed treatment, n = 42)

How strongly do you agree or disagree with the following statements?	Strongly disagree (%)	Disagree (%)	Somewhat disagree (%)	Somewhat agree (%)	Agree (%)	Strongly Agree (%)
8. I felt a rapport with other participants.	2	1	2	0	22	15
9. I am satisfied with my interactions with my peers.	2	0	0	1	24	15
10. I felt a part of a learning community.	1	0	0	4	21	16
11. I found the online format of the ARCS/Code VA K-5 Coaches Academy as effective as previous in-person PD I've attended.	1	1	3	5	14	18
12. The ARCS/Code VA K-5 Coaches Academy met my needs as a teacher-learner.	0	2	2	14	24	0
13. I would recommend the ARCS/Code VA K-5 Coaches Academy to other colleagues.	2	0	1	3	14	22
14. I will integrate what I learned … in my teaching.	0	1	0	1	17	23

Challenges

Delayed treatment/control participants' (n = 42) open-ended responses following the CodeVA K-5 Coaches Academy highlight several recurring challenges that teachers encounter when integrating computer science (CS) into their curricula. These challenges can be categorized as follows: lack of time (n = 47), lack of resources and technological support (n = 13), lack of training (n = 4), lack of CS content knowledge (n = 7), lack of confidence in teaching CS (n = 2), limited CS knowledge among students (n = 4), curriculum alignment and integration (n = 24), and lack of administrative support (n = 6). Participants could indicate more than one challenge.

The most significant challenge teachers face in integrating computer science into their curricula was **lack of time.** Many teachers noted that existing curriculum requirements and pacing guides make it difficult to add additional material, and that their time with students is often limited. This was exemplified by the following responses:

- *As the school librarian, I have other standards I'm required to teach throughout the year as well. Finding time to incorporate CS as well is tricky.*
- *I only have my students for about 50 minutes and between things that are required and our daily routine, there isn't much time for explanation and integration of computer science.*
- *We continue to additional things added to our plates, new standards, new students, and big behaviors. Integration is tricky when there is no time.*

Many teachers reported a **lack of resources and technological support**, such as up-to-date materials and devices, as a key challenge for CS integration*:*

- *The only challenge I face at times is having the necessary materials.*
- *Lack of Resources may be a problem.*

One teacher expressed the need for "*resources that align to VA standards and CS standards (intertwining them) already ready to teach,*" highlighting the desire for readily available and integrated curriculum materials.

Several teachers indicated the **need for more training** to build their CS knowledge and pedagogical skills on CS integration. One respondent wrote that:

- *There is a lack of training and a lack of time to train teachers on the knowledge and support them with CS SOL integration*.

Many teachers expressed **a lack of familiarity with CS concepts**, which makes them **feel unprepared and less confident in teaching CS**:

- *We have not began our course on Computer Science yet, so I still am not confident in teaching computer science SOLs.*
- *Many teachers are not familiar with computer science and are scared to try it.*

Several teachers noted that **students' varying levels of technological proficiency** and prior exposure to CS can create challenges. Some students may lack basic computer skills, which can hinder their ability to engage in CS activities effectively:

- *Accessibility and filling gaps for students who do not have as much experience.*
- *Challenges would possibly be differentiating based on student skills/abilities…*
- *However, many students are not able to type and are not even familiar with basic computer commands and it takes them a lot of time to type and debug. Our lessons were rushed and some students felt they did not do their best.*

Regarding to **curriculum alignment and integration**, many teachers found it difficult to align CS standards with existing curricula and find meaningful ways to integrate CS concepts into other subjects:

- *It is hard to find lessons that incorporate and reinforce concepts (SOLs) students learn in the classroom. I especially have difficulty at this time of the year (end) finding engaging lessons for them.*
- *The stand along computer science standards are challenging to teach because they don't easily lend themselves to be integrated in other subject areas.*
- *The biggest challenge is timing and making sure that it is integrated into our pacing for each subject (when applicable).*

Some teachers noted that a **lack of buy-in from administrators** can make it difficult to integrate computer science into the curriculum:

- *…Getting approval to use new programs and technologies from the school board (it is a lengthy process); finding a funding source to replenish technologies that were purchased with previous grant money…*
- *Our district lacks PD days, so computer science isn't a focus when mandates such as the science of reading are in place.*

Useful Components of the PD

Cohort 2 delayed treatment/control participants' (n = 41) open-ended responses of the most useful components of the ARCS CodeVA K-5 Coaches Academy were categorized and closely mirrored those articulated by Cohort 1 teachers at the same time point. These included: resources they received (n = 22), pedagogical knowledge about CS integration (n = 8), and engaging lessons on AI and cybersecurity (n = 7). Other responses (n = 10) are related to better understanding of CS content knowledge (n = 4), improved confidence and self-efficacy in teaching CS (n = 5), and collaboration and networking (n = 1). Participant responses could be coded into more than one category.

One recurring theme highlighted was **resources;** participants appreciated exposure to various teaching materials and tools available, such as lesson plans templates, activities, and online resources. They expressed appreciation for the easy accessibility and the practicality of integrating these resources into their lesson plans. As one participant wrote:

The most useful thing I learned in the ARCS PD was the plethora of resources available and how they could be integrated into instruction.

Another one similarly indicated:

It was useful to see the resources in action - this was a first-hand account of how to convey particular standards as well as how to utilize other available resources.

Regarding **pedagogical knowledge about CS** integration, participants found the process of integrating computer science into their instructional methods to be valuable. They appreciated the ease with which standards could be applied, thanks to the variety of options and built-in awareness. As one participant mentioned:

…I learned strategies to be able to help my co-workers to understand and implement CS into their curriculum…

Another similarly indicated:

It's not what I learned - it opened my eyes to the possibility of what could be done. You CAN teach CS and merge it with your curriculum.

Many teachers valued the **engaging lessons on AI and cybersecurity**, noting that these topics offered valuable insights for their personal interests and teaching. One participant wrote:

I learned about a variety of topics, but the one on cybersecurity, cyphers, and puzzles. I saw a way I could integrate this knowledge into the breakout puzzles I currently make and use.

Another one noted:

The different aspects of cybersecurity and teaching that in the classroom was engaging for me.

A few teachers commented that ARCS CodeVA K-5 Coaches Academy helped **enhance their understanding of CS content knowledge** and some indicated that they **felt more confident in integrating CS**. Participants reported gaining a deeper understanding of what computer science is. One participant wrote:

My understanding of what computer science is has deepened and broadened.

Another one noted:

I also learned that CS is more than just technology.

Several teachers reported **improved confidence in integrating CS**:

How to help classroom teachers understand that computer science isn't scary and it's things they are already doing.

How easy it was to integrate the CS SOL's and objectives.

One teacher appreciated the opportunity for **collaboration and networking**, valuing:

the chance to collaborate and learn with and from others

Additional Supports Needed

Open-ended responses from delayed treatment/control participants (n = 40) highlight the need of additional support in several areas (see Figure 2): more resources and lesson examples (n = 7), collaborative opportunities (n = 4), time allocation and management (n = 7), grade-level and subject-specific CS integration support (n = 5), support with technology integration (n = 2), coding knowledge (n = 1), and peer coaching strategies for CS Integration (n = 1). 17 out of 40 respondents indicated that they do not need additional support.

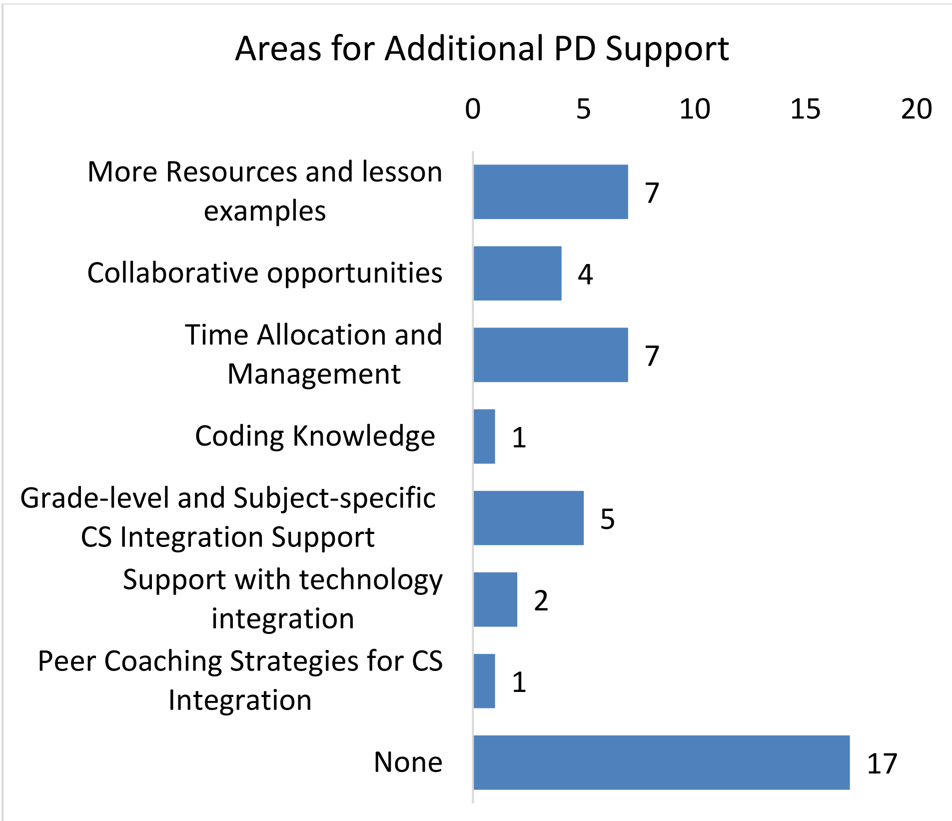

Figure 2. Topics for Future PD

Most of the participants' responses related to **resources** emphasized a need for instructional materials and ideas that can be readily applied to integrate CS. They expressed a need for **lesson examples** to serve as models for how CS instruction can be implemented in class. This was exemplified by the following responses:

- *I would have liked to have seen examples of how that concept being taught was integrated into the different subject matter.*
- *I would love more resources for promoting teacher by-in.*
- *More resources are always welcome!*
- *I think seeing exemplar lessons is definitely useful for everyone, including myself.*

Regarding the **need for collaborative opportunities**, responses suggested that working with other teachers on lesson planning and having opportunities to interact with peers for support would be valuable. Noteworthy comments reflecting these sentiments include:

- *Collaborative Planning Opportunities: Collaborating with colleagues who have also participated in the ARCS PD would allow me to share ideas, strategies, and resources for incorporating attention-grabbing, relevant, confidence-building, and satisfying elements into my lessons. Joint planning sessions could facilitate the development of engaging instructional activities.*
- *I love the community we are building within our school to help each other with computer science.*

Regarding the **time allocation and management**, many respondents expressed that they need more time to plan and implement what they learned in the lessons:

- *More time to fit it all into the day!*
- *I would love more time to go through all the resources that were provided.*

Related to the **grade-level and subject-specific CS integration support,** many respondents indicated that they need more support on how to effectively integrate CS into their curriculum across various subjects and grade levels:

- *Probably more lessons specifically aligned to the math, science, and social studies standards for VA.*
- *How to create meaningful lessons that incorporate core standards with CS standards*
- *Information needs to be more fitting to the grade level taught.*

Related to the ***support with technology integration***, respondents expressed a need for additional support on how to integrate CS instruction with technology:

- *I need more ways to allow first graders to interact with the actual devices and things like Indi.*
- *More training on Spheros.*

One respondent expressed a need for more lessons focused on **coding language fundamentals**:

- *I need the coaching to be less focused on finding resources and more focused on the actual coaching or at least a preprimary in coding languages*

Another respondent expressed a need for practical strategies to assist other teachers in integrating CS into their lessons:

I would love more ideas for way to coach other teachers on incorporating computer science into their lessons.

Recommendations

When asked for recommendations for modifications of the ARCS CodeVA K-5 Coaches academy, 23 of the 40 respondents (57.5%) from the delayed treatment/control condition indicated that they had no recommendations for improvement. The most common recommendations were related to organization and course structure (n = 10) and content (n = 8).

Participants suggested **structuring** the PD program to include both online and in-person sessions offered at multiple times, **organizing** teachers by grade level, and adjusting instruction to different levels based on their CS backgrounds. For example, many participants recommended scheduling both in-person and virtual classes at various times, allowing teachers flexibility in choosing sessions. These are some example comments:

- *The only recommendation I have is to offer more options for dates/times for the PDs.*
- *I think that having the classes online and available whenever would be helpful. As a single mom of 3 young kids it was a struggle to attend all of them.*

- *I understand the need for the additional 2 hour sessions but I always felt as if I was giving up a Saturday or I was not as attentive to the after school sessions.*

Several participants suggested offering PD lessons at varying levels based on teachers' grade levels and backgrounds in CS:

- *Maybe splitting the cohort into grade levels and share resources and how to incorporate computer SOLs with content SOLs.*
- Also if possible have different PD to choose from in case some teachers already know some of the CS information.
- *I wish there were some more challenging options for those who really want to beef up their knowledge.*

Regarding **content**, participants requested **additional resources, more example lessons, and further detailed guidance on integrating CS into core subjects across different grade levels**:

- *more templates or ready-made resources would be helpful*
- *Show different lessons and exactly HOW computer science was integrated and give other examples of lessons with the lesson plans that we can access.*
- *It would be helpful if there were more lessons plans/activities shared.*

Learning Bytes and Other CodeVA Online Resources

Of the 48 Cohort 2 immediate treatment teachers that completed the 2023 Summer Institute, 46 participated in the Learning Bytes sessions to some extent. 32 completed the required 4 learning bytes during the 2023-24 academic year, with another 11 attending three sessions, two attending two sessions, and one attending one learning bytes session. Additionally, 22 immediate treatment participants attended at least one “Keeping in Touch” session focused on instructional support for classroom educational technology resources they received through the program. Of the 34 immediate treatment teachers who responded to the year end survey, teachers indicated they received Spheros (n = 15), Indi (n = 15), and Bolts (n = 4) to use in their classrooms during the academic year. Twenty teachers indicated they attended an ARCS-sponsored session to learn to use the resources and most (85%) agreed or strongly agreed that they found these sessions both engaging and useful. Of the 34 teachers, 29 (85%) somewhat to strongly agreed that they used the resource in their CS instruction.

RCT Cohort 2 Teacher Results

Of participants, 41 immediate treatment participants completed both the pre- and post-assessment and were included in the analytic sample, 43 control participants completed the pre-assessment and were included in the analytic sample.

CS Content Knowledge

Results indicated significant improvement in immediate treatment teacher CS knowledge following participation in the Code VA K-5 Coaches Academy (pre/post PD), t (39) = 2.3, $p < .05$. Preliminary results of ANCOVA indicated no significant difference between immediate treatment teacher CS content knowledge ($p = .16$) at the end of the first year of ARCS (spring 2023) after controlling for pre-CS knowledge, race, gender, and prior CS PD.

Table 25. Teacher Content Knowledge Outcomes

Item	Immediate Treatment			Control/Delayed Treatment		
	[1] Pre-Year 1 M (*SD*)	[2] Post PD M (*SD*)	[2] Year 1 End PD M (*SD*)	[3] Pre-Year 1 M (*SD*)	[8] Post Year 1 M *(SD)*	Year 1 End PD M (*SD*)
1. What is computer science?	1.7 (0.6)	1.7 (0.5)	1.6 (0.8)	1.6 (0.5)	1.8 (0.8)	1.3 (0.6)
2. Describe what a computer programmer does.	1.9 (0.6)	2.1 (0.6)	2.3 (0.5)	2.0 (0.6)	2.5 (0.8)	2.1 (0.6)
3. What makes a device a computer?	1.5 (0.6)	1.5 (0.6)	1.6 (0.6)	1.3 (0.5)	1.7 (0.8)	1.6(0.7)
4. What is an algorithm?	2.1 (0.7)	2.6 (0.6)	2.1 (0.7)	2.3 (0.7)	2.7 (0.8)	1.7 (0.7)
5. In what ways is the term "variable" used differently in computer science than in math and science?	1.2 (0.4)	1.3 (0.5)	1.7 (0.8)	1.1 (0.4)	1.5 (0.7)	1.3 (0.6)

Note. Each item scored 1-3. [1] Immediate treatment pre n = 46, 2 Immediate treatment post n = 42, Year End n= 37 [3] Control pre n = 42. Control post n=42 Delayed treatment year end n=39. Each item scored 1-3. Scale: did not meet expectations = 1, partially met expectations = 2, met expectations = 3.

CS Pedagogical Knowledge

Pedagogical knowledge was measured through several scales with high reliability (Cronbach's $\alpha > .8$). Results indicated significant improvement in immediate treatment teacher experience in programming, participant experience teaching programming, and experience integrating CS SOLs from pre- to post-PD (p's $< .05$).

Table 26. Experience Programming

	Immediate Treatment			Control/Delayed Treatment		
Rate your experience:	Pre-Year 1 M (*SD*)	Post PD M (*SD*)	[2] Year 1 End PD M (*SD*)	Pre-Year 1 M (*SD*)	Post-Year 1 M *(SD*	Year-1 End PD M (*SD*)
Programming (any language)	2.5 (1.4)	3.3 (1.2)	3.5 (1.2)	2.7 (1.3)	3.3 (1.3)	3.0 (1.3)
Coding in a block language	3.3 (1.6)	3.7 (1.3)	4.3 (1.3)	3.3 (1.5)	2.9 (1.3)	3.8 (1.3)
Coding in a text-based language	1.9 (1.0)	2.5 (1.2)	2.8 (1.2)	1.9 (1.1)	2.5 (1.2)	2.1 (1.0)
Running an "Hour of Code" event	3.2 (1.7)	4.0 (1.6)	4.1 (1.5)	3.3 (1.6)	3.9 (1.3)	3.7 (1.4)

Note. Immediate treatment group (pre n = 48, post n = 43, year-end n=37), control/delayed treatment group (pre n = 44; post n=42, year-end n=39). Each item scored 1-6. Cronbach's α pre = 0.85, Cronbach's α post = 0.84. Scale: very inexperienced = 1, Very experienced = 6.

Table 27. Experience Integrating CS SOLs

	Immediate Treatment			Control/Delayed Treatment)		
Rate your experience with the following:	Pre-Year 1 M (*SD*)	Post PD M (*SD*)	Year 1 End PD M (SD)	Pre-Year 1 M (*SD*)	Post Year 1 End M (SD)	Year-1 End PD M (*SD*)
The Virginia Computer Science Standards	3.7 (1.3)	4.2 (1.3)	4.6 (1.0)	3.6 (1.2)	5.1 (0.7)	3.7 (1.5)
Algorithms and programming	2.8 (1.5)	4.1 (1.4)	4.4 (1.0)	2.9 (1.6)	4.8 (0.8))	3.2 (1.6)
Information about computer systems	3.0 (1.4)	4.1 (1.3)	4.4 (1.0)	2.8 (1.3)	4.8 (0.9)	3.1 (1.4)
Information about cybersecurity	3.3 (1.4)	4.3 (1.2)	4.4 (1.2)	3.0 (1.3)	4.8 (0.8)	3.2 (1.4)
Data and analysis	3.0 (1.4)	4.1 (1.3)	4.3 (1.1)	2.9 (1.4)	4.7 (0.8)	3.4 (1.4)
Information about the impacts of computing	3.0 (1.3)	4.2 (1.2)	4.6 (1.0)	3.0 (1.3)	4.8 (0.9)	3.3 (1.5)

Note. Immediate treatment group (pre n = 48, post n = 42, year-end n=37), control/delayed treatment group (pre n = 44, post n=42, year-end n=39.) Each item scored 1-6. Cronbach's α pre = .942, Cronbach's α post = 0.968. Scale: very inexperienced = 1, Very experienced = 6.

Table 28. Experience Teaching Programming

	Immediate Treatment			Control/Delayed Treatment)		
Rate your experience:	Pre Year 1 M (*SD*)	Post PD M (*SD*)	Year 1 End PD M (SD)	Pre Year 1 M (*SD*)	Post Year 1 End M (SD)	Year 1 End PD M (SD)
Teaching Programming (any language)	2.5 (1.5)	3.2 (1.4)	3.7 (1.2)	2.5 (1.4)	3.2 (1.3)	2.6 (1.2)
Teaching coding in a block language	3.2 (1.6)	3.6 (1.5)	4.4 (1.2)	3.2 (1.6)	3.8 (1.3)	3.5 (1.3)
Teaching coding in a text-based language	1.9 (1.1)	2.6 (1.2)	2.6 (1.3)	1.8 (1.0)	2.3 (1.2)	1.7 (1.06)

Note. Immediate treatment group (pre n = 48, post n = 43, year-end n= 37), control/delayed treatment group (pre n = 44; post n= 42, year-end n=39). Each item scored 1-6. Cronbach's α pre = 0.80, Cronbach's α post = 0.86. Scale: very inexperienced = 1, Very experienced = 6.

Table 29. Other Items Related to Pedagogical Knowledge

	Immediate Treatment			Control/Delayed Treatment)		
How strongly do you agree or disagree with the following statements?	Pre-Year 1 M (SD)	Post PD M (SD)	Year 1 End M (SD)	Pre-Year 1 M (SD)	Year 1 Post M (SD)	Year 1 End M (SD)
I understand what computer science is.	4.3 (1.0)	5.1 (0.6)	5.4 (0.6)	4.5 (1.0)	5.2 (0.5)	4.6 (0.9)
I am familiar with my school division's plan for computer science education at the K-5 level.	3.8 (1.4)	4.4 (1.3)	4.9 (1.1)	3.9 (1.3)	3.9 (1.1)	3.9 (1.3)
I can engage students from rural areas in computer science.	4.3 (1.2)	5.2 (0.7)	5.2 (0.8)	4.4 (1.2)	4.8 (0.7)	4.4 (1.2)
I can engage students from low socioeconomic backgrounds in computer science.	4.4 (1.2)	5.2 (0.7)	5.3 (0.7)	4.8 (1.0)	4.9 (0.7)	4.7 (0.9)
I can engage students who are traditionally underrepresented in STEM in computer science	4.4 (1.2)	5.2 (.7)	5.3 (0.7)	4.9 (1.0)	5.1 (0.6)	4.8 (0.9)
I can address issues of access to computer technologies for students in my school.	4.1 (1.3)	5.0 (1.0)	5.0 (0.8)	4.3 (1.2)	4.7 (0.8)	4.2 (1.0)

Note. Immediate treatment group (pre n = 48, post n = 43, year-end n=37), control/delayed treatment group (pre n = 44; post n=42; year-end n=39). Each item scored 1-6. Cronbach's α pre = 0.911, Cronbach's α post = 0.853. Scale: very inexperienced = 1, Very experienced = 6.

CS Self-efficacy and Confidence

CS self-efficacy and confidence were measured through several scales with high reliability (Cronbach's α > .8). Results indicated significant improvement in immediate treatment teacher self-efficacy for teaching CS, confidence programming, confidence teaching programming, and confidence integrating CS SOLs from pre- to post (all *p*'s < .05). Treatment teacher self-efficacy for teaching CS was significantly greater than that of control teachers, $p = .001$; $R^2 = .5$.

Table 30. Self-Efficacy Scale

	Immediate Treatment			Control/Delayed Treatment)		
How strongly do you agree or disagree with the following statements	Pre-Year 1 M (*SD*)	Post PD M (*SD*)	Year 1 End M (SD)	Pre-Year 1 M (*SD*)	Year 1 Post M (SD)	Year 1 End M (SD)
I feel confident using computer technology.	4.9 (1.1)	5.3 (0.7)	5.4 (0.6)	4.7 (1.2)	5.1 (0.6)	4.7 (1.1)
I know how to teach programming concepts effectively.	3.3 (1.4)	4.3 (1.3)	4.7 (1.0)	3.5 (1.5)	4.2 (0.9)	3.6 (1.4)
I feel confident writing simple programs for the computer.	2.9 (1.4)	3.8 (1.5)	4.2 (1.2)	3.0 (1.3)	3.4 (1.1)	2.9 (1.4)
I can promote a positive attitude toward programming in my students.	5.0 (1.1)	5.4 (0.5)	5.3(0.7)	5.0 (1.1)	5.2 (0.5)	4.9 (1.0)
I can guide students in using programming as a tool while we explore other topics.	4.0 (1.4)	4.7 (1.2)	4.7 (1.1)	4.1 (1.4)	4.7 (0.8)	4.0 (1.3)
I feel confident using programming as an instructional tool within my classroom.	3.7 (1.4)	4.6 (1.2)	4.8 (1.1)	3.8 (1.5)	4.5 (0.8)	3.9 (1.3)
I can adapt lesson plans incorporating programming as an instructional tool.	4.0 (1.3)	4.7 (1.1)	4.8 (0.9)	4.0 (1.4)	4.7 (0.6)	4.1 (1.1)
I can create original lesson plans incorporating programming as an instructional tool.	3.7 (1.4)	4.7 (1.1)	4.8 (1.1)	4.0 (1.5)	4.6 (0.7)	4.0 (1.2)
I can identify how programming concepts relate to the Virginia Standards of Learning.	4.0 (1.3)	5.0 (1.0)	5.0 (0.8)	4.2 (1.3)	5.0 (0.5)	4.1 (1.1)

Note. Immediate treatment group (pre n = 48, post n = 43; year-end n=37), control/delayed treatment group (pre n = 44, post n=42, year-end n= 39). Each item scored 1-6. Cronbach's α pre = 0.93, Cronbach's α post = 0.93. Scale: very inexperienced = 1, Very experienced = 6.

Table 31. Confidence Programming

	Immediate Treatment			Control/Delayed Treatment)		
Rate your confidence with the following:	Pre-Year 1 M (*SD*)	Post PD M (*SD*)	Year 1 End M (SD)	Pre-Year 1 M (*SD*)	Year 1 Post M (SD)	Year 1 End M (SD)
Programming (any language)	2.7 (1.2)	3.7 (1.0)	3.7 (1.0)	2.6 (1.2)	3.6 (1.0)	2.8 (1.3)
Coding in a block language	3.4 (1.4)	4.2 (1.2)	4.5 (1.1)	3.3 (1.5)	4.1 (1.1)	3.7(1.3)
Coding in a text-based language	2.1 (1.1)	2.9 (1.2)	3.0 (1.2)	1.8 (1.0)	2.7 (1.1)	2.0 (1.1)
Running an “Hour of Code” event	3.6 (1.8)	4.5 (1.4)	4.6 (1.3)	3.7 (1.6)	4.6 (0.9)	3.2 (1.5)

Note. Immediate treatment group (pre n = 48, post n = 43, year-end n= 37), control/delayed treatment group (pre n = 44, post n=42, year-end n= 39). Each item scored 1-6. Max possible mean scale score is 24, min possible mean score is 4. Cronbach’s α pre = .89, Cronbach’s α post = .80. Scale: 1 = not at all confident, 6 = very confident.

Table 32. Confidence Teaching Programming

	Immediate Treatment			Control/Delayed Treatment)		
Rate your confidence with the following:	Pre-Year 1 M (*SD*)	Post PD M (*SD*)	Year 1 End M (SD)	Pre-Year 1 M (*SD*)	Year 1 Post M (SD)	Year 1 End M (SD)
Teaching Programming (any language)	2.7 (1.3)	3.7 (1.1)	3.6 (1.1)	2.6 (1.3)	3.5 (1.1)	2.8 (1.2)
Teaching coding in a block language	3.4 (1.6)	4.0 (1.3)	4.4 (1.2)	3.3 (1.6)	4.1 (1.1)	3.8 (1.3)
Teaching coding in a text-based language	2.1 (1.1)	2.7 (1.2)	3.0 (1.2)	1.9 (1.1)	2.7 (1.1)	2.0 (1.0)

Note. Immediate treatment group (pre n = 48, post n = 43; year-end n= 37), control/delayed treatment group (pre n = 44 post n=42, year-end n= 39). Each item scored 1-6. Cronbach’s α pre = .89, Cronbach’s α post = .81. Scale: 1 = not at all confident, 6 = very confident.

Table 33. Confidence Integrating CS SOLs

	Immediate Treatment			Control/Delayed Treatment)		
Rate your confidence integrating the following into your K-12 instruction:	Pre Year 1 M (*SD*)	Post PD M (*SD*)	Year 1 End M (SD)	Pre Year 1 M (*SD*)	Year 1 Post M (SD)	Year 1 End M (SD)
The Virginia Computer Science Standards	4.0 (1.3)	5.0 (0.7)	5.0 (0.8)	4.0 (1.2)	5.1 (0.7)	3.7 (1.5)
Algorithms and programming	3.2 (1.4)	4.6 (0.9)	4.8 (0.9)	3.3 (1.6)	4.8 (0.8)	3.2 (1.6)
Information about computer systems	3.6 (1.2)	4.6 (0.7)	4.7 (1.0)	3.2 (1.5)	4.8 (0.9)	3.1 (1.4)
Information about cybersecurity	3.7 (1.2)	4.9 (0.7)	4.9 (1.0)	3.3 (1.4)	4.8 (0.8)	3.2 (1.4)
Data and analysis	3.7 (1.2)	4.7 (0.8)	4.7 (1.0)	3.2 (1.5)	4.7 (0.8)	3.4 (1.4)
Information about the impacts of computing	3.7 (1.3)	4.8 (0.8)	4.8 (1.1)	3.4 (1.4)	4.8 (0.9)	3.3 (1.5)

Note. Immediate treatment group (pre n = 48, post n = 43, year-end n=37), control/delayed treatment group (pre n = 44; post n= 42, year-end n=39). Each item scored 1-6. Cronbach's α pre = .94, Cronbach's α post = .93. Scale: 1 = not at all confident, 6 = very confident.

Culturally Responsive Teaching

Culturally responsive teaching confidence and frequency were measured with high reliability (Cronbach's $\alpha > .8$). Results indicated no change in immediate treatment teacher confidence for culturally responsive teaching from pre- to post-PD, t (24) = 2.7, p = .63.

Table 34. Culturally Responsive Teaching Confidence

	Immediate Treatment			Control/Delayed Treatment)		
Please indicate how confident you are that you can:	Pre Year 1 M (*SD*)	Post PD M (*SD*)	Year 1 End M (SD)	Pre Year 1 M (*SD*)	Year 1 Post M (SD)	Year 1 End M (SD)
Identify ways that the school culture is different from my students' home culture.	4.1 (1.1)	4.4 (1.0)	4.4 (1.1)	4.1 (0.8)	4.5 (1.0)	4.1 (1.0)
Implement strategies to minimize the effects of any mismatch between my students' home culture and the school culture.	3.9 (1.0)	4.2 (1.1)	4.3 (1.1)	3.9 (0.9)	4.2 (1.1)	3.8 (0.9)
Develop a community of learners when my class consists of students from diverse backgrounds.	4.5 (1.0)	4.7 (0.9)	4.7 (0.9)	4.6 (0.8)	4.8 (0.9)	4.4 (1.0)
Use my students' cultural background to help make learning meaningful.	4.5 (0.9)	4.9 (0.9)	4.5 (1.0)	4.3 (0.9)	4.7 (0.8)	4.2 (1.0)
Use my students' prior knowledge to help them make sense of new information.	4.5 (1.0)	4.7 (0.9)	4.8 (1.0)	4.4 (0.8)	4.8 (0.7)	4.5 (0.9)
Revise instructional material to include a better representation of cultural groups.	4.3 (0.9)	4.5 (1.0)	4.6 (1.0)	4.3 (0.8)	4.6 (0.9)	4.2 (1.0)
Critically examine the curriculum to determine whether it reinforces negative cultural stereotypes.	4.1 (1.0)	4.6 (1.0)	4.4 (1.0)	4.1 (1.0)	4.5 (0.9)	4.0 (1.1)
Use examples that are familiar to students from diverse cultural backgrounds.	4.2 (1.0)	4.6 (1.0)	4.4 (1.0)	4.1 (1.0)	4.6 (0.9)	4.3 (1.0)
Sum of 8 items above (max 48)	34.1	36.7	35.1	33.8	36.7	33.5

Note. Immediate treatment group (pre n = 47, post n = 43, year-end n=37), control/delayed treatment group (pre n = 42; post n= 42, year-end n=38). Each item scored 1-6. Cronbach's α pre = .96, Cronbach's α post = .96. Scale: 1= not at all confident, 6 = completely confident.

Table 35. Culturally Responsive Teaching Frequency

Please indicate how often you do the following:	Group	Never (%)	Very Rarely (%)	Rarely (%)	Occasionally (%)	Frequently (%)	Always (%)
Spend time outside of class learning about the cultures and languages of my students.	Pre-Year 1 Immediate treatment	2.1	6.4	8.5	51.1	31.9	0
	Post PD Immediate treatment	0	2.1	7.0	53.5	34.9	2.3
	Year 1 End Immediate treatment	1.8	3.5	3.5	33.3	19.3	3.5
	Pre-Year 1 Control	0	7.1	14.3	47.6	31.0	0
	Post-Year 1 Control	2.4	4.8	7.1	47.6	33.3	4.8
	Year 1 End Delayed treatment		1.8	12.5	33.9	14.3	5.4
Make an effort to get to know my students' families and backgrounds.	Pre-Year 1 Immediate treatment	0	4.3	0	29.8	34.0	31.9
	Post PD Immediate treatment	0	2.3	0	23.3	48.8	25.6
	Year 1 End Immediate treatment	0	1.8	0	8.8	26.3	28.1
	Pre Year 1 Control	0	2.4	2.4	21.4	50.0	23.8
	Post-Year 1 Control	2.4	0	2.4	19.0	47.6	28.6
	Year 1 End Delayed treatment	0	1.8	1.8	19.6	32.1	12.5
Examine class materials for culturally appropriate images and themes.	Pre-Year 1 Immediate treatment	2.1	2.1	6.4	27.7	46.8	4.9
	Post PD Immediate treatment	0	2.3	0	18.6	60.5	18.6
	Year 1 End Immediate treatment	0	1.8	1.8	14.0	28.1	19.3
	Pre-Year 1 Control	0	0	11.9	21.4	47.6	19.0
	Post-Year 1 Control	0	0	0	35.7	45.2	19
	Year 1 End	0	0	0	28.6	32.1	7.1

	Delayed treatment						
Encourage students to use cross-cultural comparisons when analyzing material	Pre-Year 1 Immediate treatment	6.4	4.3	14.9	42.6	23.4	8.5
	Post PD Immediate treatment	0	2.3	9.3	44.2	30.2	4.0
	Year 1 End Immediate treatment	0	1.8	1.8	22.8	26.3	12.3
	Pre-Year 1 Control	2.4	2.4	26.2	35.7	26.2	7.1
	Post-Year 1 Control	2.4	2.4	2.4	33.3	47.6	11.9
	Year 1 End Delayed treatment	1.8	0	7.1	37.5	16.1	5.4

Note**.** Immediate treatment group (pre n = 47, post n = 43, year-end n=37), control/delayed treatment group (pre n = 42, post n= 42, and year end n= 38). Cronbach's α pre = .76, Cronbach's α post = 77. Scale: 1 = never, 6 = always.

Cohort 2 Student Outcomes

The CKACKS pre-assessment was administered to students between August 3, 2023 and October 29, 2023 based on the school start date. The CKACKS post-assessment was administered to students between March 15 and May 15, 2024. Students took the assessment during class time or at home. Completion rates for CKACS components are shown in Table 36.

Table 36. Student Assessment

Condition	School Identifier	Target Grade	[1] Number Enrolled in Target Grade	Pre Number Completed Knowledge and Affective Items	Post Number Completed Knowledge and Affective Items
Immediate treatment (n =19)	Sanville	5	35	34	30
	Rich Valley	3	17	13	11
	Courthouse Road	5	133	108	64
	Ferrum	5	97	84	81
	Simonsdale	3	82	65	51
	Snow Creek	4	32	33	32
	Albert Harris	5	70	38	41
	Madison	4	84	13	33
	Powhatan	4	63	51	50
	Sinai	3	25	24	22
	Waterman	4, 5	94	73	69
	Dinwiddie	4	68	41	41
	Achilles	3	71	60	69
	Bethel	5	74	58	39
	Forrest	3	59	76	94
	Botetourt	5	99	66	76
	Chesterfield Academy	5	36	7	10
	Brighton	3	60	45	41
	Victory	3	80	63	70
	Total	--	1279	914	924

Table 36. Student Assessment (con't)

Condition	School Identifier	Target Grade	[1] Number Enrolled in Target Grade	Pre Number Completed Knowledge and Affective Items	Post Number Completed Knowledge and Affective Items
Control/delayed treatment (n = 18)	Norton	3	66	20	42
	Potomac	5	94	2	50
	Grafton Village	5	139	144	128
	TC McSwain	4	73	48	39
	Troutville	3	40	38	31
	Flatwoods	3	49	39	15
	Elydale	5	47	32	36
	Armel	3	122	63	64
	Richmond County	3	94	95	87
	Meadow View	5	107	102	70
	Henrico Virtual	4	66	1	22
	Lakeside	4	49	40	45
	Barack Obama	3	50	34	42
	Middlesex	3	91	88	75
	Westover Hills	3	48	3	18
	Oceanair	4	72	51	52
	Mary Peake	3	54	42	24
	Waterview	3	91	26	57
	Total	--	1352	868	897

Note. [1] From 2022-23 VDOE fall membership.

CS Knowledge Outcomes

Overall student pre- and post-content knowledge scores for immediate treatment and control students are reported in table 37. Although this is not a matched sample, scores indicate improvement across both groups. The immediate treatment group's overall content knowledge scores rose from 12.1 to 15.0.

Table 37. Content knowledge scores

	Time	Immediate treatment M (SD)	Delayed treat-ment/Control M (SD)
Computing Systems and Impacts of Computing [1]	Pre	6.2 (1.3)	6.2 (1.3)
	Post	7.6 (1.6)	7.0 (1.5)
Data Analysis [2]	Pre	4.8 (1.9)	4.7 (2.0)
	Post	6.1 (1.3)	5.9 (1.4)
Cybersecurity [3]	Pre	1.1 (.31)	1.1 (.30)
	Post	1.2 (.51)	1.2 (.43)
Overall Content Knowledge[4]	**Pre**	**12.1 (2.9)**	**11.9 (3.0)**
	Post	**15.0 (2.5)**	**14.1 (2.4)**

Note. [1] Computing Systems and Impacts of Computing: 4 items, max score: 12; [2] Data Analysis: 3 items, max score: 9; [3] Cybersecurity: 1 item, max score: 3; [4] Overall content knowledge: 8 items, max score: 24.

CS Affective Outcomes

Below we provide outcomes for CS Affect (interest, confidence, utility) for students in immediate treatment and control teacher classrooms. Overall affective scores for students in treatment teachers' classrooms increased from *M* = 38.6 to *M* = 41 (Table 38).

Table 38. CS Affective Scores

	Time	Immediate treatment M (SD)	Delayed treatment/Control M (SD)
Confidence [1]	Pre	15.0 (4.0)	15.7 (4.3)
	Post	16.6 (3.8)	16.2 (4.1)
Interest [2]	Pre	12.8 (3.6)	13.2 (4.0)
	Post	13.1 (3.9)	12.9 (3.9)
Utility [3]	Pre	10.8 (3.0)	11.0 (3.2)
	Post	11.3 (2.9)	11.1 (2.9)
Overall Affect [4]	**Pre**	**38.6 (9.1)**	**39.8 (10.0)**
	Post	**41.0 (9.2)**	**40.2 (9.5)**

Note. [1] Confidence: 6 items, max score: 24; [2] Interest: 5 items, max score: 20; [3] Utility: 4 items, max score: 16; [4] Overall affect: 15 items, max score: 60.

Classroom Integration

Frequency of CS-integrated Instruction

Seventy-eight teachers completed the fall CS-integration survey (36 treatment, 35 control, 7 non-RCT) and 79 completed the year end CS-integration survey (35 treatment, 37 control, 7 non-RCT). On the fall CS-integration survey, teachers were asked about their integration between the beginning of the year and Thanksgiving. On the year-end CS-integration survey, teachers were asked about their integration from after Thanksgiving break through May.

Of teachers completing one or both surveys 89% of treatment teachers and 78% of control teachers indicated they taught at least one lesson that explicitly targeted CS Standards at some point during the 2023-24 academic year. Across conditions, teachers who reported teaching at least one CS-integrated lesson were asked to respond about the frequency with which they integrated CS topics (Tables 38 and 39).

Table 38. Frequency of CS-Integrated Instruction (Fall 2023)

SOL Strand	[1]Condition	None (% of teachers)	1-2 Lessons (% of teachers)	3-4 Lessons (% of teachers)	5 or more Lessons (% of teachers)
Algorithms and Programming	Treatment	6.9	55.2	20.7	17.2
	Control	11.1	61.1	16.7	11.1
	Non-RCT	0.0	60.0	20.0	20.0
Computing systems	Treatment	18.8	31.3	6.3	6.9
	Control	27.8	66.7	5.6	0.0
	Non-RCT	60.0	40.0	0.0	0.0
Cybersecurity	Treatment	37.9	41.4	20.7	0.0
	Control	44.4	50.0	5.6	0.0
	Non-RCT	80.0	20.0	0.0	0.0
Data and Analysis	Treatment	51.7	34.5	13.8	0.0
	Control	44.4	50.0	5.6	0.0
	Non-RCT	40.0	40.0	20.0	0.0
Impacts of Computing	Treatment	34.5	55.2	10.3	0.0
	Control	50.0	38.9	11.1	0.0
	Non-RCT	60.0	40.0	0.0	0.0
Networking and the Internet	Treatment	27.6	58.6	13.8	0.0
	Control	55.6	38.9	5.6	0.0
	Non-RCT	80.0	0.0	20.0	0.0

Note. [1] treatment n = 29, control n = 18, non-RCT n = 5

Table 39. Frequency of CS-Integrated Instruction (Spring 2024)

SOL Strand	[1] Condition	None (% of teachers)	1-2 Lessons (% of teachers)	3-4 Lessons (% of teachers)	5+ Lessons (% of teachers)
Algorithms and Programming	Treatment	3.6	32.1	42.9	21.4
	Control	5.0	75.0	15.0	5.0
	Non-RCT	0	66.7	16.7	16.7
Computing systems	Treatment	21.4	50.0	21.4	7.1
	Control	50.0	45.0	0	5.0
	Non-RCT	50.0	50.0	0	0
Cybersecurity	Treatment	28.6	42.9	25.0	3.6
	Control	40.0	60.0	0	0
	Non-RCT	33.3	33.3	16.7	16.7
Data and Analysis	Treatment	28.6	39.3	28.6	3.6
	Control	45.0	40.0	5.0	10.0
	Non-RCT	16.7	66.7	16.7	0
Impacts of Computing	Treatment	21.4	53.6	17.9	7.1
	Control	45.0	50.0	0	5.0
	Non-RCT	66.7	16.7	16.7	0
Networking and the Internet	Treatment	28.6	46.4	21.4	3.6
	Control	65.0	25.0	10.0	0
	Non-RCT	83.3	0	16.7	0

Note. [1] treatment n = 28, delayed treatment/control n = 20, non-RCT n = 6

Teachers who indicated they did not integrate lessons that explicitly targeted CS SOLs into instruction were asked to explain why. These teachers (7 treatment, 17 control, 2 non-RCT in the fall; 7 treatment, 17 control, 1 non-RCT in the spring) indicated that they did not teach lessons incorporating CS because of lack of CS content and pedagogical knowledge, competing priorities, time constraints, role limitations, difficulty aligning CS with their curricula, and/or shifted emphasis due to testing or administration. These themes were consistent across survey administrations.

Representative teacher responses about **time constraints** included**:**

- *Time restraints with other SOL focused lessons and implementation of other new programs.* [Treatment, Fall]
- *Time restraint is the only reason. Although I implemented part of the standards I couldn't explicitly teach them.* [Control, Fall]
- *Time and trying to teach other standards, and behaviors* (Treatment, Spring)
- *I am not a full-time classroom teacher and not in the building every day. It was challenging to find the time* (Treatment, Spring)
- *First grade computer science SOL are limited or time available in their schedule to teach it (Treatment, Spring)*

Representative teacher responses about **competing priorities** included**:**

- *Pulled for other responsibilities*. [Treatment, Fall]
- *Much of my time/ lessons were spent on behaviors, procedures, and library/literacy basics. I planned to implement the CS lessons in the spring months when my curriculum is less vigorous. I also needed more time to update my plans!* [Treatment, Fall]
- *Focused on the Math Standards of Learning objectives and assessments* (Control, Spring)
- *It has not been an emphasis, given our state's work in revising English and mathematics standards. (*Control, Spring)
- *We have new administration that focused so much on reading skills that time was allotted for that instead of computer science (*Control, Spring)
- *Focused primarily on Core Curriculum in preparation for district assessments, benchmarks, simulations, and SOL's (*Treatment, Spring)

Representative teacher responses about **lack of CS content and pedagogical knowledge:**

- *I'm in the late start group. I did do some google slides lessons, but nothing explicitly CS.* [Control, Fall]
- *I am still not familiar with implementing CS into the curriculum. My group is in the delayed start.* [Control, Fall]
- *Still learning how to implement CS SOLs in a Science driven class.* [Control, Fall]
- *I do not understand the CS* (Control, Spring)
- *I had no idea where to start (*Control, Spring)
- *Although my lessons include CS standards, I'm not very good at explicitly recognizing them or pointing them out to students. Definitely something I need to get better at."* (Control, Spring)

Representative teacher responses about **difficulty in aligning CS with their curricula:**

- *They do not fall in my library curriculum.* [Treatment, Fall]
- *There was no room in our pacing guide.* [Control, Fall]
- *While I did use some CS activities, they were more focused on the subject of science rather than the CS itself (Control, Spring)*

Representative teacher responses about shifted emphasis due to **testing or administration**

- *Shift focus for data purposes* (Control, Spring)
- *SOL's, other testing, and preparation (*Treatment, Spring)

Perceptions of Student Engagement in CS Lessons

For the fall administration, most treatment teachers (91.3 %) indicated that their students were more engaged in CS now than at the beginning of the school year (strongly to somewhat agreed). This contrasts with the 68.6% of control teachers that indicated that their students were more engaged in CS now than at the beginning of the school year (strongly to somewhat agreed, Table 40). For spring administration 88.6% of treatment teachers indicated that their students were more engaged in CS now than at the beginning of the school year (strongly to somewhat agreed). In comparison 77.9% of control teachers endorsed increased engagement (Table 41).

Table 40. Teacher perceptions of student engagement in CS (Fall 2023)

Condition	Strongly agree (% of teachers)	Agree (% of teachers)	Somewhat agree (% of teachers)	Somewhat disagree (% of teachers)	Disagree (% of teachers)	Strongly disagree (% of teachers)
Treatment (n = 34)	17.6	44.1	29.4	2.9	2.9	2.9
Control (n = 35)	5.7	31.4	31.4	14.3	17.1	0.0
Non-RCT (n = 7)	14.3	71.4	14.3	0.0	0.0	0.0

Table 41. Teacher perceptions of student engagement in CS (Spring 2024)

Condition	Strongly agree (% of teachers)	Agree (% of teachers)	Somewhat agree (% of teachers)	Somewhat disagree (% of teachers)	Disagree (% of teachers)	Strongly disagree (% of teachers)
Treatment (n = 35)	28.6	42.9	17.1	5.7	2.9	2.9
Control (n = 36)	5.6	30.6	41.7	8.3	13.9	0
Non-RCT (n = 7)	14.3	71.4	14.3	0	0	0

Perceptions of Student Engagement during CS-SOL strand-related lessons

Generally, for both fall and spring administrations, treatment teachers reported that students were most engaged in lessons about algorithms and programming (69.2% in the fall and 55.6% in the spring, Tables 42 and 43).

Table 42. Teacher Perceptions of Student Engagement during CS SOL Strand Lessons (Fall 2023)

SOL Strand	Condition	Not at all engaged (% of teachers)	Slightly engaged (% of teachers)	Moderately engaged (% of teachers)	Highly engaged (% of teachers)
Algorithms and Programming (n = 47)	Treatment (n=26)	0	3.8	26.9	69.2
	Control (n=16)	6.3	12.5	12.5	68.8
	Non-RCT (n=5)	0.0	0.0	40.0	60.0
Computing systems (n= 34)	Treatment (n=19)	5.3	26.3	63.2	5.3
	Control (n=13)	0.0	46.2	46.2	7.7
	Non-RCT (n=2)	0.0	0.0	50.0	50.0
Cybersecurity (n= 29)	Treatment (n=18)	0.0	38.9	44.4	16.7
	Control (n=10)	10.0	10.0	60.0	20.0
	Non-RCT (n=1)	0.0	0.0	100.0	0.0
Data and Analysis (n= 27)	Treatment (n=14)	0.0	42.9	35.7	21.4
	Control (n=10)	0.0	40.0	40.0	20.0
	Non-RCT (n=3)	0.0	0.0	66.7	33.3
Impacts of Computing (n= 30)	Treatment (n=19)	5.3	36.8	36.8	21.1
	Control (n=9)	11.1	33.3	44.4	11.1
	Non-RCT (n=2)	0.0	50.0	50.0	0.0
Networking and the Internet (n= 30)	Treatment (n=21)	9.5	28.6	23.8	38.1
	Control (n=8)	12.5	50.0	25.0	12.5
	Non-RCT (n=1)	0.0	0.0	0.0	100.0

Note. Teacher n varies for each CS strand varies because only teachers who reported that they taught a lesson in that strand were asked about student engagement for that strand.

Table 43. Teacher Perceptions of Student Engagement during CS SOL Strand Lessons (Spring 2024)

SOL Strand	Condition	Not at all engaged (% of teachers)	Slightly engaged (% of teachers)	Moderately engaged (% of teachers)	Highly engaged (% of teachers)
Algorithms and Programming (n=51)	Treatment (n = 27)	0	16.7	27.8	55.6
	Control (n = 18)	0	11.1	29.6	59.3
	Non-RCT (n = 6)	0	0	50	50
Computing systems (n=34)	Treatment (n=22)	0	18.2	59.1	22.7
	Control (n=9)	11.1	33.3	44.4	11.1
	Non-RCT (n=3)	0	0	33.3	66.7
Cybersecurity (n= 35)	Treatment (n=20)	0	25.0	50.0	25.0
	Control (n=11)	18.2	36.4	27.3	18.2
	Non-RCT (n=4)	0	0	50.0	50.0
Data and Analysis (n=18)	Treatment (n=8)	25.0	50.0	25.0	0
	Control (n=9)	33.3	44.4	22.2	0
	Non-RCT (n=1)	100	0	0	0
Impacts of Computing (n=34)	Treatment (n=22)	40.9	0	36.4	22.7
	Control (n=10)	0	30.0	50.0	20.0
	Non-RCT (n=2)	0	0	50.0	50.0
Networking and the Internet (n=27)	Treatment (n=20)	15.0	0	65.0	20.0
	Control (n=6)	0	50.0	33.3	16.7
	Non-RCT (n=1)	0	0	0	100

Teachers were also asked to describe the CS-related activities that they perceived to be engaging and/or effective for their students. Teachers' responses indicated that **programming with technology**, **unplugged activities**, **hands-on learning of data**, **using everyday examples** were effective in engaging students.

Representative teacher responses about **programming with technology:**

- *Use of devices with algorithms and programming.* [Treatment, Fall]
- *Students were asked to use Scratch to demonstrate a portion of a story that repeated multiple times. After coding it without a loop, they were introduced to loops to show how much easier the process will be. They repeated the task using the loop. Now they want to create loops for everything! They have also used Ozobots to demonstrate rotation and revolution with the planets, moon, and sun, which was extremely engaging.* [Treatment, Fall]
- *Coding is their favorite. Some of the students did coding with Scratch while others did code.org.* [Treatment, Fall]
- *My fifth graders are using Dash robots (block coding). They created algorithms and debugged their lines of code. My kindergarteners identify different types of hardware by playing Kahoot!* [Treatment, Fall]
- *I have a class set of MicroBits and my 5th graders created digital name tags, use the input buttons to create music. My K-2 students engaged in block coding using Oslo Coding (Treatment, Spring)*
- *Sphero programming activities, especially the LED matrix on the Bolts, was engaging. I've been trying to incorporate Reading skills more.* [Control, Fall]
- *We build skateparks out of cardboard and used block-based coding with Sphero's to go through the skatepark (Control, Spring)*

Representative teacher responses about **unplugged activities:**

- *Some second-grade students needed help understanding ordinal positions. Students placed self-selected items on a map with grid lines. The students selected the space to identify the item in a particular position by choosing the number from a pile of cards numbered 0 - 9. Sphero was then used to navigate to the item in the ordinal position the student selected from the cards.* [Treatment, Fall]
- *We started with an unplugged lesson on the steps to sharpen a pencil, they loved when they walked me into a wall or out the door due to bugs in their algorithms. We then went to Code.org and began lessons on this site. We also did a few lessons on a program called Neptune Navigate. I also went over everything in the lesson before II had them complete these lessons, and then followed up with a recap and Q&A time.* [Control, Fall]
- *The unplugged to plugged lessons are helpful for the younger grades (Treatment, Spring)*
- *Unplugged coding mazes and then moving to using the beebots - many content standards can be used with this format. I have done many lessons with this format including story sequence, math facts, life cycles, various content vocabulary, cause and effect, problem and solution, and math story problems. (Non-RCT, Spring)*

Representative teacher responses about **hands-on learning data analysis:**

- *One lesson that I did with third grade was involving data and analysis. They had to take data that was given and count the number of different bird species. They created a Google Sheet with* *their data and then created a bar chart to analyze and answer questions.* [Treatment, Fall]

- *The students seemed to be mostly engaged when creating data from the labs. They grasped the concept of creating the appropriate graph and were able to analyze the data quicker using the graphs.* [Control, Fall]

Representative teacher responses about **using everyday examples:**

- *Lessons that the students feel apply to their everyday lives keep them engaged the most. I showed clips of the kinds of videos they might watch on social media in one lesson, and every student had something to contribute to our discussion.* [Treatment, Fall]
- *I like sharing stories that model the ideas of programming/ step-by-step that can relate to the future processes and goals of coding activities. I share stories like Gabi's If/Then Garden or Ava in Codeland to help them see the concepts they will be using and we worked together as a class on the interactive aspects in the books. This helps prepare them when we do a group coding activity.* [Control, Fall]
- *When teaching impacts of computing and cybersecurity, it was easy to engage the students when talking about their own experiences online. They love to talk about what they do online, and easily make connections between their experiences and what I am teaching. (Treatment, Spring)*

Project Dissemination

Presentations

Adams, A., Belcher, A., Burton, C., Chappell Moots, S., Courey, S., Herrick, K., Jensess, S., Littlebear, J., Mix, K., Nimer, J., & Schaefer, V. (November, 2023). *Raising rural: Rural educators' learning as the pathway to improved student outcomes.* Panel presentation at the annual National Forum to Advance Rural Education, Chattanooga, TN.

Boulay, B., Martin, R., Terry, K., Lee, J., O'Connor, A., Chappell Moots, S. & Maeng, J. (October, 2022). *Challenges of evaluation in rural schools*. Multi-project presentation (invited) at the annual EIR Project Directors Meeting, Virtual.

Brobst, J., Maeng, J., & Garner, J. (April, 2021). *Variations in Rural Elementary Teachers' Confidence and Experience with Computer Science Integration by Teacher Type*. A paper for the NARST Annual International Conference, Virtual.

Chappell Moots, S. (November, 2023). *Strategies for success! Conducting federal-level evaluations in rural settings.* Poster at the annual National Forum to Advance Rural Education, Chattanooga, TN.

Chappell Moots, S., Garner, J.K., Brobst, J. & Tennessee, K. (April, 2023). *Professional development through microcredentials: Building teacher capacity to integrate computer science in rural settings.* Paper presented at the annual conference of the American Educational Research Association. Chicago.

Chappell Moots, S., Loney, M., Tennessee, K., & Rhodes, N. (November, 2022). *Integrating computer science in the K-5 classroom*. Presentation at the annual conference of the Virginia Association of Science Teachers. Williamsburg, VA.

Garner, J., Chappell Moots, S., Brobst, J., Tennessee, K., Rhodes, N., Ferrell, V., & Maeng, J.L. (October, 2022). *Advancing STEM and CS integration through partnerships and professional development*. Multi-agency presentation at the annual EIR Project Directors Meeting (virtual).

Garner, J.K., Mark, J., Sorensen, N. & Taylor, J. (2024, February). Approaches to Successful Recruitment When Scaling. Presented at the EIR Project Directors Meeting, Washington, DC.

Liu, R. & Maeng, J. L. (October, 2023) Building Elementary Teachers' Capacity for Computer Science Instruction through Professional Development: A Randomized Control Trial. Paper presented at the annual Association for Educational Communications and Technology International Convention, Orlando, FL.

Loney, M., Chappell Moots, S., Tennessee, K., Graybill, M., & Steffian, L. (November 2022). *Advancing Rural Computer Science.* Presentation at the annual conference of the Virginia Association of Supervsion and Curriculum Development. Williamsburg, VA.

Publications

Liu, R., Maeng, J. L., Garner, J., & Chappell-Moots, S. (under review). Building elementary teachers' capacity for Computer Science instruction through professional development: A randomized control trial.

Other Dissemination

Teachers from several schools requested school-level reports of pre-/post-student assessment results in order to use the information to inform improvements within their schools and or as evidence of improvement in support of their professional annual goals. To support these teachers, we created and disseminated 7 school reports as requested.

Conclusion and Recommendations

Cohort 1

Implementation for Cohort 1 during the 2023-24 reporting timeframe focused on teachers randomized into the delayed treatment/control condition completing the microcredentials.

Implementation

The ARCS professional development was implemented as proposed for Cohort 1 delayed treatment/control teachers completing the microcredentials. As of October 2024, 9 delayed treatment teachers had completed all 5 microcredentials (p. 16). At the same timepoint last year, 6 treatment teachers had completed the microcredentials. While few teachers (n = 6) completed the end of year survey in the spring of 2024, those who did indicated positive perceptions of the Microcredentials, appreciating the staggered start dates and self-paced nature. They all agreed that the microcredentials supported improved CS content knowledge and effective integration of CS standards. None used the office hours (p. 16).

Most teachers who completed implementation-related questions indicated they taught at least one lesson that explicitly targeted CS Standards and perceived that their students were more engaged in CS than at the beginning of the year (p. 17-18).

Teacher Outcomes

Consistent with our exploratory outcomes for teachers proposed for the impact study, we compared Cohort 1 treatment and delayed treatment/control teachers CS content knowledge and self-efficacy for teaching CS at the end of year 1 of the program. At the end of year 1, immediate treatment teacher CS content knowledge was significantly greater than control teachers, $p = .05$; $R^2 = .3$, after controlling for prescore, race, gender, prior CS PD experience (p. 19).

Treatment teacher self-efficacy for teaching CS was significantly greater than that of control teachers, $p = .001$; $R^2 = .6$. Treatment teacher confidence in programming, $p = .002$; $R^2=.5$, confidence in teaching programming, $p = .003$; $R^2=.5$, and confidence in integrating CS SOLs, $p < .001$; $R^2=.4$, were also significantly greater than that of control teachers after controlling for prescore, race, gender, prior CS PD experience (p. 24).

These results indicate both statistically and practically meaningful improvements in treatment teacher content knowledge, self-efficacy, confidence in programming, confidence in teaching programming, and confidence in integrating CS SOLs compared to control teachers at the end of their first year of ARCS.

Cohort 2

Implementation for Cohort 2 during the 2023-24 reporting timeframe focused on teachers randomized into the immediate treatment condition completing the microcredentials and teachers in the delayed treatment/control condition completing the CodeVA K-5 Summer Coaches Academy and academic year supports (e.g., Learning bytes, resources) provided by ARCS/CodeVA.

Implementation

The ARCS professional development for Cohort 2 immediate treatment teachers completing the micro-credentials. As of October 2024, 2 immediate treatment teachers had completed all 5 microcredentials (p. 30). At the same timepoint for cohort 1, 6 treatment teachers had completed the microcredentials. However, unlike with cohort 1, 41 teachers are currently enrolled in and working on the microcredentials, which represents a substantial improvement in potential for microcredential completion for cohort 2 immediate treatment teachers compared to cohort 1 immediate treatment teachers.

Delayed treatment/control teachers began their PL year, which consisted of the CodeVA K-5 Summer Coaches Academy and academic year supports. Data indicate the CodeVA K-5 Summer Coaches Academy was implemented in a manner consistent with all prior cohorts. Participant attendance and engagement were high during CodeVA K-5 Summer Coaches Academy for RCT Cohort 2 delayed treatment/control teachers (p. 32). RCT Cohort 2 delayed treatment/control teachers reported positive perceptions of the ARCS PD on the post-survey (p. 32-33). Perceived challenges to CS integration among these teachers and supports needed were consistent with prior cohorts of teachers (p. 33-38).

Academic year engagement with ARCS was higher for delayed treatment/control teachers in Cohort 2 than for all other groups. Data indicated that approximately 70% of teachers completed all required learning bytes and several others completing a subset. In addition, just under half of teachers attended sessions during the academic year design to support them using the resources they received. Most teachers found these sessions and the resources useful in their CS instruction (p. 38).

Of teachers who completed implementation-related questions, 89% of treatment teachers and 78% of control teachers indicated they taught at least one lesson that explicitly targeted CS Standards at some point during the 2023-24 academic year (p. 52).

Teacher Outcomes

Consistent with our exploratory outcomes for teachers proposed for the impact study, we compared Cohort 1 treatment and delayed treatment/control teachers CS content knowledge and self-efficacy for teaching CS at the end of year 1 of the program. At the end of year 1, for cohort 2 teachers, there was no significant difference in immediate treatment teacher CS content knowledge compared to control teachers after controlling for prescore, race, gender, prior CS PD experience (p. 39).

Treatment teacher self-efficacy for teaching CS was significantly greater than that of control teachers, $p = .001$; $R^2 = .5$ (p. 42). This is a statistically and practically meaningful improvement in treatment teacher self-efficacy for integrating CS SOLs compared to control teachers at the end of Cohort 2 teachers' first year of ARCS.

Student Outcomes

Pre and post content knowledge and affect toward CS scores were calculated for students in treatment and control teachers' classrooms. Although this is not a matched sample, scores indicate slight improvement across both groups for both constructs. The immediate treatment group's overall content knowledge scores increased from 12.1 to 15.0 and from 38.6 to 41 for affect toward CS (p. 51-52).

Combined analysis

The year 6 report will use a matched pre/post sample and combine outcomes for cohort 1 and 2 teachers as per the confirmatory (student) and exploratory (teacher) evaluation questions.

Recommendations

Overall, given the positive improvements in microcredential start and completion, and positive responses toward academic year supports (e.g., learning bytes, "keep in touch" sessions), our recommendations are similar to those of year 4.

Microcredentials. Teachers continue to report overwhelmingly positive perceptions of the microcredentials; and attrition between years 1 and 2 is less for Cohort 2 teachers than Cohort 1 teachers. Therefore, we recommend continuing:

(1) Support for teachers to begin and complete the Microcredentials; actively and consistently follow up with teachers (e.g., send reminders monthly to teachers who have registered but not yet started, started but not yet completed) to ensure they are actively working toward microcredential completion since these are asynchronous and self-paced.

(2) Share example schedules of completion (e.g., completion of all microcredentials by the end of the summer, completion of all microcredentials by the end of the fall semester, completion of all microcredentials by the end of spring semester) so that teachers have pacing guides for completion.

Retention between Y1 and Y2. Many participants withdrew from the program between year 1 (ARCS CODE VA K-5 Coaches Academy) and year 2 (Microcredentials) for Cohort 1, but this seems to have stabilized for Cohort 2. In order to continue to retain teachers for the entirety of the ARCS intervention, we recommend

(1) Continuing to maintain consistent contact with teachers during the academic year following the ARCS Code VA K-5 Coaches Academy to develop rapport and support them in integrating what they learned and sharing resources, which has improved completion of the Learning Bytes.

(2) Hi-lighting to teachers the professional value of completing the Microcredentials and the positive perceptions reported by teachers in prior cohorts that completed them.

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Appendices

Appendix A: Teacher Assessment

Items asked Pre/Post/Year End 1 and Year End 2

Confidence Programming, Teaching Programming, and Integrating CS SOLs into instruction

Rate your confidence with the following:	Not at all confident	Unconfident	Somewhat unconfident	Somewhat confident	Confident	Very Confident
1. Programming (any language)						
2. Coding in a block language (e.g. Scratch)						
3. Coding in a text-based language (e.g. Python)						
4. Running an "Hour of Code" event						
1. Teaching Programming (any language)						
2. Teaching coding in a block language (e.g. Scratch)						
3. Teaching coding in a text-based language (e.g. Python)						

Rate your confidence integrating the following into your K-12 instruction:	Not at all confident	Unconfident	Somewhat unconfident	Somewhat confident	Confident	Very Confident
1. The Virginia CS Standards						
2. Algorithms and programming						
3. Information about computer systems						
4. Information about cybersecurity						
5. Data and analysis						
6. Information about the impacts of computing						

Experience Programming, Teaching Programming, and Integrating CS SOLs into instruction

Rate your experience:	Very inexperienced	Inexperienced	Somewhat inexperienced	Somewhat experienced	Experienced	Very Experienced
7. Programming (any language)						
8. Coding in a block language (e.g. Scratch)						
9. Coding in a text-based language (e.g. Python)						
10. Running an “Hour of Code” event						
17. Teaching Programming (any language)						
18. Teaching coding in a block language (e.g. Scratch)						

19. Teaching coding in a text-based language (e.g. Python)						

Rate your experience integrating the following into your K-12 instruction:	Very inexperienced	Inexperienced	Somewhat inexperienced	Somewhat experienced	Experienced	Very Experienced
20. The Virginia Computer Science Standards						
21. Algorithms and programming						
22. Information about computer systems						
23. Information about cybersecurity						
24. Data and analysis						
25. Information about the impacts of computing						

How strongly do you agree or disagree with the following statements?	Strongly Disagree	Disagree	Somewhat Disagree	Somewhat Agree	Agree	Strongly Agree
26. I understand what computer science is.						
27. I am familiar with my school division's plan for computer science education at the K-5 level.						
28. I can engage students from rural areas in computer science.						
29. I can engage students from low socioeconomic backgrounds (i.e., students receiving free and reduced price meals) in computer science.						
30. I can engage students who are traditionally underrepresented in STEM						

(i.e., Black, Hispanic, female, receiving special education services) in computer science						
31. I can address issues of access to computer technologies for students in my school.						

Self-Efficacy Scale.

How strongly do you agree or disagree with the following statements?	Strongly Disagree	Disagree	Somewhat Disagree	Somewhat Agree	Agree	Strongly Agree
32. I feel confident using computer technology.						
33. I know how to teach programming concepts effectively.						
34. I feel confident writing simple programs for the computer.						
35. I can promote a positive attitude toward programming in my students.						
36. I can guide students in using programming as a tool while we explore other topics.						
37. I feel confident using programming as an instructional tool within my classroom.						
38. I can adapt lesson plans incorporating programming as an instructional tool.						
39. I can create original lesson plans incorporating programming as an instructional tool.						
40. I can identify how programming concepts relate to the Virginia Standards of Learning.						

Culturally Responsive Teaching Confidence.

Please indicate how confident you are that you can:	Not at all Confident	Not Very Confident	Somewhat Confident	Confident	Very Confi-dent	Completely Confident
41. Identify ways that the school culture (e.g., values, norms, and practices) is different from my students' home culture.						
42. Implement strategies to minimize the effects of any mismatch between my students' home culture and the school culture.						
43. Develop a community of learners when my class consists of students from diverse backgrounds						
44. Use my students' cultural background to help make learning meaningful.						
45. Use my students' prior knowledge to help them make sense of new information						
46. Revise instructional material to include a better representation of cultural groups.						
47. Critically examine the curriculum to determine whether it reinforces negative cultural stereotypes.						
48. Use examples that are familiar to students from diverse cultural backgrounds.						

Culturally Responsive Teaching Frequency.

Please indicate how often you do the following:	Never	Very Rarely	Rarely	Occasionally	Frequently	Always
49. Spend time outside of class learning about the cultures and languages of my students.						
50. Make an effort to get to know my students' families and backgrounds.						
51. Examine class materials for culturally appropriate images and themes.						
52. Encourage students to use cross cultural comparisons when analyzing material						

Content Knowledge Items and Rubric

What is computer science?

Met expectations (3)	Partially met expectations (2)	Did not meet expectations (1)
Description accurately describes computer science as the study of computers, computational systems, algorithmic processes, including their principles, design, implementation, and impact on society. Responses may identify programming, artificial intelligence, computer systems and networks, security, database systems, human computer interaction, vision and graphics, numerical analysis, software engineering, bioinformatics, and theory of computing as key components of the field. Responses may indicate that computer scientists design and analyze algorithms to solve programs and study the performance of computer hardware and software.[1]	Description accurately describes computer science as the study of computers and computational systems but may overemphasize the role of programming in the field or deemphasize the importance of understanding how computers are used to solve problems.	Description identifies CS as *only* related to programming or response indicates participant doesn't know.

[1]Adapted from https://undergrad.cs.umd.edu/what-computer-science and https://teacherslounge.codevirginia.org/portal/en/kb/articles/what-is-computer-science

Describe what a computer programmer does.

Met expectations (3)	Partially met expectations (2)	Did not meet expectations (1)
Response indicates that computer programmers write and test code that allows computer applications and software programs to function properly. They turn the program designs created by software developers and engineers into instructions that a computer can follow. They may translate designs from software developers and engineers into workable code. They may also update or expand the code of existing programs or test programs for errors, finding and resolving faulty lines of code.[1]	Response indicates that computer programmers write OR test code, but not both.	Response indicates participant doesn't know.

[1]Adapted from https://www.bls.gov/ooh/computer-and-information-technology/computer-programmers.htm and https://www.computerscience.org/careers/computer-programmer/

What makes a device a computer?

Met expectations (3)	Partially met expectations (2)	Did not meet expectations (1)	Did not know (0)
Response identifies the 4 key components of a computer: input, output, processor, and memory and any description or elaboration of these components accurately describes them and their relationship to each other. Input: a way of translating information into a digital format that the computer can process. Output: a way of translating the digital information computers process and store into a format humans can understand. Processor: the part of the machine that controls storing digital information and caries out the instructions. It is the control center for everything the computer does. Memory: computers need things to process, this is stored in memory.[1]	Response accurately identifies 2 of the key components of a computer, but may also include non-components. Any description or elaboration of the accurately-identified components accurately describes them and/or their relationship to each other.	Response accurately identifies fewer than two key components of a computer, and may also include non-components. Any description or elaboration of the accurately-identified components may not accurately describe them and/or their relationship to each other. Or Response indicates participant doesn't know.	Response indicates participant doesn't know.

1 https://teacherslounge.codevirginia.org/portal/en/kb/articles/overview-computing-systems

What is an algorithm?

Met expectations (3)	Partially met expectations (2)	Did not meet expectations (1)	Did not know (0)
Describes algorithms as step by step instructions that produce a result. Response may indicate that humans use algorithms to decompose processes into step by step instructions, and often algorithms are used to create processes that can be automated. Algorithms have the following characteristics: (1) Use a common set of instructions that are clearly defined and produce consistent results, (2) The instructions are carried out in the correct order to produce the desired result, and (3) Produce a result and eventually end.	Describes an algorithm as a mathematical formula without elaboration or indication of the stepwise nature of algorithms.	Response indicates participant doesn't know.	Response indicates participant doesn't know.

1 https://teacherslounge.codevirginia.org/portal/en/kb/articles/overview-algorithms-and-programming

In what ways is the term "variable" used differently in computer science than in math and science?

Met expectations (3)	Partially met expectations (2)	Did not meet expectations (1)	Did not know (0)
Response accurately describes how the term variable is used in both computer science and math or science. In computer science, a variable is a name that represents data stored in memory. While the program is running the variable's value can change. When the program is done running the values entered are lost unless they are moved to a more permanent type of memory like a text file. Variable names can contain letters and numbers and must start with a letter and should describe the data the variable holds.[1] In math, a variable is a symbol which functions as a placeholder for varying expression or quantities, and is often used to represent an arbitrary element of a set. In addition to numbers, variables are commonly used to represent vectors, matrices, and functions.[2] In science, a variable is an object, event, idea, feeling, time period, or any other type of category you are trying to measure; anything that can change or be changed (i.e., any factor that can be manipulated, controlled for, or measured in an experiment).[3]	Response accurately describes how the term variable is used in computer science but does not include a description of how a variable is used in either math or science.	Response conflates how the term variable is used in computer science and math or science or Response indicates participant doesn't know.	Response indicates participant doesn't know.

[1] https://teacherslounge.codevirginia.org/portal/en/kb/articles/input-and-variables.
[2] https://en.wikipedia.org/wiki/Variable_(mathematics)
[3] https://nces.ed.gov/nceskids/help/user_guide/graph/variables.asp

Items on Post- and Year-end Only

How strongly do you agree or disagree with the following statements?	Strongly disagree	Disagree	Somewhat disagree	Somewhat agree	Agree	Strongly agree
1. Communications regarding the ARCS/Code VA K-5 Coaches Academy were received in a timely manner						
2. The ARCS/ Code VA K-5 Coaches Academy objectives were clear to me.						
3. The ARCS/ Code VA K-5 Coaches Academy provided me with lesson plans that fit state standards.						
4. The facilitators had adequate knowledge of the subject.						
5. The facilitators created an atmosphere of trust and open communication.						
6. I am satisfied with my interactions with the facilitators						

7. As needed, the facilitators were available to answer questions and provide direction.						
8. I felt a rapport with other participants.						
9. I am satisfied with my interaction with my peers.						
10. I felt part of a learning community.						
11. I found the online format of the ARCS/ Code VA K-5 Coaches Academy as effective as previous in-person PD I've attended.						
12. The ARCS/ Code VA K-5 Coaches Academy met my needs as a teacher-learner.						
13. I would recommend the ARCS/ Code VA K-5 Coaches Academy to other colleagues.						
14. I will integrate what I learned in the ARCS/ Code VA K-5 Coaches Academy in my teaching.						

15. I would benefit from additional PD in (select all that apply):

Integrating the Virginia Computer Science Standards into instruction
Integrating algorithms and programming into instruction
Integrating information about computing systems into instruction
Integrating cybersecurity into instruction
Integrating data and analysis into instruction
Teaching about the impacts of computing
Teaching about networking and the Internet
Programming (any language)
Coding in a block language (e.g., Scratch)
Coding in a text-based language (e.g., Python)
Participating in curriculum writing (related to CS)
Integrating CS instruction into remote teaching
Other (Write in) ____

What additional support do you need to implement what you learned during the ARCS/ Code VA K-5 Coaches Academy into your instruction?

What is the most useful thing you learned in the ARCS/ Code VA K-5 Coaches Academy?

Do you have any recommendations for modification of the ARCS/ Code VA K-5 Coaches Academy? If so, please describe these.

Appendix B: Final Version of CKACS Student Assessment and Rubric (Pilot Cohort Year 2, RCT Cohorts)

Content Knowledge Items

Part 1 Task: Your teacher has asked you to teach a lesson about computers to the second grade students at your school. In this lesson, you need to teach about the parts of a computer, how they work, and why computers are important.

1. The items on this page are computing system input and output items. Drag the items to the input or output box based on their role in a computing system. You will use the finished picture in your lesson.

2. Now you will make a second picture for your lesson that shows how a computing system works. Drag and drop 1 item to put in each of the boxes on the diagram to make a picture of a computing system.

3. Describe each of the four items in your computer system diagram and how each one is used in the computing system.

4. Explain how each item works with the other items to make your computer system work.

It is important that the second graders you are teaching not only understand *how* a computer system works, but also *why* computer technologies are important.

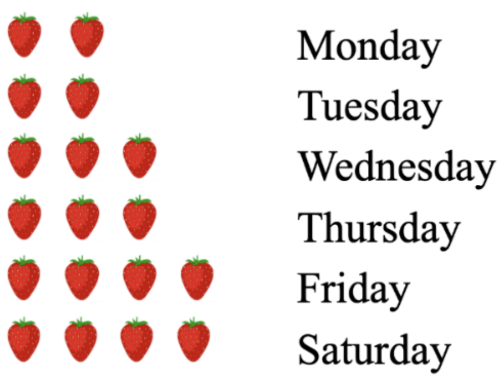
5. Which of the technologies listed below are ***computing technologies*** that you could teach the second graders about? (Select all that apply.)
   Internet search engine
   Light up sneakers
   Fidget spinner
   Smartphone application (software)/App

6. What statements below can you use to explain to the second graders how computing technologies affect how people ***communicate*** with one another. (Select all that apply.)
   People can learn new things by watching YouTube
   People write letters by hand
   People can talk on video apps
   People can add things to an online shopping cart
   People can learn new things by watching a Zoom lesson

Part 2 Task: For the school science fair, you have been asked to design an experiment, collect, and analyze data. For your project, you decide to grow strawberries and see how many are produced each day for a week.

7. Drag the steps into the order that you would take to conduct your investigation.
   Plant the plants
   Make dessert with the strawberries
   Put soil in the pots
   Pick and count the strawberries
   Water the plants

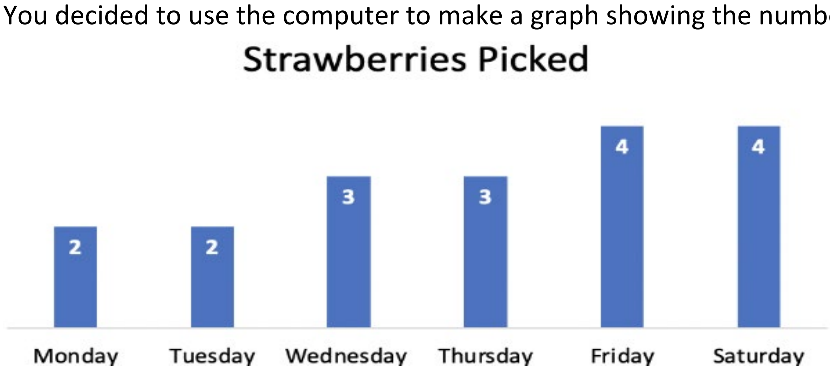
Once the plants have grown and strawberries appear, you pick them every day for six days. The following picture shows the number of strawberries that you picked each day.



8. How can you use a computer to show your findings for the strawberry data?

Not shown until students advance to the next page of the assessment.

You decided to use the computer to make a graph showing the number of strawberries picked each day.



9. Based on the pattern of strawberries picked on day 1 through day 6, select the letter for the number of strawberries that most likely will be collected on Sunday, day 7.
   2
   3
   4
   5

10. Explain why the response you picked is a pattern.

Part 3 Task: You learn about cybersecurity in school and want to share what you learned with your grown up at home to make sure that your family is safe.

11. Which of the following can cause cybersecurity problems when using a computer or iPad at home or school?
    Emailing a family member
    Following people on social media
    Cyberbullying
    Strong passwords

12. For the items you selected, describe what your family could do to avoid or deal with each of the cybersecurity problems you identified.

Affective Items

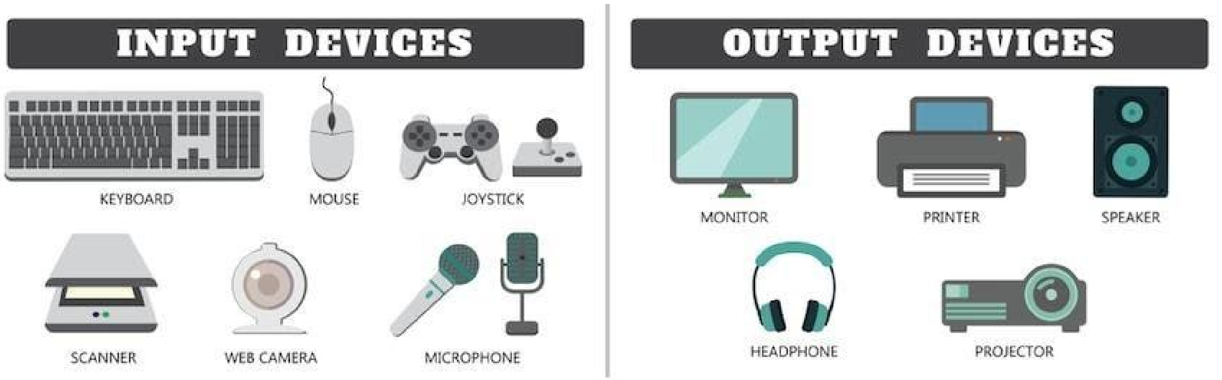
Respond to the following items using this 4-pt Likert scale: Strongly disagree (1), Disagree (2), Agree (3), Strongly agree (4)

Proposed Factor	Item
Confidence	13. I know what computer science is.
	14. I can learn computer science.[1]
	15. I am good at computer science.[1,2]
	16. I can do computer science.[3]
	17. People like me can do computer science.[2]
	18. I know a lot about computers.[2]
Interest	19. I would like to learn more about computer science. [1,2]
	20. I like computer science.[2,4]
	21. I would like to get a job in computer science when I get older.[3]
	22. I think computer science is interesting. [4]
	23. It is fun to do computer science. [2]
CS Utility	24. I can use computer science skills in my life. [2]
	25. Knowing computer science will help me to meet my goals. [2,3]
	26. I can use computers to help people and solve problems.[1,2,3]
	27. I will need to know computer science for my future job.[1]

Note. [1] Adapted from Elementary Student Coding Attitudes Survey, Mason & Rich, 2019. [2]Adapted from STARS Outreach Computer Attitude Survey, 2015 [3]Adapted from Programming Empowerment Survey, Kong et al., 2018. [4]Adapted from Hour of Code, Phillips & Brooks, 2017.

Student Content Knowledge Scoring Rubric

1.



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Met expectations (3)	Partially met expectations (2)	Did not meet expectations (1)
Placed all 6 items correctly	Placed between 3 and 5 items correctly	Placed fewer than 3 items correctly

2 – 4. Input and output is the communication between an information processing system, such as a computer, and the outside world, possibly a human or another information processing system. Inputs are the signals or data received by the syste0m; these include electricity, the movements and clicks of your mouse, and the keys you type on a keyboard. An output is whatever comes out of the system; for example, outputs include data and what can be seen on the computer screen.

Met expectations (3)	Partially met expectations (2)	Did not meet expectations (1)
Placed all selected items correctly and explanation accurately describes the purpose of items in all 4 components and the relationships between the processer and input, output, and storage.	Placed 2 or 3 items correctly and explanation accurately describes the purpose of these items and at least 1 relationship between the processer and other component.	Placed fewer than 2 items correctly and explanation may or may not accurately describe the purpose of the components and the relationships between the processor and other components.

5.

Met expectations (3)	Partially met expectations (2)	Did not meet expectations (1)
Answer correctly identifies A and D only	Answer correctly identifies A or D or Answer correctly identifies A and D but may identify another incorrect response.	Answer *does not* correctly identify A or D

6.

Met expectations (3)	Partially met expectations (2)	Did not meet expectations (1)
Answer correctly identifies A, C, and E only	Answer correctly identifies at least two of A, C, and/or E, but not all or Answer correctly identifies A, C, and E as correct, but may identify D as a correct response.	Answer *does not* correctly identify at least two of A, C, and E as correct or identifies B as a correct response

7.

Met expectations (3)	Partially met expectations (2)	Did not meet expectations (1)
Answer correctly identifies the sequence as C, A, E, D, B	Answer correctly sequences at least 3 steps.	Answer correctly sequences fewer than three steps.

8. The computer can be used to construct tables and graphs from data collected in class; it can also be the source of existing data sets that have been compiled by others.

Met expectations (3)	Partially met expectations (2)	Did not meet expectations (1)
Answer correctly identifies computers being useful in constructing at least one of the following: table, graph, chart, presentation software and accurately explains the answer.	Answer correctly identifies computers being useful in constructing at least one of the following: table, graph, chart, presentation software but does not accurately explain the answer.	Answer does not identify the computer as being useful in showing the data.

9 and 10.

Met expectations (3)	Partially met expectations (2)	Did not meet expectations (1)
Answer correctly identifies D as the answer and provides an accurate description of an increasing pattern of strawberry growth.	Answer correctly identifies D as the answer but does not provide an accurate description of an increasing pattern of strawberry growth. Or Answer does not correctly identify D as the answer but the explanation provided consistent with the selected answer for #9.	Answer does not correctly identify D as the answer **and** the explanation provided is inconsistent with the selected answer for #9.

11 and 12.

Met expectations (3)	Partially met expectations (2)	Did not meet expectations (1)
Answer correctly identifies A, B, and C as potential security issues **and** provides accurate explanations of how to avoid/ deal for each. (e.g., don't answer suspicious email, use strong passwords, don't talk with people you don't know on the computer)	Answer correctly identifies 2 potential security issues **and** provides accurate explanations of how to avoid each. May identify non-cybersecurity problems as well. Or Answer correctly identifies 2 or 3 potential security issues and at least one correct explanation. May identify non-cybersecurity problems as well.	Answer correctly identifies fewer than 2 potential security issues with or without accurate explanations and may identify non-cybersecurity problems as well. or Answer correctly identifies 3 potential security issues and provides no correct explanations. May identify non-cybersecurity problems as well.