ARCS External Evaluation
Year 4 Annual Report

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November 27, 2023

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.

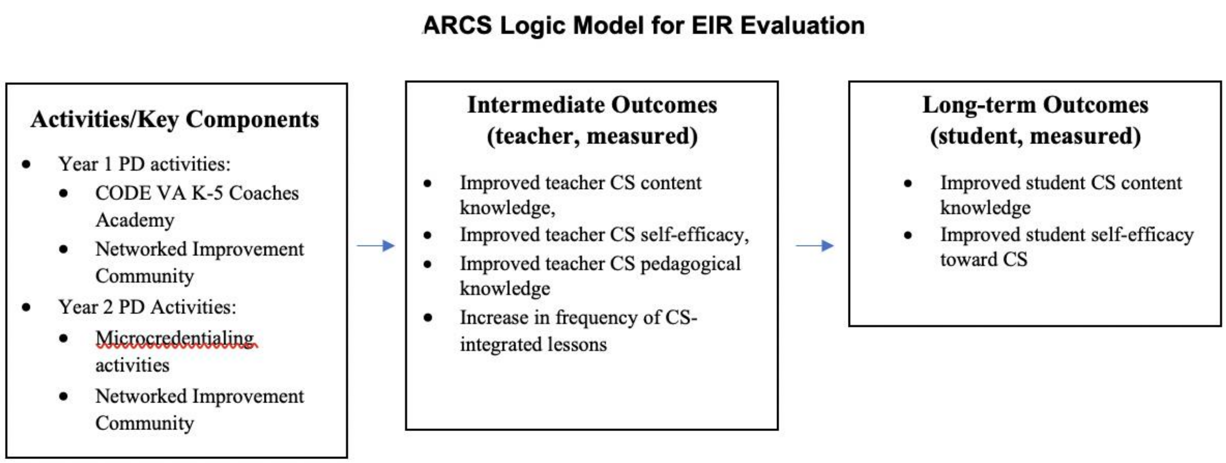

Figure 1. ARCS Logic Model

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 teachers) 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. Pilot and treatment teachers participate for 2 years and control (delayed treatment teachers participate for 3 years (an initial year of data collection 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 Treatment (2021-2023)	RCT Cohort 1 Control (delayed treatment) (2021-2024)	RCT Cohort 2 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 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 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 2025
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, 2022 to September 30, 2023 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 4 Evaluation Activities

1. Documented implementation of microcredentials for the RCT Cohort 1 treatment (through June 2023) and delayed treatment (June through September 2023) teachers.
2. Administered and analyzed end-of-year assessments for RCT Cohort 1 teachers.
3. Assisted in recruitment and randomized RCT Cohort 2 teachers.
4. Analysis of demographic data for elementary teachers in RCT Cohort 2.
5. Documented 2023 summer PD attendance of RCT Cohort 2 treatment teachers.
6. Administered and analyzed post-summer PD assessments to RCT Cohort 2 treatment teachers.
7. Administered pre-CKACS to students in RCT Cohort 2 teacher classrooms in August/September/October 2023.
8. Analyzed RCT Cohort 2 student pre-assessment data.

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. & Liu, R. (2023). *ARCS External Evaluation Year 4 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, the summer 2023 ARCS CODE VA K-5 Coaches Academy was modified to be a five-day online PD consisting of asynchronous and synchronous components and follow up PD with coaching during the 2023-24 academic year.

Participants were assigned by school to attend one of two five 3.5-hour synchronous sessions: Session 1 (June 26, 2023-June 30 2023) or Session 2 (July 10, 2023-July 14 2023) 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. 2023 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 will be 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 videotaped 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 α = .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 α = .72), data and analysis (Cronbach's α = .60), and cybersecurity. The 15- item affective component of the instrument (Cronbach's α = .89) included 3 subscales: confidence (Cronbach's = .80), interest (Cronbach's α = .85), and utility (Cronbach's α = .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

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	
	Treatment	Control	Treatment	Control	Non-RCT	Treatment	Control
Schools	11	12	10	10	7 (11 applied)	n/a	n/a
Teachers	33	44	29	39	9 (14 applied)	6	2

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, or non-RCT condition).

Sample Demographics

Table 4 describes the demographic characteristics of the 77 elementary teachers participating in ARCS Year 2 (n = 29 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 treatment teachers did not self-report demographic information. These data are self-reported.

Table 4. Cohort 1 Demographics

	Treatment (n = 25)[1] n (%)	Control (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 treatment group did not provide demographic data.

Table 5. Educational Background

	Treatment (n = 25)[1] n (%)	Control (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 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, 29 teachers in the RCT Cohort 1 treatment group were eligible and had access to complete the microcredentials. As of October 2023, 6 teachers in the RCT Cohort 1 treatment group completed the microcredentials.

As of October 2023, 20 teachers in the RCT Cohort 1 control (delayed treatment) group were eligible and had access to complete the microcredentials; 2 teachers in the RCT Cohort 1 delayed treatment group have completed the microcredentials. Teachers in the delayed treatment group have until June 2024 to complete microcredentials.

Table 6. Microcredential completion by course

	Pilot Cohort	Cohort 1 Treatment	Cohort 1 Delayed Treatment
Introduction to Computers, Digital Impact, and Digital Citizenship	1	6	3
Computing Systems, Networks and the Internet, and Cybersecurity	1	6	3
Algorithms and Programming	1	6	2
Data and Analysis	1	6	2
Elementary Computer Science and Lesson Integration	1	6	2

Teachers who completed the year-end survey questions about the microcredentials (n = 5) were overwhelmingly positive. One teacher noted, "*These courses really helped me to learn more about CS and how to implement them in my classes*." Regarding format, all somewhat to strongly agreed that they liked the self-paced nature of the microcredentials, and the staggered opening dates for the microcredentials. All of the 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 80% of the respondents (4/5) indicated that they can effectively teach the VA CS Standards for their grade after completing the microcredentials. One teacher noted that the microcredentials could be improved by considering alternative ways to include CS Standards for non-classroom teachers. Notably, none of the teachers reported using the office hours.

Learning Bytes and Other CodeVA Online Resources

The 39 Cohort 1 control (delayed treatment) teachers that completed the 2022 ARCS Code VA K-5 Coaches Academy were expected to complete 4 learning bytes during the 22-23 academic year. According to CodeVA records, none of the teachers completed any learning bytes during the 22-23 academic year. Teachers were also asked on the year-end survey whether they completed any learning bytes. Of the 10 teachers who responded to this item, 3 indicated completing 1 learning byte and 2 indicated completing 2 learning bytes. This lack of consistency between CodeVA and teacher self-reported completion of learning bytes needs to be further investigated. These teachers indicated that the learning bytes were very unhelpful (n = 1), somewhat helpful (n = 3) and helpful (n = 1) both in meeting their needs regarding knowledge of CS concepts and integration of CS Standards in the curriculum.

Teachers also reported using other CodeVA-provided online resources during the 22-23 academic year. Two teachers reported accessing resources monthly and 8 teachers reported accessing these resources one to two times. Teachers identified three aspects of the CodeVA-provided online resources that could be improved to make them more useful: **access**, **format**, and **content**. In terms of access, three teachers highlighted the need of easy access to online resources, one teacher commented "*I do know (sic) have easy access to the online resources*." Another teacher similarly stated that "*The resources were made available. I need to access them and make use of them more often*." Regarding resource format, one teacher suggested that online classes would be more flexible, this teacher stated that "*If they were online classes I could watch on my own time vs a prescribed PD time.*" Regarding the content of resources, one teacher highlighted that providing the grade-specific resources would be more beneficial. This teacher commented "*Possibly sending out notifications of new resources for my grade level of students that I can use.*"

Implementation

Teachers received resources to support classroom implementation of what they learned during the ARCS Code VA Coaches Academy. One teacher indicated that they were unaware that they could receive a resource from ARCS. Of the 9 teachers who responded to the year-end survey questions about the online resources they received, 2 indicated they participated in an informational session about their chosen resource, and both found these to be engaging and useful (somewhat to strongly agree). The majority (7 out of 9 teachers) indicated they used the resource they received to teach CS concepts (somewhat to strongly agreed).

Teacher self-report data indicated that of 18 teachers (treatment and delayed treatment) who completed the frequency of integration survey in December 2022, 15 (83%) reported teaching at least one lesson that explicitly targeted CS SOLs between the beginning of the school year and Thanksgiving break. Of the 15 teachers (treatment and delayed treatment) who completed the frequency of integration survey in Spring 2023, 11 (73%) reported teaching at least one lesson that explicitly targeted CS SOLs between the Thanksgiving and the end of the year.

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.

For the teachers that did not teach CS-related lessons, their themes were related to time or completing priorities, or the Standards being outside of their content area (e.g., teaching Special Education - "predominately math and reading").

RCT Cohort 1 Teacher Results

Participant Outcomes. Of participants, 25 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 (treatment = 4, control = 12), inferential statistics were not conducted to compare pre- to year-2-end outcomes for treatment or control teachers.

CS Content Knowledge

Results indicated no significant improvement in treatment teacher CS knowledge following participation in the Code VA K-5 Coaches Academy (pre/post PD), t (21) = .8, p = .4 (Table 7). In addition, there was no significant difference in 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 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), 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 7. Teacher Content Knowledge Outcomes

	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)
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)
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)
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)
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)
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)
Sum of 5 items, max 15	9.4 (1.9)	9.6 (1.5)	9.4 (2.1)	8.2 (1.3)	9.8 (1.9)	8.0 (2.4)	9.6 (2.6)	9.2 (1.3)

Note. Each item scored 1-3. [1] Treatment Pre and Post: Summer 2021, [2]Treatment Year 1 End: Spring 2022, [3]Treatment Year 2 End: Spring 2023, [4]Control Pre Year 1: Summer 2021, [5]Control Year 1 End: Spring 2022, [6]Control Post PD: Summer 2022, [7]Control Year 2 End: Spring 2023. 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).

CS Pedagogical Knowledge

Pedagogical knowledge was measured through several scales with high reliability (Cronbach's α > .8). Results indicated significant improvement in 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 8. Experience Programming

	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)
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)
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)
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)
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)
Sum of 4 items above	9.0 (5.1)	12.7 (3.4)	13.3 (4.1)	10.2 (4.9)	10.3 (5.3)	11.1 (6.3)	12.3 (5.5)	14 (4.8)

Note. 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). 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 (treatment) and [3]Year 2 end (control): 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 delayed treatment teachers.

Table 9. Experience Integrating CS SOLs

	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)
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)
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)
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. 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)
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)
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)
Sum of 6 items above	14.5 (6.4)	24.6 (4.9)	23.1 (5.8)	17.5 (10.1)	16.7 (8.0)	20.4 (1.6)	23.1 (7.5)	25.6 (3.6)

Note. 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). 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 (treatment) and [3]Year 2 end (control): 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 delayed treatment teachers.

Table 10. Experience Teaching Programming

	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)
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)
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)
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)
Sum of 3 items above	6.3 (3.6)	8.7 (3.1)	9.6 (2.9)	8.2 (3.8)	6.6 (3.7)	6.6 (3.8)	7.5 (4.2)	10.4 (3.5)

Note. 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). 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 (treatment) and [3]Year 2 end (control): 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 delayed treatment teachers.

Table 11. Other Items Related to Pedagogical Knowledge

	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)
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)
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)
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. 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. 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)
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)

Note. 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). 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 (treatment) and [3]Year 2 end (control): 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 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, 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. These results indicate a both statistically and practically meaningful improvement in 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 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 12. Self Efficacy Scale

	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)
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)
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)
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. 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)
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)
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)
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)
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)
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)
Sum of 9 items above	34.7 (8.5)	41. (8.0)	40.8 (6.2)	36.0 (15.0)	35.3 (9.7)	33.7 (10.1)	35.9 (11.5)	41.0 (8.4)

Note. 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). 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 (treatment) and [3]Year 2 end (control): 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 13. Confidence Programming

	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)
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)
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)
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)
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)
Sum of 4 items above	10.0 (5.2)	14.2 (3.8)	15.5 (3.2)	11.6 (5.0)	11.0 (5.1)	11.7 (5.4)	12.9 (6.3)	16.0 (4.6)

Note. 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). 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 (treatment) and [3]Year 2 end (control): 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 14. Confidence Teaching Programming

	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)
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)
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)
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)
Sum of 3 items above	6.8 (4.1)	9.5 (3.2)	10.7 (2.8)	8.0 (3.8)	7.4 (3.9)	7.7 (3.9)	9.0 (4.2)	11.3 (3.3)

Note. 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). 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 (treatment) and [3]Year 2 end (control): 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 Integrating CS SOLs

	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)
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)
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)
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)
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)
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)
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)
Sum of 6 items above	17.6 (7.8)	28.4 (4.8)	26.4 (4.8)	23.6 (10.9)	20.3 (7.1)	20.4 (7.9)	28.3 (5.8)	28.3 (4.2)

Note. 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). 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 (treatment) and [3]Year 2 end (control): 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 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 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 16. Culturally Responsive Teaching Confidence

	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)
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)
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)
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)
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. 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)
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)
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)
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)
Sum of 8 items above (max 48)	36.1 (6.7)	36.6 (.6.3)	36.4 (7.0)	41.2 (7.0)	36.2 (6.9)	34.7 (7.6)	39.2 (6.2)	36.5 (8.2)

Note. 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). 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 (treatment) and [3]Year 2 end (control): 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. Culturally Responsive Teaching Frequency

	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)
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)
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)
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)
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)

Note. 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). 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 (treatment) and [3]Year 2 end (control): 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, 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 treatment condition and 23 schools (n = 61 teachers) were randomized into the control condition (Table 18).

Table 18. Elementary RCT Cohort 2 Randomization and Retention Data

	Randomized		Completed Pre Assessment		Completed 2023 Summer Institute		
	Treatment	Control	Treatment	Control	Treatment	Control	Non-RCT
Schools	24	23	20	21	20	N/A	4 (6 applied)
Teachers	60	61	48	48	46	N/A	10 (15 applied)

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., treatment = 20, control = 20).

Sample Demographics

Table 19 describes the demographic characteristics of the 96 elementary teachers included in the analytic sample participating in ARCS Cohort 2 group (n = 48 treatment, n = 48 control). Table 20 describes their CS background. The mean years of teaching experience was: treatment *M* = 15.2 (*SD* = 9.2), control *M* = 15.5 (*SD* = 7.2), non-RCT *M* = 18.2 (*SD* = 7.4). These data are self-reported.

Table 19. Cohort 2 Demographics

	[1]Treatment (n =48) n (%)	Control (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 group did not provide demographic data.

Table 20. Educational Background

	[1]Treatment (n =48) n (%)	[2]Control (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 treatment group, [2]6 teachers in the control 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 4 of the ARCS CodeVA K-5 Coaches Academy for both teachers in the RCT analytic sample randomized into the treatment condition and teachers who completed the ARCS CodeVA K-5 Coaches Academy but were not randomized.

Attendance

Table 21. ARCS K-5 Coaches Academy Daily Attendance

	Day 1 n	Day 2 n	Day 3 n	Day 4 n	Day 5 n
Treatment week 1 Summer 2023 (n = 26)	24	25	23	25	24
Treatment week 2 Summer 2023 (n = 27)	27	27	24	26	27

Implementation

Overall, the ARCS CODE VA K-5 Coaches Academy Summer PD appeared to be implemented as planned for the 2023 Summer (Cohort 2 Treatment) teachers. In addition, it appeared that in general, the 2023 ARCS CODE VA K-5 Coaches Academy Summer PD was consistent with the summer 2022 PD, with the few exceptions we describe below. As in prior years of the ARCS CODE VA K-5 Coaches Academy Summer PD implementation, the goals of the project were addressed in various ways: presentations, modeling, and small group discussions as illustrated above. Each session was videotaped for participants for them to view afterward. These differences were primarily related to considering how to teach CS content and an increased emphasis on equity and inclusion. For details of the ARCS Code VA K-5 Coaches Academy Summer PD, please see Maeng & McCoy, 2021.

PD Perceptions

Table 22. Perceptions of the PD (Cohort 2 treatment, n = 41)

How strongly do you agree or disagree with the following statements?	Strongly disagree (%)	Disagree (%)	Somewhat disagree (%)	Somewhat agree (%)	Agree (%)	Strongly Agree (%)	Mean (SD)
1. Communications regarding the ARCS/Code VA K-5 Coaches Academy were received in a timely manner	0	0	2.4	7.3	39	51.2	5.4 (0.8)
2. The ARCS/Code VA K-5 Coaches Academy objectives were clear to me.	0	0	2.4	14.6	31.7	51.2	5.3 (0.9)
3. The ARCS/Code VA K-5 Coaches Academy provided me with lesson plans that fit state standards.	0	2.4	2.4	14.6	43.9	36.6	5.1 (0.9)
4. The facilitators had adequate knowledge of the subject.	0	0	2.4	2.4	31.7	63.4	5.5 (0.8)
5. The facilitators created an atmosphere of trust and open communication.	0	0	0	4.9	26.8	68.3	5.6 (0.6)

6. I am satisfied with my interactions with the facilitators	0	0	0	4.9	31.7	63.4	5.6 (0.6)
7. As needed, the facilitators were available to answer questions and provide direction.	0	0	0	2.4	36.6	61.0	5.6 (0.5)
8. I felt a rapport with other partici-pants.	0	0	2.4	22.0	34.1	41.5	5.1 (0.9)
9. I am satisfied with my interactions with the my peers.	0	0	0	9.8	46.3	43.9	5.3 (0.7)
10. I felt a part of a learning commu-nity.	0	0	0	14.6	39.0	46.3	5.3 (0.7)
11. I found the online format of the ARCS/Code VA K-5 Coaches Acad-emy as effective as previous in-per-son PD I've attended.	2.4	2.4	4.9	9.8	41.5	39.0	5.0 (1.2)
12. The ARCS/Code VA K-5 Coaches Academy met my needs as a teacher-learner.	0	2.4	7.3	7.3	43.9	39.0	5.1 (1.1)
13. . I would recommend the ARCS/Code VA K-5 Coaches Acad-emy to other colleagues.	0	2.4	7.3	4.9	34.1	51.2	5.2 (1.1)
14. I will integrate what I learned … in my teaching.	0	0	2.4	7.3	34.1	56.1	5.4 (0.8)

Note. Cohort 2 control (delayed treatment) teachers will participate in the ARCS CODE VA K-5 Coaches Academy Summer PD in 2024, results about their perceptions of PD will be presented in year 5 report.

Useful Components of the PD

Participants' open-ended responses (n = 45) of the most useful components of the ARCS CodeVA K-5 Coaches Academy were categorized and closely mirrored these articulated by Cohort 1 teachers at the same time point. These included: **resource they received (n = 25)**, **pedagogical** knowledge **about CS integration (n = 24)**, **collaboration and networking (n = 14)**. Other responses (n = 10) are related to **improved confidence and self-efficacy in teaching CS (n = 6)**, and **better understanding of CS (n = 5)**.

One recurring theme highlighted was **resources;** participants appreciated exposure to various teaching materials and tools available. 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/Code VA K-5 Coaches Academy is the **plethora of resources** available to integrate computer science into instruction.*

Another one similarly indicated:

> *There were so many useful slides and activities that were used in the academy training that I will use to directly engage my students, such as using Jamboard more, using gifs to express feelings, and so on!*

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 was unaware of the computer Science **standards** but now am aware and feel that it is easy to implement them in many unplugged ways into my day.*

Another similarly indicated:

…the difference between 'adding in' and truly integrating. It was also helpful to get feedback/input from other educators and see how they intended to implement CS.

Many teachers valued the **collaboration and networking** opportunities, especially those outside their schools and divisions. They appreciated the quality time, communication, and not feeling alone in the process. One participate wrote:

I think the best part of our academy was having our school team complete it together.

Another one noted:

...*I also enjoyed the time to work with colleagues (both from my county and new colleagues met) to discuss applications of these concepts with our students*.

A few teachers commented that ARCS CodeVA K-5 Coaches Academy helped **enhance their understanding of CS** and some indicated that they **felt more confident in integrating CS**. About enhanced understanding of CS, one participant indicated improved understanding that CS is more than coding, they wrote:

Computer science is NOT just coding! Computer science integration isn't scary!

Another teacher described a better understanding of the importance of teaching CS:

How important it is that computer science is accessible to all students.

Several teachers reported improved confidence in integrating CS:

Confidence-there is a wealth of information easily accessible and it's a simple step by step foundation.

It's not something to fear, but to understand there is help and plenty of resources to assist.

Additional Supports Needed

Participants identified several areas in which they perceived they would benefit from future PD (Figure 2). Commonly, teachers wanted additional more support in programming (n = 29), text-based coding (n = 27), and block-based coding (n = 22).

In addition to Figure 2, participant open-ended responses indicate their need of additional suppprt in four areas: **more resources (n = 12),** o**pportunities to collaborate and follow up (n = 10)**, and **support with technology integration (n = 3)**, and **teaching practice and modeling of teaching (n = 2)**.

Most of the participants' responses related to **resources** emphasized a need of instructional materials and ideas that can be readily applied to integrate CS. This was exemplified by the following responses:

- *I would like to see more examples of what a lesson would like with computer science incorporated at my grade level.*
- *I need a more in depth view of the standards and more integrated lesson ideas.*
- *I need additional support and ideas on integration that are easy and don't require a lot of planning.*

Regarding the ***need of opportunities to collaborate and follow up***, responses indicated that collaborating with other teachers on lesson planning and the opportunities to connect with coaches to seek support would be beneficial. Noteworthy comments reflecting these sentiments include:

- *I would appreciate regular check-ins, or a regular zoom meeting with peers from the Coaches Academy to discuss how implementation is going. This could be done every 2-3 months throughout the school year.*

- *I don't think that I need any explicit support, but just the availability to ask questions as they may arise. I need to spend some time exploring the resources provided during the Coaches Academy and digging deeper into SOL standards and CS standards to align these.*
- *Continued community of teachers.*

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

- *Use the computer on a daily basic with the core subjects. Also, having students to implment it with writing.*
- *I need the bee bots, etc.*

Related to ***teaching practice and modeling of teaching***, participants expressed a need for targted support and modeling of how CS instruction can be implemented in class, their comments including:

- *Specific hands on training on how to implement lessons.*
- *Seeing someone else teach some computer science lessons effectively.*

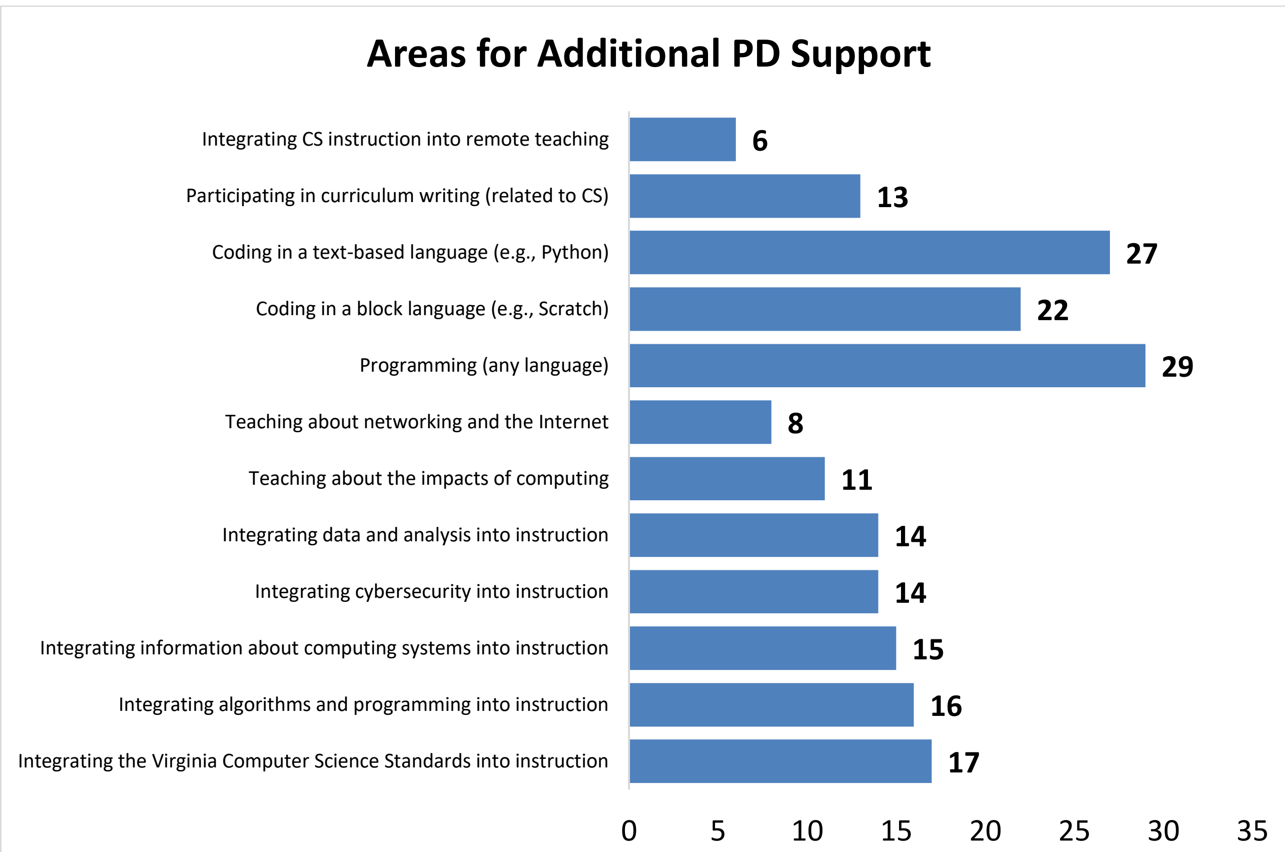

Figure 2. Topics for Future PD

Recommendations

When asked for recommendations for modifications of the ARCS CodeVA K-5 Coaches academy, 31 of the 45 respondents (68.9%) indicated that they had no recommendations for improvement. The most common recommendations were related to **organization** (n = 9) and **content** (n = 7).

Regarding organization, participants suggested reduced breakout room time and including more opportuties for collaboration and resources sharing. For example, many participants indicated there was too much time spent on breakout rooms and wished they had more time with the resources itself. These are some example comments:

- *Most of the break our room sessions could have been a lot **shorter**, we spent a lot of time just waiting to move on.*
- *The only recommendation I would have is maybe **not have so many breakouts**. I heard several people comment about having to be in so many breakout rooms.*

Several participants suggested including **more opportunities to collaborate and platforms for resource sharing**:

- *The time spent interacting with peers in small groups was the most valuable; however it was also useful to work with my school group for the majority of the time. Perhaps a time to share ideas that we are already using at the beginning and new ideas at the end would be great*.
- *Yes, have someone place an online class where you can participate so if we are coaching we have a resource and have a website too. This all needs to be more robust!*

Regarding content, participates also asked for **more descriptive and further details on CS integration integration and more clear examples of this**. These are some example comments:

- ***More examples** of what a lesson should look like and maybe the class could be divided into groups of people who have some computer science and coding background and people who don't have much experience (like me)*.
- *Maybe **more examples** of where the computer science SOLs fit specifically into the general education curriculum.*
- *Providing more specific ways to integrate, examples of integration in action*

RCT Cohort 2 Teacher Results

Of participants, 41 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 treatment teacher CS knowledge following participation in the Code VA K-5 Coaches Academy (pre/post PD), t (39) = 2.3, $p < .05$.

Table 29. Teacher Content Knowledge

Item	Treatment		Control (Delayed Treatment)
	[1] Pre Year 1 M (*SD*)	[2] Post PD M (*SD*)	[3] Pre Year 1 M (*SD*)
1. What is computer science?	1.7 (0.6)	1.7 (0.5)	1.6 (0.5)
2. Describe what a computer programmer does.	1.9 (0.6)	2.1 (0.6)	2.0 (0.6)
3. What makes a device a computer?	1.5 (0.6)	1.5 (0.6)	1.3 (0.5)
4. What is an algorithm?	2.1 (0.7)	2.6 (0.6)	2.3 (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)	1.1 (0.4)
Sum of 5 items, max 15	8.4 (1.8)	9.1 (1.5)	8.3 (1.5)

Note. Each item scored 1-3. [1] Treatment pre n = 46, 2 Treatement post n = 42, [3] Control pre n = 42. Each item scored 1-3. Scale: did not meet expectations = 1, partially met expectations = 2, met expectations = 3. Summer 2023.

CS Pedagogical Knowledge

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

Table 23. Experience Programming

	Treatment		Control (Delayed Treatment)
Rate your experience:	Pre Year 1 M (*SD*)	Post PD M (*SD*)	Pre Year 1 M (*SD*)
Programming (any language)	2.5 (1.4)	3.3 (1.2)	2.7 (1.3)
Coding in a block language	3.3 (1.6)	3.7 (1.3)	3.3 (1.5)
Coding in a text-based language	1.9 (1.0)	2.5 (1.2)	1.9 (1.1)
Running an "Hour of Code" event	3.2 (1.7)	4.0 (1.6)	3.3 (1.6)
Sum of 4 items above	10.9 (5.0)	13.5 (4.6)	11.1 (4.7)

Note. Treatment group (pre n = 48, post n = 43), control group (pre n = 44). 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 24. Experience Integrating CS SOLs

	Treatment		Control (Delayed Treatment)
Rate your experience with the following:	Pre Year 1 M (*SD*)	Post PD M (*SD*)	Pre Year 1 M (*SD*)
The Virginia Computer Science Standards	3.7 (1.3)	4.2 (1.3)	3.6 (1.2)
Algorithms and programming	2.8 (1.5)	4.1 (1.4)	2.9 (1.6)
Information about computer systems	3.0 (1.4)	4.1 (1.3)	2.8 (1.3)
Information about cybersecurity	3.3 (1.4)	4.3 (1.2)	3.0 (1.3)
Data and analysis	3.0 (1.4)	4.1 (1.3)	2.9 (1.4)
Information about the impacts of computing	3.0 (1.3)	4.2 (1.2)	3.0 (1.3)
Sum of 6 items above	18.6 (7.4)	25.0 (7.1)	18.3 (7.1)

Note. Treatment group (pre n = 48, post n = 42), control group (pre n = 44). Each item scored 1-6. Cronbach's α pre = .942, Cronbach's α post = 0.968. Scale: very inexperienced = 1, Very experienced = 6.

Table 25. Experience Teaching Programming

	Treatment		Control (Delayed Treatment)
Rate your experience:	Pre Year 1 M (*SD*)	Post PD M (*SD*)	Pre Year 1 M (*SD*)
Teaching Programming (any language)	2.5 (1.5)	3.2 (1.4)	2.5 (1.4)
Teaching coding in a block language	3.2 (1.6)	3.6 (1.5)	3.2 (1.6)
Teaching coding in a text-based language	1.9 (1.1)	2.6 (1.2)	1.8 (1.0)
Sum of 3 items above	7.5 (3.7)	9.4 (3.7)	7.5 (3.4)

Note. Treatment group (pre n = 48, post n = 43), control group (pre n = 44). 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 26. Other Items Related to Pedagogical Knowledge

	Treatment		Control (Delayed Treatment)
How strongly do you agree or disagree with the following statements?	Pre Year 1 M (*SD*)	Post PD M (*SD*)	Pre Year 1 M (*SD*)
I understand what computer science is.	4.3 (1.0)	5.1 (0.6)	4.5 (1.0)
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)	3.9 (1.3)
I can engage students from rural areas in computer science.	4.3 (1.2)	5.2 (0.7)	4.4 (1.2)
I can engage students from low socioeco-nomic backgrounds in computer science.	4.4 (1.2)	5.2 (0.7)	4.8 (1.0)
I can engage students who are traditionally underrepresented in STEM in computer sci-ence	4.4 (1.2)	5.2 (.7)	4.9 (1.0)
I can address issues of access to computer technologies for students in my school.	4.1 (1.3)	5.0 (1.0)	4.3 (1.2)

Note. Treatment group (pre n = 48, post n = 43), control group (pre n = 44). 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 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).

Table 27. Self Efficacy Scale

	Treatment		Control (Delayed Treatment)
How strongly do you agree or disagree with the following statements	Pre Year 1 M (*SD*)	Post PD M (*SD*)	Pre Year 1 M (*SD*)
I feel confident using computer technology.	4.9 (1.1)	5.3 (0.7)	4.7 (1.2)
I know how to teach programming concepts effectively.	3.3 (1.4)	4.3 (1.3)	3.5 (1.5)
I feel confident writing simple programs for the computer.	2.9 (1.4)	3.8 (1.5)	3.0 (1.3)
I can promote a positive attitude toward programming in my students.	5.0 (1.1)	5.4 (0.5)	5.0 (1.1)
I can guide students in using programming as a tool while we explore other topics.	4.0 (1.4)	4.7 (1.2)	4.1 (1.4)
I feel confident using programming as an instructional tool within my classroom.	3.7 (1.4)	4.6 (1.2)	3.8 (1.5)
I can adapt lesson plans incorporating programming as an instructional tool.	4.0 (1.3)	4.7 (1.1)	4.0 (1.4)
I can create original lesson plans incorporating programming as an instructional tool.	3.7 (1.4)	4.7 (1.1)	4.0 (1.5)
I can identify how programming concepts relate to the Virginia Standards of Learning.	4.0 (1.3)	5.0 (1.0)	4.2 (1.3)
Sum of 9 items above	35.4 (9.5)	43.6 (8.1)	36.1 (10.3)

Note. Treatment group (pre n = 48, post n = 43), control group (pre n = 44). Each item scored 1-6. Cronbach's α pre = , Cronbach's α post = . Scale: very inexperienced = 1, Very experienced = 6.

Table 28. Confidence Programming

	Treatment		Control (Delayed Treatment)
Rate your confidence with the following:	Pre Year 1 M (*SD*)	Post PD M (*SD*)	Pre Year 1 M (*SD*)
Programming (any language)	2.7 (1.2)	3.7 (1.0)	2.6 (1.2)
Coding in a block language	3.4 (1.4)	4.2 (1.2)	3.3 (1.5)
Coding in a text-based language	2.1 (1.1)	2.9 (1.2)	1.8 (1.0)
Running an "Hour of Code" event	3.6 (1.8)	4.5 (1.4)	3.7 (1.6)
Sum of 4 items above	11.6 (4.8)	15.3 (3.8)	11.5 (4.5)

Note. Treatment group (pre n = 48, post n = 43), control group (pre n = 44). 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 29. Confidence Teaching Programming

	Treatment		Control (Delayed Treatment)
Rate your confidence with the following:	Pre Year 1 M (*SD*)	Post PD M (*SD*)	Pre Year 1 M (*SD*)
Teaching Programming (any language)	2.7 (1.3)	3.7 (1.1)	2.6 (1.3)
Teaching coding in a block language	3.4 (1.6)	4.0 (1.3)	3.3 (1.6)
Teaching coding in a text-based language	2.1 (1.1)	2.7 (1.2)	1.9 (1.1)
Sum of 3 items above	8.1 (3.6)	10.4 (3.0)	7.8 (3.4)

Note. Treatment group (pre n = 48, post n = 43), control group (pre n = 44). 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 30. Confidence Integrating CS SOLs

	Treatment		Control (Delayed Treatment)
Rate your confidence integrating the following into your K-12 instruction:	Pre Year 1 M (*SD*)	Post PD M (*SD*)	Pre Year 1 M (*SD*)
The Virginia Computer Science Standards	4.0 (1.3)	5.0 (0.7)	4.0 (1.2)
Algorithms and programming	3.2 (1.4)	4.6 (0.9)	3.3 (1.6)
Information about computer systems	3.6 (1.2)	4.6 (0.7)	3.2 (1.5)
Information about cybersecurity	3.7 (1.2)	4.9 (0.7)	3.3 (1.4)
Data and analysis	3.7 (1.2)	4.7 (0.8)	3.2 (1.5)
Information about the impacts of computing	3.7 (1.3)	4.8 (0.8)	3.4 (1.4)
Sum of 6 items above	22.0 (6.9)	28.7 (3.7)	20.4 (7.7)

Note. Treatment group (pre n = 48, post n = 43), control group (pre n = 44). 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 a > .8). Results indicated no change in treatment teacher confidence for culturally responsive teaching from pre- to post-PD, t (24) = 2.7, p = .63.

Table 31. Culturally Responsive Teaching Confidence

	Treatment		Control (Delayed Treatment)
Please indicate how confident you are that you can:	Pre Year 1 M (*SD*)	Post PD M (*SD*)	Pre Year 1 M (*SD*)
Identify ways that the school culture is different from my students' home culture.	4.1 (1.1)	4.4 (1.0)	4.1 (0.8)
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)	3.9 (0.9)
Develop a community of learners when my class consists of students from diverse backgrounds.	4.5 (1.0)	4.7 (0.9)	4.6 (0.8)
Use my students' cultural background to help make learning meaningful.	4.5 (0.9)	4.9 (0.9)	4.3 (0.9)
Use my students' prior knowledge to help them make sense of new information.	4.5 (1.0)	4.7 (0.9)	4.4 (0.8)
Revise instructional material to include a better representation of cultural groups.	4.3 (0.9)	4.5 (1.0)	4.3 (0.8)
Critically examine the curriculum to determine whether it reinforces negative cultural stereotypes.	4.1 (1.0)	4.6 (1.0)	4.1 (1.0)
Use examples that are familiar to students from diverse cultural backgrounds.	4.2 (1.0)	4.6 (1.0)	4.1 (1.0)
Sum of 8 items above (max 48)	34.1 (6.5)	36.7 (7.0)	33.8 (6.0)

Note. Treatment group (pre n = 47, post n = 43), control group (pre n = 42). 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 32. Culturally Responsive Teaching Frequency

Please indicate how often you do the following:	Group	Never (%)	Very Rarely (%)	Rarely (%)	Occassion-ally (%)	Fre-quently (%)	Always (%)
Spend time outside of class learning about the cultures and languages of my students.	Pre Year 1 Treatment	2.1	6.4	8.5	51.1	31.9	0
	Post PD Treatment	0	2.1	7.0	53.5	34.9	2.3
	Pre Year 1 Control	0	7.1	14.3	47.6	31.0	0
Make an effort to get to know my students' families and backgrounds.	Pre Year 1 Treatment	0	4.3	0	29.8	34.0	31.9
	Post PD Treatment	0	2.3	0	23.3	48.8	25.6
	Pre Year 1 Control	0	2.4	2.4	21.4	50.0	23.8
Examine class materials for culturally appropriate images and themes.	Pre Year 1 Treatment	2.1	2.1	6.4	27.7	46.8	4.9
	Post PD Treatment	0	2.3	0	18.6	60.5	18.6
	Pre Year 1 Control	0	0	11.9	21.4	47.6	19.0
Encourage students to use cross-cultural comparisons when analyzing material	Pre Year 1 Treatment	6.4	4.3	14.9	42.6	23.4	8.5
	Post PD Treatment	0	2.3	9.3	44.2	30.2	4.0
	Pre Year 1 Control	2.4	2.4	26.2	35.7	26.2	7.1

Note. Treatment group (pre n = 47, post n = 43), control group (pre n = 42). 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. Students took the assessment during class time or at home. Completion rates for CKACS components are shown in Table 33.

Table 33. Student Assessment

Condition	School Identifier	Target Grade	[1] Number Enrolled in Target Grade	Pre Number Completed Knowledge Items only	Pre Number Completed Affective Items only	Pre Number Completed Knowledge and Affective Items
Treatment (n =19)	Sanville	5	35	0	5	34
	Rich Valley	3	17	0	0	13
	Courthouse Road	5	133	9	0	108
	Ferrum	5	97	2	0	84
	Simonsdale	3	82	2	0	65
	Snow Creek	4	32	0	0	33
	Albert Harris	5	70	0	0	38
	Madison	4	84	0	0	13
	Powhatan	4	63	3	0	51
	Sinai	3	25	1	0	24
	Waterman	4, 5	94	1	0	73
	Dinwiddie	4	68	0	7	41
	Achilles	3	71	1	2	60
	Bethel	5	74	1	1	58
	Forrest	3	59	4	0	76
	Botetourt	5	99	0	0	66
	Chesterfield Academy	5	36	0	0	7
	Brighton	3	60	3	1	45
	Victory	3	80	7	0	63
	Total	--	1279	34	16	914

Table 33. Student Assessment (con't)

Condition	School Identifier	Target Grade	[1] Number Enrolled in Target Grade	Pre Number completed knowledge only	Pre Number Completed Affective Items only	Pre Number Completed Knowledge and Affective Items
Control (n = 18)	Norton	3	66	6	0	20
	Potomac	5	94	0	0	2
	Grafton Village	5	139	0	0	144
	TC McSwain	4	73	0	0	48
	Troutville	3	40	0	0	38
	Flatwoods	3	49	0	0	39
	Elydale	5	47	1	0	32
	Armel	3	122	5	4	63
	Richmond County	3	94	0	0	95
	Meadow View	5	107	0	6	102
	Henrico Virtual	4	66	0	0	1
	Lakeside	4	49	5	0	40
	Barack Obama	3	50	2	0	34
	Middlesex	3	91	1	0	88
	Westover Hills	3	48	0	30	3
	Oceanair	4	72	0	0	51
	Mary Peake	3	54	4	0	42
	Waterview	3	91	7	0	26
	Total	--	1352	31	40	868

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

CS Affective Outcomes

Below we provide outcomes for CS Affect (interest, confidence, utility) for students in treatment and control teacher classrooms. We are currently still analyzing CS knowledge items for Cohort 2 students. These analyses will be rerun after year 4 of the project when we have post-items and can combine Cohort 1 and Cohort 2 teachers' students.

Table 34. CS Affective Scores

	Pre Treatment M (SD) (n = 875)	Pre Control M (SD) (n = 903)
Confidence [1]	15.0 (4.0)	15.7 (4.3)
Interest [2]	12.8 (3.6)	13.2 (4.0)
Utility [3]	10.8 (3.0)	11.0 (3.2)
Overall Affect [4]	**38.6 (9.1)**	**39.8 (10.0)**

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.

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).

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 2022-23 reporting timeframe focused on teachers randomized into the treatment condition completing the microcredentials and teachers initially randomized into the control condition (delayed treatment teachers) completing learning bytes during the academic year following their participation in the ARCS Coaches Academy during the summer of 2022.

The ARCS professional development was implemented as proposed for both Cohort 1 treatment teachers completing the Microcredentials and for Cohort 1 control teachers completing the learning bytes. 21% (6/29) teachers completed the microcredentials during the 22-23 academic year and CodeVA data indicated none completed the learning bytes.

Few teachers in both the treatment (n = 4) and control (n = 12) conditions completed the year end surveys in the spring of 2023. However, teachers who did complete year-end surveys indicated positive perceptions of the Microcredentials and more mixed perceptions of the Learning Bytes and other Code VA online resources.

Most teachers who completed implementation-related questions indicated they taught at least one lesson that explicitly targeted CS Standards and percieved that their students were more engaged in CS than at the beginning of the year. Teachers also reported using the resources they received to teach CS concepts.

Because the Cohort 1 teachers were no longer in the for the RCT impact study, to reduce the burden on teachers, we collected student pre/post data for students but allowed teachers to do so at the classroom, rather than grade level. These data are currently being analyzed for ancillary papers with particular attention to students in Cohort 1 treatment teachers' classrooms; we plan to disaggregate student outcomes based on the time teachers completed the microcredentials (either during the academic year in which student data were collected or prior to the academic year in which student data were collected) to better understand if the timing of microcredential completion for teachers impacts student CS affect and knowledge outcomes.

Cohort 2

Recruitment

A primary focus of the ARCS team during 2023 was recruitment of a second cohort of teachers for the randomized control trial. Recruitment of the first cohort of RCT teachers in the winter/spring of 2021 was lower than anticipated due to the transition of schools back into full-time in-person learning and so the ARCS team worked diligently to meet the recruitment and randomization targets. Ultimately, the team successfully recruited 136 teachers from 54 schools across Virginia and 121 teachers from 48 schools, 24 schools (n = 60 teachers) were randomized into the treatment condition and 23 schools (n = 61 teachers) were randomized into the control condition. (The others were placed into a non-RCT condition because they did not meet the randomization criteria). Of these, 46 of 60 teachers completed the ARCS Code VA Coaches Academy during the summer of 2023. Importantly, a total of 40/106 (38%) teachers from rural designation districts were randomized.

Implementation

The ARCS professional development for Cohort 2 treatment teachers, which consisted of the CodeVA K-5 Summer Coaches Academy, was implemented as proposed. Modifications made to provide the ARCS Code VA Coaches Academy PD through asynchronous and synchronous components to accommodate for the COVID-19 Pandemic were retained for the RCT Cohort 2 treatment group teachers that completed the 2023 ARCS Code VA Coaches Academy.

Participant attendance and engagement were high during CodeVA K-5 Summer Coaches Academy for RCT Cohort 2 teachers. RCT Cohort 2 teachers reported positive perceptions of the ARCS PD on the post-survey (all means > 5.0).

Teacher Outcomes. Consistent with Cohort 1 results (see Annual Report 3), results for Cohort 2 treatment teachers indicated significant improvement in treatment teacher CS content knowledge, CS pedagogical knowledge, and CS self-efficacy following participation in the Code VA K-5 Coaches Academy.

Student Outcomes will be reported in the year 5 report. Following administration of the student pre-assessment, 19 schools remain in the treatment condition and 18 schools remain in the control condition of the analytic sample. Attrition from the analytic sample was primarily due to teachers being unable to administer the pre-assessment to students.

Recommendations

Our recommendations relate to three observations from the data related to the networked improvement community, microcredentials, and participant retention between years 1 and 2 of the treatment.

Networked Improvement Community. The Networked Improvement Community component of ARCS (Learning Bytes and other Code-VA online resources) appeared to be underutilized by participants. We recommend that ARCS continue to provide

(1) Provide more guidance and support to teachers on the requirements of the Networked Improvement Community (e.g., Learning Bytes) and expectations for use (e.g., frequency of access/engagement).
(2) Provide more CS-related resources (e.g., grade-specific lesson plans, videos) to teachers for academic year use.

Microcredentials. Despite overwhelmingly positive perceptions by teachers completing the microcredentials, few eligible teachers appeared to do so. Therefore, we recommend:

(1) Better support 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) Develop 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). In order to retain teachers for the entirety of the ARCS intervention, we recommend

(1) Maintaining 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, which may also improve 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., val-ues, norms, and prac-tices) is different from my students' home culture.						
42. Implement strategies to minimize the effects of any mismatch between my students' home cul-ture and the school cul-ture.						
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 infor-mation						
46. Revise instructional ma-terial to include a better representation of cultural groups.						
47. Critically examine the curriculum to determine whether it reinforces negative cultural stereo-types.						
48. Use examples that are fa-miliar to students from diverse cultural back-grounds.						

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 back-grounds.						
51. Examine class materials for cul-turally appropriate images and themes.						
52. Encourage students to use cross cultural comparisons when ana-lyzing material						

Content Knowledge Items and Rubric

What is computer science?

Met expectations (3)	Partially met expectations (2)	Did not meet expectations (1)	Did not know (0)
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.	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)	Did not know (0)
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.	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.

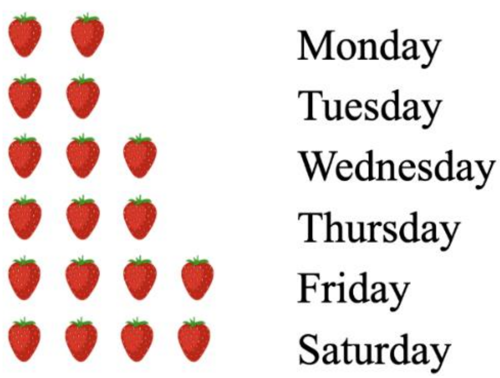
5. Which of the technologies listed below are ***computing technologies*** that you could teach the second graders about? (Select all that apply.)
   Internet search engine
   Light up sneakers
   Fidget spinner
   Smartphone application (software)/App

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

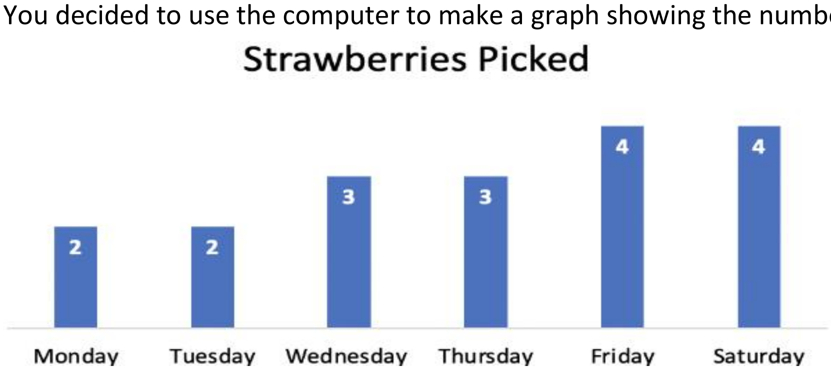
Once the plants have grown and strawberries appear, you pick them every day for six days. The following picture shows the number of strawberries that you picked each day.



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.

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.