ARCS External Evaluation
Year 3 Annual Report

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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.

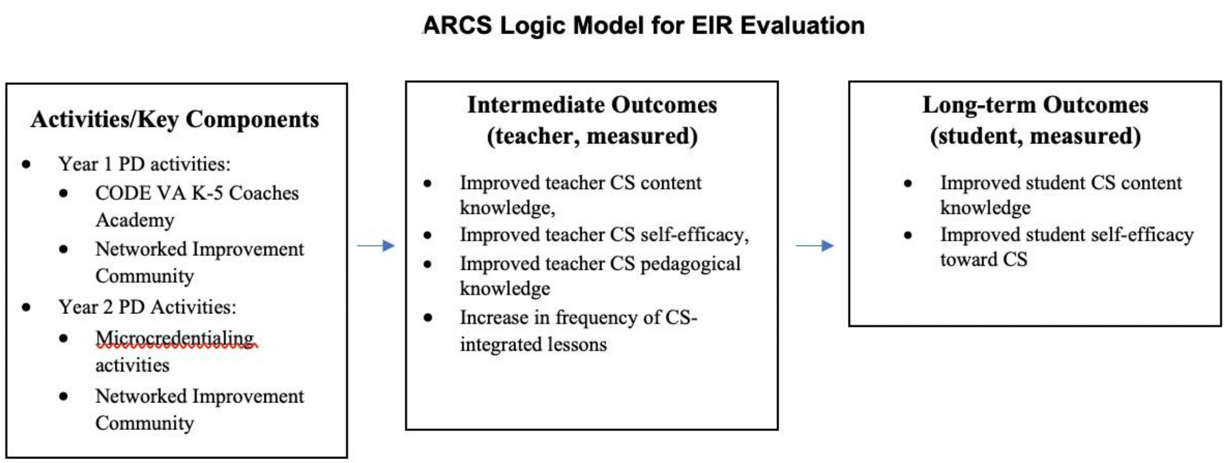

Figure 1. ARCS Logic Model

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- pilot year 2, treatment year 1, delayed treatment year 1) 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 in 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)
Year 1 Pre	Summer 2020	Summer 2021	Summer 2021
CodeVA Coaches Academy	Summer 2020	Summer 2021	Summer 2022
Year 1 Post (pilot and treatment)/ Year 2 Post (control)	Summer 2020	Summer 2021	Summer 2022
Year 1 Student Preassessment	Fall 2020	Fall 2021	Fall 2021
Mid-Year 1 Implementation Frequency	Winter 2020	Winter 2021	Winter 2022
Year 1 Student Post Assessment	Spring 2021	Spring 2022	Spring 2022
Year 1 End (pilot and treatment)/ Year 2 Pre (control)	Spring 2021	Spring 2022	Spring 2022
Microcredentials	Summer 2021 – September 30, 2022	Summer 2022- Summer 2023	Summer 2023-Summer 2024
Year 2 Student Preassessment	Fall 2021	Fall 2022	Fall 2022
Mid-Year 2 Implementation Frequency	Winter 2021	Winter 2022	Winter 2022
Year 2 Student Post Assessment	Spring 2022	Spring 2023	Spring 2023
Year 2 End	Spring 2022	Spring 2023	Spring 2023
Year 3 Student Preassessment	N/A	N/A	Fall 2023
Mid-Year 3 Implementation Frequency	N/A	N/A	Winter 2023
Year 3 Student Post Assessment	N/A	N/A	Spring 2024
Year 3 End	N/A	N/A	Spring 2024

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 October 1, 2021 to September 30, 2022 grant year, however, for context, we provide year 1 pilot cohort year 1 data.

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 3 Evaluation Activities

1. Submitted evaluation design summary, contrast tables, and fidelity matrix and worked with ABT liaison to respond to and integrate feedback into the registered design.
2. Administered student content knowledge instrument (CKACS) to students in RCT 1 Cohort classrooms.
3. Analyzed student RCT Cohort 1 data.
4. Documented 2022 summer PD attendance of RCT Cohort 1 control teachers.
5. Analysis of demographic data for elementary teachers in RCT Cohort 1.
6. Documented implementation of microcredentials for the pilot cohort and RCT Cohort 1 treatment teachers.
7. Administered and analyzed end-of-year assessments for RCT Cohort 1 teachers.
8. Administered and analyzed post-summer PD assessments to RCT Cohort 1 Control teachers.
9. Administered pre-CKACS to students in RCT Cohort 1 teacher classrooms in August/September 2022.
10. Submitted proposal to 2022 Annual EIR project directors and evaluators TA meeting.

Acknowledgments and Recommended Citation

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

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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 2022 ARCS CODE VA K-5 Coaches Academy was modified to be a five-day online PD consisting of asynchronous and synchronous components and four follow up days during the 2021-2022 academic year.

Participants attended five 3.5-hour synchronous sessions beginning June 27, 2022 and ending July 1 2022 with asynchronous meetings individually or in groups as well as office hours in the afternoon (Figure 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

Figure 2. 2022 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 (Year 1, 7.14 Coaches Academy PPT slide 21).

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 teachers in the Cohort 1 treatment group completed four "learning byte" modules; two in the fall and two in the spring.

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.

Frequency of Implementation (Appendix B).

This 17-item survey is administered at the end of the first semester and at the end of the school year. The purpose of this survey is to measure the implementation of CS instruction and teacher self-reported quality CS practices. The instrument assesses the number of lessons taught for each CS Standard of

Learning (SOL), student engagement during CS lessons for each SOL strand, and perceived changes in student engagement in CS.

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, Appendix E)

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.

Development, establishing support for face and content validity, and pilot testing of this instrument are described under "Other Evaluation Activities".

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.

Pilot Cohort

The documentation and evaluation of activities in this section represent a synthesis of the implementation data for ARCS that have been analyzed from the beginning of their participation in ARCS inn 2020 to present. These data were obtained through observations, document analysis, and surveys of participants.

Recruitment, Attrition, and Analytic Sample

Elementary teachers (n = 121) were recruited and started applications for the ARCS program. Ultimately, 90 teachers from 12 partner divisions completed applications and agreed to the informed consent. The ARCS program was advertised primarily via communication with division superintendents and central office staff as well as via Virginia Department of Education announcements. As of June 14, 2020, the first day of ARCS, 70 teachers began the CODE VA K-5 Coaches Academy and 67 completed it (96%).

Table 2. Pilot Elementary Study Randomization and Retention Data

	Applied n	Started ARCS n	Completed Year 1 (2020-2021) n	Completed Year 2 Microcredentials (2021-2022)
Schools	38	34	28	11
Teachers	78	70	67	12

Rural teacher participation

For this analysis, rural school divisions were defined based on Virginia School Division Locale Descriptions, as identified by the Virginia Department of Education[1]. Seventy-eight school divisions in Virginia meet the classification as “rural, distant,” “rural, fringe,” or “rural, remote.” Of the 12 divisions represented by ARCS Pilot Cohort participants, 10 meet the “rural, distant,” “rural, fringe,” or “rural, remote” designations. A total of 57/67 (85.1%) teachers from rural designation districts are participating in the ARCS PD.

Sample Demographics

Table 3 describes the demographic characteristics of the 67 elementary teachers who completed year 1 of ARCS professional development and Table 2 describes participants’ CS backgrounds. The mean years of teaching experience among participants were *M* = 14.0, *SD* = 9.3, with a minimum of 1 year of experience and a maximum of 42 years of experience. These data are self-report.

[1] http://www.doe.virginia.gov/directories/sch_division_locales_schedules/school_division_locale_descriptions.pdf

Table 3. Pilot Cohort Demographics

	Pilot Cohort N (%)
Gender[1]	
Male	2 (2.9)
Female	65 (94.2)
Race/Ethnicity[1]	
White	61 (88.4)
Black	4 (5.8)
Other	2 (2.9)
Hispanic	0 (0)
Has Ed Degree[2]	56 (81.2)
Elementary	45 (65.2)
Secondary	1 (1.4)
SPED	1 (1.4)
Ed Tech	1 (1.4)
Other[3]	9 (12.6)
Has STEM Degree[4]	2 (2.9)

Note. [1] Two participants declined to respond. [2] Four participants declined to respond. [3] Other degree includes childhood education, counselor education, education with teacher leadership, ESOL, gifted education, library science, middle school education, reading specialist, and research. [4]Three participants declined to respond.

Pilot Cohort Implementation Results

Perceptions of the PD

On Post (Summer 2020), Year 1-end (Spring 2021), and Year 2-end (Spring 2022) Surveys, items with Likert scales of 1-6, means over 4.0 were considered strong indicators while means below 4.0 indicated potential areas of weakness in program delivery. Overall, participants reported positive perceptions of the PD, with means for all items above 4.0 for all post- and year-end items (Table 4). Year-end survey responses indicated that most participants (75.9%) agreed or strongly agreed that the ARCS PD met their needs as a teacher leader and that they would integrate what they learned in the ARCS PD into their teaching (82.8%).

Table 4. Post and Year-end PD Perceptions

How strongly do you agree or disagree with the following statements?	Time	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	Post	0	1.7	0	6.9	39.7	51.7	4.9 (0.4)
	Year 1 End	0	0	0	6.9	62.1	31.0	5.2 (0.6)
	Year 2 End	0	0	0	0	54.5	45.5	5.5 (0.5)
2. The ARCS/Code VA K-5 Coaches Academy objectives were clear to me.	Post	0	0	8.6	8.6	43.1	39.7	4.7 (0.9)
	Year 1 End	0	0	3.4	20.7	48.3	27.6	4.9 (0.9)
	Year 2 End	0	0	0	18.2	54.5	45.5	5.3 (0.8)
3. The ARCS/Code VA K-5 Coaches Academy provided me with lesson plans that fit state standards.	Post	0	0	3.4	6.9	34.5	55.2	4.8 (0.6)
	Year 1 End	0	0	0	20.7	51.7	27.6	5.0 (0.8)
	Year 2 End	0	0	0	0	36.4	63.6	5.6 (0.5)

Note. post n = 58; year 1-end n = 30; year 2-end n = 11. For means, strongly disagree = 1, disagree = 2, somewhat disagree = 3, somewhat agree = 4, agree = 5, and strongly agree = 6.

Table 4. Post and Year-end PD Perceptions (Con't)

How strongly do you agree or disagree with the following statements?	Time	Strongly disagree (%)	Disagree (%)	Somewhat disagree (%)	Somewhat agree (%)	Agree (%)	Strongly Agree (%)	Mean (SD)
4. The facilitators had adequate knowledge of the subject.	Post	0	0	1.7	1.7	25.9	70.7	5.6 (0.7)
	Year 1 End	0	0	0	3.4	55.2	41.4	5.3 (0.6)
	Year 2 End	0	0	0	0	27.3	72.7	5.7 (0.5)
5. The facilitators created an atmosphere of trust and open communication.	Post	0	0	1.7	0	24.1	74.1	5.7 (0.7)
	Year 1 End	0	0	0	3.4	51.7	44.8	5.4 (0.6)
	Year 2 End	0	0	0	0	36.4	63.6	5.6 (0.5)
6. I am satisfied with my interactions with the facilitators	Post	0	0	1.7	1.7	32.8	63.8	5.6 (0.7)
	Year 1 End	0	0	0	13.8	41.4	44.8	5.3 (0.7)
	Year 2 End	0	0	0	0	36.4	63.6	5.6 (0.5)
7. As needed, the facilitators were available to answer questions and provide direction.	Post	0	0	1.7	3.4	22.4	72.4	5.6 (0.7)
	Year 1 End	0	3.4	0	6.9	41.4	48.3	5.3 (0.8)
	Year 2 End	0	0	0	9.1	36.4	54.5	5.5 (0.7)
8. I felt a rapport with other participants.	Post	0	0	0	12.1	44.8	43.1	5.3 (0.7)
	Year 1 End	0	3.4	0	24.1	48.3	24.1	4.9 (0.8)
	Year 2 End	0	0	9.1	18.2	54.5	18.2	4.8 (0.9)

Note. post n = 58; year 1-end n = 30; year 2-end n = 11. For means, strongly disagree = 1, disagree = 2, somewhat disagree = 3, somewhat agree = 4, agree = 5, and strongly agree = 6.

Table 4. Post and Year-end PD Perceptions (Con't)

How strongly do you agree or disagree with the following statements?	Time	Strongly disagree (%)	Disagree (%)	Somewhat disagree (%)	Somewhat agree (%)	Agree (%)	Strongly Agree (%)	Mean (SD)
9. I am satisfied with my interaction with my peers.	Post	0	0	0	8.6	48.3	43.1	5.3 (0.9)
	Year 1 End	0	3.4	3.4	6.9	65.5	20.7	5.0 (0.9)
	Year 2 End	0	0	0	18.2	63.6	18.2	5.0 (0.6)
10. I felt part of a learning community.	Post	0	0	0	13.8	37.9	48.3	5.3 (0.7)
	Year 1 End	0	3.4	3.4	10.3	55.2	27.6	5.0 (0.9)
	Year 2 End	0	0	0	18.2	63.6	18.2	5.0 (0.6)
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.	Post	0	15.5	3.4	13.8	37.9	29.3	5.3 (0.7)
	Year 1 End	0	6.9	10.3	13.8	37.9	34.5	4.8 (1.3)
	Year 2 End	0	9.1	18.2	9.1	36.3	27.3	4.5 (1.5)
12. The ARCS/Code VA K-5 Coaches Academy met my needs as a teacher-learner.	Post	0	0	5.2	19	43.1	32.8	5.0 (1.0)
	Year 1 End	0	3.4	10.3	13.8	41.4	34.5	4.8 (1.2)
	Year 2 End	0	0	9.1	18.2	36.4	36.4	4.9 (1.2)

Note. post n = 58; year 1-end n = 30; year 2-end n = 11. For means, strongly disagree = 1, disagree = 2, somewhat disagree = 3, somewhat agree = 4, agree = 5, and strongly agree = 6.

Table 4. Post and Year-end PD Perceptions (Con't)

How strongly do you agree or disagree with the following statements?	Time	Strongly disagree (%)	Disagree (%)	Somewhat disagree (%)	Somewhat agree (%)	Agree (%)	Strongly Agree (%)	Mean (SD)
13. I would recommend the ARCS/Code VA K-5 Coaches Academy to other colleagues.	Post	0	0	1.7	6.9	37.9	53.4	5.4 (0.8)
	Year 1 End	0	3.4	0	13.8	43.1	41.4	5.2 (0.8)
	Year 2 End	0	0	0	0	54.5	45.5	5.5 (0.5)
14. I will integrate what I learned … in my teaching.	Post	0	0	1.7	3.4	31.0	63.8	5.6 (0.7)
	Year 1 End	0	0	6.9	10.3	43.1	41.4	5.1 (1.1)
	Year 2 End	0	0	0	0	54.5	45.5	5.5 (0.5)

Note. post n = 58; year 1-end n = 30; year 2-end n = 11. For means, strongly disagree = 1, disagree = 2, somewhat disagree = 3, somewhat agree = 4, agree = 5, and strongly agree = 6.

Useful Components of the PD.

Year 1 End (2021). Participants' open-ended responses of the most useful component of the first year of the ARCS PD were categorized and closely mirrored those articulated at the end of the summer, with the exception that many more participants mentioned resources at the end of the year compared to after the summer component of the PD. These included: learning to integrate CS into their instruction (n = 18), the resources they received (n = 7), learning programming (n = 4), better understanding of CS concepts (n = 4), learning about the CS Standards (n = 3), lesson planning (n = 2), and collaborating with colleagues (n = 2).

Regarding the **value of learning to integrate CS** into their instruction, one participant wrote,

> *The most useful thing I learned was that you can integrate CS into literally any standard. Sometimes you might have to think outside the box, but it can be done with very little alterations done to previous lessons.*

Another similarly indicated,

> *That anyone can learn to use computers, taught me to be more confident and to try different lessons and implementation of those plans and to take plans I already had and put a computer science twist on them.*

Regarding **learning about the CS Standards**, participants referenced the usefulness of a thorough discussion of the CS Standards. For example, one participant indicated, *"I really appreciate the emphasis on finding overlaps between the Computer Science Standards and other (ex. English) Standards."*

Participants also identified programming as a beneficial outcome of the ARCS PD. One participant stated, "I really enjoyed learning about Scratch."

Regarding r**esource**s, one participant noted, "I really enjoyed getting to see how other people were using CS in their classrooms and learning about the numerous resources out there that are available to teachers."

Year 2 End (2022). At the end of the second year of PD, participants' open-ended responses of the most useful component of the ARCS PD indicated that they valued the PD experience in three major aspects: improving the ability to integrate CS into their instruction (n = 4), building up CS content and pedagogical knowledge (n = 4), and access to resources (n = 2).

Regarding the value of **improving the ability to integrate CS**, one participant commented:

> *I learned that computer science is not as "scary" or confusing as I previous thought. I can also integrate it into some parts of my curriculum and I can also teach it separately and still engage my students to teach them skills that will need in the future.*

Another similarly indicated:

> *I think the most useful thing I learned was integration--how to better merge CS SOLs with those of other subjects.*

Regarding the value of **building CS content and pedagogical knowledge**, participants indicated that PD helped them gain a better understanding of CS concepts and standards. For example, one participant highlighted that "*I now have a solid understanding of algorithms*." Another shared, "*I was daunted at first. I thought CS curriculum was something specifically for computer science teachers or programmers. I learned that Virginia has a CS curriculum and it can be incorporated into various lessons.*"

Participants also indicated that their **understanding of CS pedagogy also expanded** as a result of the PD. For example, one participant commented, "I *learned that computer science doesn't just have to be plugged-in activities. I also learned that there is plenty that kindergarteners can do with regards to computer science.*"

Regarding the access to **resource**s, one participant noted, "Activities do not have to have the newest and greatest resources/ robots and etc. Students enjoy unplugged activities, listening to stories about CS and etc."

Recommendations for Modification.

Year 1 End (2021). When asked for recommendations for modifications of the ARCS/CODE VA K-5 Coaches academy, 23 of the 31 respondents (74%) indicated that they had no recommendations for improvement. The most common recommendations were related to pacing (n = 3), modality (n = 9), organization (n = 2), content (n = 1), and other (n = 2).

In terms of **pacing**, most participants referenced a slower pace or more sessions. Comments exemplifying these recommendations included:

- *PD's were very long and doing break out rooms for one activity was fine, but doing it continuously was a little exhausting.*
- *Maybe separate sessions for information technology people & classroom teachers. There are clearly to different levels of experience and knowledge. I would much rather have been in an in-person type setting with people who were as inexperienced as me.*
- *Having the slides that could be pulled up and interacted with separately from the zoom was great, and it was nice to refer back to later, but it took a lot for rural internet service to keep it all going. Not sure how that could be modified to run together better.*
- *I hope that ARCS will continually reach out to us initial participants with more and more PD opps as time goes by. I'm looking forward to enhancing my learning in Summer #2 aka Summer 2021 with the self-paced learning c/o ODU. I welcome more and more. I also think there should always be an online option vs. just face-to-face PD.*

Participants were also asked about needed additional supports needed to implement what they learned. Of the 31 respondents 8 indicated they needed no further supports and 3 were unsure of the additional supports needed. Other responses related to time (n = 8), resources (n = 7), content (n = 4), content (n = 3), format (n = 3), and individual needs (n = 2).

Related to **time**, comments included:

- *I need to see how I can fit this into the different subject areas and time to teach some of this.*
- *Time to practice and review taught material.*
- *I just need more time with students!*

Related to **resources**, comments included:

- *I thought the online resources we explored through the follow-up assignments were awesome. I love free resources and I feel like in the CS world there are a ton of free*
- *resources.*
- *maybe video resource support to refer back to*
- *I'd like more reminders with more lesson plan links. The monthly newsletters are a good start. I'd also like some sort of "bare bones" pacing guide of sorts.*

Overall, participants appeared to appreciate the ARCS/CODE VA K-5 Coaches Academy as indicated by the following comment, “Learned lots! Thank you all!”

Year 2 End (2022). At the end of the second year of PD, 7 of the 11 teachers (64%) indicated that they had no recommendations for improvement. Generally, teachers’ recommendations are related to resources (n = 2), format of learning (n = 1), and PD access (n = 1).

In terms of **resources**, teachers indicated a lack of reading materials and course guidelines:

- *Less reading.*
- *A specific set of guidelines. I was confused a little on navigating the courses.*

In terms of **format** of learning, one teacher highlighted the value of in-person learning activities.

In-person learning was most impactful for me.

In terms of PD **access**, one teacher suggested expanding the PD access to school librarians:

Again, would recommend that ARCS/Code VA attempt a partnership with Virginia Association of School Librarians and/or Longwood School of Librarianship and further help us school librarians sharpen our CS skills, competencies, etc. and encourage us to share CS lessons with our kids.

Networked Improvement Community: Code VA NING PLC.

Participants reported on the utility of the NING for the purposes of understanding CS concepts and integrating CS standards into the core curriculum.

Table 5. Participant Use of CodeVA NIC

	Time	Not helpful at all	Not very helpful	Somewhat helpful	Helpful	Very helpful
Knowledge and understanding of CS concepts	Year 1 End (2021)	0 (0%)	2 (7.7%)	7 (26.9%)	18 (69.3%)	5 (19.2%)
	Year 2 End (2022)	0 (0%)	0 (0%)	3 (27.3%)	6 (54.5%)	2 (18.2%)
Integration of CS standards into your core curriculum	Year 1 End (2021)	0 (0%)	1 (3.8%)	10 (38.5%)	14 (43.9%)	5 (19.2%)
	Year 2 End (2022)	0 (0%)	0 (0%)	1 (9.1%)	6 (54.5%)	4 (36.4%)

Year 1 End (2021). ARCS participants (n = 35) used the CodeVA NING ARCS page during the 2020-21 academic year. Respondents on the year 1 end survey (n =30) reported using the CodeVA NING PLC for the ACRS project this year with varying frequencies. Of participants, 4 (13.3%) reported never using the NING PLC, 17 (56.7%) reported using it one or two times, and 9 (30%) reported using it about monthly. Participants also reported how they used the CodeVA NING PLC for the ARCS project during the school year (Figure 3).

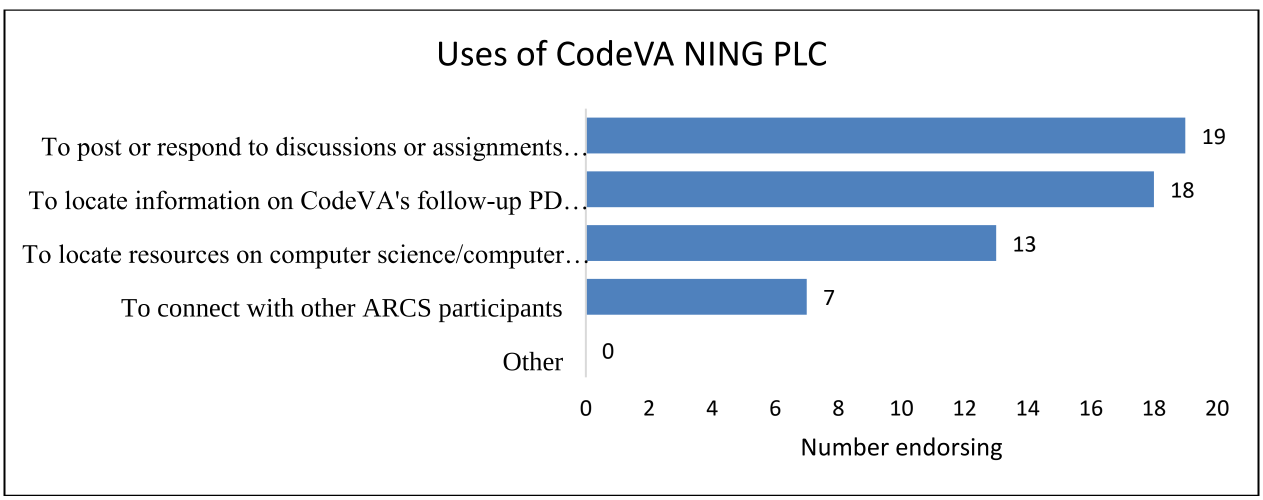

Figure 3. Participant use of the CodeVA NING PLC.

Participants also indicated how the CodeVA NING PLC could be more useful. Of 30 respondents, 4 indicated no changes were needed and 6 were unsure of changes that would increase the utility of the

NING. Responses indicating changes were categorized into 6 other categories: resources (n = 6), access (n = 5), time (n = 4), content (n = 3), modality (n = 2), and other (n = 2).
Representative comments related to **resources** included:

- *I would have loved to have video access of the zooms or some sort of quick summary videos.*
- *Perhaps make it more of a lesson plan clearinghouse?*
- *A database of questions and answers that anyone can ask and another can answer, sort of like a padlet of information and ideas.*

Representative comments related to **access** included:

- *I wasn't sure which PLC to join.*
- *Easier access.*
- *Post a link on VDOE website.*
- *Switching mid-session would not be advised in the future. There was a lot of sites/programs introduced all at once & often explanations were not given.*
- *More education about how to use and where to locate this resource. Most people didn't write or participate so hard to share and interact there.*

Related to **time**, comments included "In a normal year, I would have used the material. It wasn't that it wasn't useful, it was finding time for it" and "I think this year I wasn't able to use it as often as I would have liked because of the current school situation, not because it wasn't useful to use."
Related to **content**, teachers mentioned things like, "Maybe next steps for utilizing it in the classroom- like a template with a goal for new teachers to CS."
Related to **modality**, comments were equivocal with one participant noting:

> *For PD it's very frustrating to work with teachers who have little knowledge or experience using basic computer tools. I am hoping for a self-paced experience. I know we all learn at different levels but when someone can't open a PowerPoint… it's very frustrating. A remedial course might make everyone more comfortable. …there's just generational differences between groups of teachers that are frustrating rather than encouraging a sense of community.*

Another expressed the opposite desire for in-person PD, "I believe in-person learning is the key for me to better understand all aspect of CS."

Year 2 End (2022). Pilot teachers also reported on the NIC (i.e., CodeVA Connect, Learning Bytes) resources provided by CodeVA in Year 2. All but 1 on of the 11 respondents on the year 2 end survey indicated that they participated in at least one Code VA online training or event. Respondents on the year 2 end survey (n =11) reported using the CodeVA NIC this year with varying frequencies, 3 (27%) used it one or two times, 7 (63%) reported using it about monthly, and 1 (9.1%) reported using it weekly.

Open-ended comments regarding how to make the online resources more useful related to access (n = 2), content (n = 6), or were generally positive feedback about the PD.
Comments about **access** included:

- *Hard to keep track of the bitly after closing out.*
- *Can't think of any ways to make more useful- unless app creation with all of the resources available there but they are very useful the way they are*

Comments about content included:

- *I found the python programming too difficult.*
- *By providing additional training on coding and programming.*
- *It would be great if Code VA could provide us with more lesson plans--and here's to their being very do-able, easy-to-replicate ones. I'd also love a database of sorts (perhaps a Padlet) that links to picture books (or to reviews of such) that help promote computer science.*

- *Having materials in-hand has made the biggest difference while exploring.*
- *This ARCS class relied too much on reading which is not my best learning style.*
- *I think the Code-VA resources are user friendly.*

Microcredentials

As of October 26, 2021, 67 teachers were eligible and had access to complete the Microcredentials on a rolling schedule since July 1, 2021. As of June 30, 2022 (the end of the microcredentials period for the pilot cohort), 10 teachers completed all 5 microcredentials. Another 2 teachers completed the microcredentials as of September 30, 2022. Table 6 shows microcredential completion by course.

Pilot Cohort Teacher Outcomes

Of participants, n = 67 completed the preassessment and n = 60 completed the post-assessment; 58 participants completed both the pre- and post-assessment and were included in the analytic sample; 30 of the 58 participants completed the year-end- assessment. 11 of the 58 participants completed the year2-end assessment.

CS Content Knowledge

Results indicated participants' CS knowledge improved from pre-to post- participation in the Code VA K-5 Coaches Academy and that these improvements were retained post to year 1-end, $t(29) = .88$, $p = .39$ (Table 6). Improvements were also retained from pre to year 2-end, $t(10) = 2.3$, $p = .04$. From year 1 end to year 2 end, participants' CS knowledge significantly decreased, $t(8) = -2.3$, $p = .04$. Overall, this suggests that teachers' CS content knowledge generally improved across the two years of the ARCS PD, and that there was a slight regression between the end of year 1 and the end of year 2. These results should be interpreted with caution given the small number of teachers that completed the year 2 end survey.

Table 6. Content Knowledge

Item	Time	I don't know	Did not meet expectations	Partially met expectations	Met expectations	[1]Mean (SD)
1. What is computer science?	Pre	1.7%	24.1%	70.7%	3.4%	1.8 (0.5)
	Post	0%	3.4%	84.5%	12.1%	2.1 (0.4)
	Year 1 End	0%	16.7%	53.3%	30%	2.1 (0.7)
	Year 2 End	0	9.1%	63.6%	27.3%	2.2 (0.6)
2. Describe what a computer programmer does.	Pre	0%	8.6%	84.5%	6.9%	2.0 (0.4)
	Post	1.7%	15.5%	55.2%	26.7%	2.1 (0.7)
	Year 1 End	0%	10%	70%	20%	2.1 (0.6)
	Year 2 End	0	0	63.6%	36.4%	2.4 (0.5)

Note. pre n = 58, post n = 58, year 1 end n = 30, year 2 end n = 11; I don't know = 0, did not meet expectations = 1, partially met expectations = 2, met expectations = 3. [1] For means, I don't know and did not meet expectations are combined and coded as 1, max is 15. [2] *p* values are based on paired t-tests for pre to post, pre to year 1 end, pre to year 2 end.

Table 6. Content Knowledge (Con't)

Item	Time	I don't know	Did not meet expectations	Partially met expectations	Met expectations	[1]Mean (SD)
3. What makes a device a computer?	Pre	6.9%	55.2%	37.9%	0%	1.4 (0.5)
	Post	1.7%	10.3%	34.5%	53.4%	2.4 (0.7)
	Year 1 End	0%	16.7%	70%	13.3%	2.0 (0.6)
	Year 2 End	9.1%	54.5%	27.3%	9.1%	1.7 (0.8)
4. What is an algorithm?	Pre	1.7%	46.6%	25.9%	25.9%	1.8 (0.9)
	Post	0%	5.2%	50%	44.8%	2.4 (0.6)
	Year1 End	7.4%	0%	70.4%	22.2%	2.1 (0.5)
	Year 2 End	0	9.1%	63.6%	27.3%	2.2 (0.6)
5. In what ways is the term "variable" used differently in computer science than in math and science?	Pre	53.4%	31%	8.6%	6.9%	1.2 (0.6)
	Post	27.6%	36.2%	13.8%	22.4%	1.5 (0.9)
	Year 1 End	13.8%	3.4%	58.6%	24.1%	2.1 (0.7)
	Year 2 End	9.1%	54.5%	27.3%	9.1%	1.4 (0.8)
		Sum of 5 items above *M* (*SD*)			[2]*p*	
	Pre	8.2 (1.5)			__	
	Post	10.6 (1.9)			< .001	
	Year 1 End	10.4 (1.6)			< .001	
	Year 2 End	9.8 (1.6)			= . 04	

Note. pre n = 58, post n = 58, year 1 end n = 30, year 2 end n = 11; I don't know = 0, did not meet expectations = 1, partially met expectations = 2, met expectations = 3. [1] For means, I don't know and did not meet expectations are combined and coded as 1, max is 15. [2] *p* values are based on paired t-tests for pre to post, pre to year 1 end, pre to year 2 end.

CS Pedagogical Knowledge

Pedagogical knowledge was measured through several scales with high reliability (Cronbach's $\alpha > .8$). Results indicated significant improvement in participant experience programming, teaching programming, and integrating CS SOLs from pre- to post- and pre- to year 1-end. Increases in experience were retained from pre-to year 2-end (all *p*'s < .05). Improvements in teachers' experience programing (t (9) = .6, p = .6), teaching programming (t (9) = .9, p = .4), and integrating CS SOLs (t (9) = 1.7, p = .1) from year-1-end to year-2-end were not significant. These results suggest that teachers' experience improved and then was retained across the 2-year ARCS PD; these results should be interpreted with caution given the small number of respondents on the year 2-end survey.

Table 7. Experience Programming

Rate your experience:	Group	Very inexperienced	Inexperienced	Somewhat inexperienced	Somewhat experienced	Experienced	Very Experienced
1. Programming (any language)	Pre	44.8%	19.0%	20.7%	13.8%	1.7%	0%
	Post	5.2%	19.0%	25.9%	36.2%	13.8%	0%
	Year 1 End	10.3%	10.3%	31.0%	37.9%	10.3%	0%
	Year 2 End	0%	8.3%	16.7%	50%	25%	0%
2. Coding in a block language (e.g., Scratch)	Pre	46.6%	20.7%	8.6%	19.0%	3.4%	1.7%
	Post	1.7%	10.3%	24.1%	41.4%	20.7%	1.7%
	Year 1 End	6.9%	10.3%	24.1%	27.6%	27.6%	3.4%
	Year 2 End	0%	0%	25%	25%	41.7%	8.3%
3. Coding in a text-based language (e.g., Python)	Pre	60.3%	22.4%	8.6%	6.9%	1.7%	0%
	Post	32.8%	27.6%	17.2%	19.0%	3.4%	0%
	Year 1 End	24.1%	6.9%	37.9%	27.6%	3.4%	0%
	Year 2 End	16.7%	0%	50%	25%	8.3%	0%

Note. Note. pre n = 58, post n = 58, year 1 end n = 32, year 2 end n = 12. Each item scored 1-6. Cronbach's α pre = .86, Cronbach's α post = .80, Cronbach's α year end = .87. [1] *p* values are based on paired t-tests for pre to post, pre to year 1 end, pre to year 2 end.

Table 7. Experience Programming (Con't)

Rate your experience:	Group	Very inexperienced	Inexperienced	Somewhat inexperienced	Somewhat experienced	Experienced	Very Experienced
4. Running an "Hour of Code" event	Pre	31.0%	25.9%	13.8%	20.7%	5.2%	3.4%
	Post	19.0%	17.2%	13.8%	29.3%	12.1%	8.6%
	Year 1 End	13.8%	13.8%	20.7%	24.1%	10.3%	17.2%
	Year 2 End	0%	8.3%	25%	16.7%	33.3%	16.7%
		Sum of 4 items above *M* (*SD*)			[1] *p*		
	Pre	8.5 (4.3)			.00		
	Post	12.7 (4.0)					
	Year 1 End	13.3 (4.5)			.001		
	Year 2 End	15.6(3.5)			<.001		

Note. pre n = 58, post n = 58, year 1 end n = 32, year 2 end n = 12. Each item scored 1-6. Cronbach's α pre = .86, Cronbach's α post = .80, Cronbach's α year end = .87. [1] *p* values are based on paired t-tests for pre to post, pre to year 1 end, pre to year 2 end.

Table 8. Experience Teaching Programming

Rate your experience:	Group	Very inexperienced	Inexperienced	Somewhat inexperienced	Somewhat experienced	Experienced	Very Experienced
1. Teaching Programming (any language)	Pre	53.4%	20.7%	12.1%	13.8%	0%	0%
	Post	13.8%	19.0%	24.1%	39.7%	3.4%	0%
	Year 1 End	10.3%	27.6%	24.1%	13.8%	24.1%	0%
	Year 2 End	0%	8.3%	16.7%	41.7%	33.3%	0%
2. Teaching coding in a block language	Pre	50.0%	17.2%	10.3%	19.0%	1.7%	1.7%
	Post	8.6%	22.4%	19.0%	34.5%	13.8%	1.7%
	Year 1 End	10.3%	27.6%	20.7%	13.8%	17.2%	10.3%
	Year 2 End	8.3%	8.3%	25%	8.3%	33.3%	16.7%
3. Teaching coding in a text-based language	Pre	60.3%	22.4%	13.8%	3.4%	0%	0%
	Post	37.9%	27.6%	22.4%	12.1%	0%	0%
	Year 1 End	24.1%	31.0%	31.0%	10.3%	3.4%	0%
	Year 2 End	16.7%	16.7%	33.3%	16.7%	8.3%	8.3%
		Sum of 3 items above *M* (*SD*)			[1] *p*		
	Pre	5.6 (3.0)			.00		
	Post	8.4 (2.9)					
	Year 1 End	8.8 (3.7)			.001		
	Year 2 End	11.1(3.7)			<.001		

Note. pre n = 58, post n = 58, year 1 end n = 32, year 2 end n = 12. Each item scored 1-6. Cronbach's α pre = .88, Cronbach's α post = .81, Cronbach's α year-end = .91. [1] *p* values are based on paired t-tests for pre to post, pre to year 1 end, pre to year 2 end.

Table 9. Experience Integrating CS SOLs

Rate your experience integrating the following into your K-12 instruction:	Group	Very inexperienced	Inexperienced	Somewhat inexperienced	Somewhat experienced	Experienced	Very Experienced
1. The Virginia Computer Science Standards	Pre	19.0%	24.1%	20.7%	29.3%	5.2%	1.7%
	Post	5.2%	6.9%	25.9%	34.5%	24.1%	3.4%
	Year 1 End	3.4%	0%	0%	65.5%	27.6%	3.4%
	Year 2 End	0%	0%	8.3%	25%	33.3%	33.3%
2. Algorithms and programming	Pre	46.6%	17.2%	13.8%	22.4%	0%	0%
	Post	6.9%	3.4%	34.5%	37.9%	13.8%	3.4%
	Year 1 End	3.4%	6.9%	20.7%	48.3%	13.8%	6.9%
	Year 2 End	0%	0%	8.3%	25%	50%	16.7%
3. Information about computer systems	Pre	32.8%	24.1%	10.3%	27.6%	5.2%	0%
	Post	6.9%	6.9%	36.2%	31.0%	17.2%	1.7%
	Year 1 End	3.4%	3.4%	17.2%	58.6%	10.3%	6.9%
	Year 2 End	0%	0%	16.7%	8.3%	58.3%	16.7%

Note. pre n = 58, post n = 58, year 1 end n = 32, year 2 end n = 12. Each item scored 1-6. Cronbach's α pre = .95, Cronbach's α post = .95, Cronbach's α year-end = .95. [1] *p* values are based on paired t-tests for pre to post, pre to year 1 end, pre to year 2 end.

Table 9. Experience Integrating CS SOLs (Con't)

Rate your experience integrating the following into your K-12 instruction:	Group	Very inexperienced	Inexperienced	Somewhat inexperienced	Somewhat experienced	Experienced	Very Experienced
4. Algorithms and programming	Pre	46.6%	17.2%	13.8%	22.4%	0%	0%
	Post	6.9%	3.4%	34.5%	37.9%	13.8%	3.4%
	Year 1 End	3.4%	6.9%	20.7%	48.3%	13.8%	6.9%
	Year 2 End	0%	0%	8.3%	25%	50%	16.7%
5. Information about computer systems	Pre	32.8%	24.1%	10.3%	27.6%	5.2%	0%
	Post	6.9%	6.9%	36.2%	31.0%	17.2%	1.7%
	Year 1 End	3.4%	3.4%	17.2%	58.6%	10.3%	6.9%
	Year 2 End	0%	0%	16.7%	8.3%	58.3%	16.7%
6. Information about cybersecurity	Pre	29.3%	15.5%	15.5%	31.0%	6.9%	1.7%
	Post	6.9%	5.2%	29.3%	37.9%	17.2%	3.4%
	Year 1 End	3.4%	3.4%	3.4%	72.4%	6.9%	10.3%
	Year 2 End	0%	0%	8.3%	25%	50%	16.7%
7. Data and analysis	Pre	27.6%	17.2%	24.1%	22.4%	6.9%	1.7%
	Post	6.9%	5.2%	31.0%	39.7%	13.8%	3.4%
	Year 1 End	6.9%	6.9%	20.7%	51.7%	6.9%	6.9%
	Year 2 End	0%	8.3%	16.7%	25%	33.3%	16.7%

Note. pre n = 58, post n = 58, year 1 end n = 32, year 2 end n = 12. Each item scored 1-6. Cronbach's α pre = .95, Cronbach's α post = .95, Cronbach's α year-end = .95. [1] *p* values are based on paired t-tests for pre to post, pre to year 1 end, pre to year 2 end.

Table 9. Experience Integrating CS SOLs (Con't)

Rate your experience integrating the following into your K-12 instruction:	Group	Very inexperienced	Inexperienced	Somewhat inexperienced	Somewhat experienced	Experienced	Very Experienced
8. Information about the impacts of computing	Pre	31.0%	19.0%	19.0%	25.9%	5.2%	0%
	Post	3.4%	5.2%	32.8%	39.7%	17.2%	1.7%
	Year 1 End	3.4%	10.3%	24.1%	44.8%	10.3%	6.9%
	Year 2 End	0%	0%	8.3%	33.3%	41.7%	16.7%
		Sum of 6 items above *M* (*SD*)			[1] *p*		
	Pre	15.4 (7.1)			.00		
	Post	21.7 (6.0)					
	Year 1 End	23.4 (5.6)			.001		
	Year 2 End	28.3 (5.6)			<.001		

Note. pre n = 58, post n = 58, year 1 end n = 32, year 2 end n = 12. Each item scored 1-6. Cronbach's α pre = .95, Cronbach's α post = .95, Cronbach's α year-end = .95. [1] *p* values are based on paired t-tests for pre to post, pre to year 1 end, pre to year 2 end.

Table 10. Other Items Related to Pedagogical Knowledge

How strongly do you agree or disagree with the following statements?	Group	Strongly Disagree	Disagree	Somewhat Disagree	Somewhat Agree	Agree	Strongly Agree
1. I understand what computer science is.	Pre	0%	3.4%	12.1%	39.7%	37.9%	6.9%
	Post	1.7%	0%	0%	10.3%	55.2%	32.8%
	Year 1 End	0%	0%	0%	13.8%	62.1%	24.1%
	Year 2 End	0%	0%	0%	16.7%	25%	58.3%

Note. pre n = 58, post n = 58, year 1 end n = 32, year 2 end n = 12. Each item scored 1-6.

Table 10. Other Items Related to Pedagogical Knowledge (Con't)

How strongly do you agree or disagree with the following statements?	Group	Strongly Disagree	Disagree	Somewhat Disagree	Somewhat Agree	Agree	Strongly Agree
2. I am familiar with my school division's plan for computer science education at the K-5 level.	Pre	3.4%	12.1%	15.5%	41.4%	24.1%	3.4%
	Post	0%	3.4%	10.3%	37.9%	36.2%	12.1%
	Year 1 End	0%	6.9%	17.2%	44.8%	24.1%	6.9%
	Year 2 End	0%	16.7%	0%	25%	33.3%	25%
3. I can engage students from rural areas in computer science.	Pre	1.7%	1.7%	5.2%	36.2%	39.7%	15.5%
	Post	0%	0%	0%	15.5%	55.2%	29.3%
	Year 1 End	0%	0%	0%	24.1%	65.5%	10.3%
	Year 2 End	0%	0%	0%	16.7%	33.3%	50%
4. I can engage students from low socioeconomic backgrounds in computer science.	Pre	1.7%	0%	3.4%	31.0%	50.0%	13.8%
	Post	0%	0%	0%	13.8	55.2%	31.0%
	Year 1 End	0%	0%	0%	24.1%	55.2%	20.7%
	Year 2 End	0%	0%	0%	25%	25%	50%
5. I can engage students who are traditionally underrepresented in STEM in computer science	Pre	1.7%	1.7%	5.2 %	27.6%	48.3%	15.5%
	Post	0%	0%	0%	12.1%	55.2%	32.8%
	Year 1 End	0%	0%	0%	23.3%	56.7%	20%
	Year 2 End	0%	0%	0%	25%	33.3%	41.7%

Note. pre n = 58, post n = 58, year 1 end n = 32, year 2 end n = 12. Each item scored 1-6.

Table 10. Other Items Related to Pedagogical Knowledge (Con't)

How strongly do you agree or disagree with the following statements?	Group	Strongly Disagree	Disagree	Somewhat Disagree	Somewhat Agree	Agree	Strongly Agree
6. I can address issues of access to computer technologies for students in my school.	Pre	3.4%	5.2%	17.2%	29.3%	39.7%	5.2%
	Post	1.7%	1.7%	5.2%	37.9%	41.4%	12.1%
	Year 1 End	0%	3.4%	10.3%	24.1%	44.8%	17.2%
	Year 2 End	0%	8.3%	8.3%	16.7%	41.7%	25%
7. I can address issues of access to computer technologies for students in my school.	Pre	3.4%	5.2%	17.2%	29.3%	39.7%	5.2%
	Post	1.7%	1.7%	5.2%	37.9%	41.4%	12.1%
	Year 1 End	0%	3.4%	10.3%	24.1%	44.8%	17.2%
	Year 2 End	0%	8.3%	8.3%	16.7%	41.7%	25%

Note. pre n = 58, post n = 58, year 1 end n = 32, year 2 end n = 12. Each item scored 1-6.

CS Self-efficacy and Confidence

CS self-efficacy and confidence were measured through several scales with high reliability (Cronbach's α > .7). Results indicated significant improvement in participant self-efficacy for teaching CS, confidence programming, confidence teaching programming, and confidence integrating CS SOLs from pre- to post and pre- to year- 1 end. These improvements were retained from pre to year 2 end (all *p*'s < .05). There was no significant difference in self-efficacy ($t(9) = .9$, $p = .4$), confidence in programming ($t(9) = .4$, $p = .7$), confidence in teaching programming ($t(9) = 1.8$, $p = .1$), or confidence in integrating CS SOLs ($t(9) = .4$, $p = .7$) from year-1-end to year-2-end. These results suggest that teacher confidence and self-efficacy improved and then was retained across the 2-year ARCS PD; these results should be interpreted with caution given the small number of respondents on the year 2-end survey.

Table 11. Self Efficacy Scale

How strongly do you agree or disagree with the following statements	Group	Strongly Disagree	Disagree	Somewhat Disagree	Somewhat Agree	Agree	Strongly Agree
1. I feel confident using computer technology.	Pre	1.7%	5.2%	5.2%	24.1%	36.2%	27.6%
	Post	0%	0%	0%	19.0%	55.2%	25.9%
	Year 1 End	0%	0%	0%	27.6%	34.5%	37.9%
	Year 2 End	0%	0%	0%	16.7%	33.3%	50%
2. I know how to teach programming concepts effectively.	Pre	13.8%	29.3%	31.0%	17.2%	6.9%	1.7%
	Post	1.7%	1.7%	10.3%	53.4%	25.9%	6.9%
	Year 1 End	3.4%	6.9%	10.3%	44.8%	24.1%	10.3%
	Year 2 End	0%	8.3%	0	33.3%	41.7%	16.7%
3. I feel confident writing simple programs for the computer.	Pre	31.0%	37.9%	19.0%	8.6%	3.4%	0%
	Post	3.4%	8.6%	20.7%	34.5%	24.1%	8.6%
	Year 1 End	3.4%	13.8%	24.1%	27.6%	13.8%	17.2%
	Year 2 End	0%	16.7%	8.3%	33.3%	25%	16.7%

Note. pre n = 58, post n = 58, year 1 end n = 32, year 2 end n = 12. Each item scored 1-6. Cronbach's α pre = .92, Cronbach's α post = .92, Cronbach's α year-end = .93.[1] *p* values are based on paired t-tests for pre to post, pre to year 1 end, pre to year 2 end.

Table 11. Self Efficacy Scale (Con't)

How strongly do you agree or disagree with the following statements	Group	Strongly Disagree	Disagree	Somewhat Disagree	Somewhat Agree	Agree	Strongly Agree
4. I can promote a positive attitude toward programming in my students.	Pre	0%	1.7%	5.2%	27.6%	32.8%	32.8%
	Post	0%	0%	0%	10.3%	44.8%	44.8%
	Year 1 End	0%	0%	0%	17.2%	41.4%	41.4%
	Year 2 End	0%	0%	0%	16.7%	33.3%	50%
5. I can guide students in using programming as a tool while we explore other topics.	Pre	8.6%	10.3%	13.8%	29.3%	27.6%	10.3%
	Post	1.7%	3.4%	0%	32.8%	39.7%	22.4%
	Year 1 End	0%	3.4%	10.3%	41.4%	27.6%	17.2%
	Year 2 End	0%	0%	8.3%	33.3%	8.3%	50%
6. I feel confident using programming as an instructional tool within my classroom.	Pre	13.8%	25.9%	20.7%	25.9%	8.6%	5.2%
	Post	1.7%	1.7%	8.6%	27.6%	43.1%	17.2%
	Year 1 End	0%	6.0%	13.8%	41.4%	20.7%	17.2%
	Year 2 End	0%	0%	25%	8.3%	33.3%	33.3%
7. I can promote a positive attitude toward programming in my students.	Pre	0%	1.7%	5.2%	27.6%	32.8%	32.8%
	Post	0%	0%	0%	10.3%	44.8%	44.8%
	Year 1 End	0%	0%	0%	17.2%	41.4%	41.4%
	Year 2 End	0%	0%	0%	16.7%	33.3%	50%
8. I can guide students in using programming as a tool while we explore other topics.	Pre	8.6%	10.3%	13.8%	29.3%	27.6%	10.3%
	Post	1.7%	3.4%	0%	32.8%	39.7%	22.4%
	Year 1 End	0%	3.4%	10.3%	41.4%	27.6%	17.2%
	Year 2 End	0%	0%	8.3%	33.3%	8.3%	50%

Table 11. Self Efficacy Scale (Con't)

How strongly do you agree or disagree with the following statements	Group	Strongly Disagree	Disagree	Somewhat Disagree	Somewhat Agree	Agree	Strongly Agree
9. I feel confident using programming as an instructional tool within my classroom.	Pre	13.8%	25.9%	20.7%	25.9%	8.6%	5.2%
	Post	1.7%	1.7%	8.6%	27.6%	43.1%	17.2%
	Year 1 End	0%	6.0%	13.8%	41.4%	20.7%	17.2%
	Year 2 End	0%	0%	25%	8.3%	33.3%	33.3%
10. I can adapt lesson plans incorporating programming as an instructional tool.	Pre	8.6%	15.5%	15.5%	36.2%	12.1%	12.1%
	Post	1.7%	1.7%	0%	22.4%	51.7%	22.4%
	Year 1 End	0%	6.9%	3.4%	48.3%	24.1%	17.2%
	Year 2 End	0%	0%	8.3%	33.3%	25%	33.3%
11. I can create original lesson plans incorporating programming as an instructional tool.	Pre	10.3%	20.7%	13.8%	43.1%	8.6%	3.4%
	Post	1.7%	5.2%	0%	27.6%	44.8%	20.7%
	Year 1 End	0%	3.4%	13.8%	41.4%	31.0%	10.3%
	Year 2 End	0%	8.3%	8.3%	41.7%	16.7%	25%
12. I can identify how programming concepts relate to the Virginia Standards of Learning.	Pre	6.9%	10.3%	8.6%	44.8%	22.4%	6.9%
	Post	0%	0%	0%	19.0%	50.0%	31.0%
	Year 1 End	0%	3.4%	3.4%	37.9%	31.0%	24.1%
	Year 2 End	0%	0%	0%	25%	50%	25%

Note. pre n = 58, post n = 58, year 1 end n = 32, year 2 end n = 12. Each item scored 1-6. Cronbach's α pre = .92, Cronbach's α post = .92, Cronbach's α year-end = .93.[1] *p* values are based on paired t-tests for pre to post, pre to year 1 end, pre to year 2 end.

Table 11. Self Efficacy Scale (Con't)

How strongly do you agree or disagree with the following statements	Group	Strongly Disagree	Disagree	Somewhat Disagree	Somewhat Agree	Agree	Strongly Agree
		Sum of 9 Items Above *M* (*SD*)			[1] *p*		
	Pre	32.3 (8.8)			.001		
	Post	42.7 (6.4)					
	Year 1 End	40.5 (7.7)			.001		
	Year 2 End	43.4(8.3)			.002		

Note. pre n = 58, post n = 58, year 1 end n = 32, year 2 end n = 12. Each item scored 1-6. Cronbach's α pre = .92, Cronbach's α post = .92, Cronbach's α year-end = .93.[1] *p* values are based on paired t-tests for pre to post, pre to year 1 end, pre to year 2 end.

Table 12. Confidence Programming

Rate your confidence with the following:	Group	Not at all confident	Unconfiden t	Somewhat unconfident	Somewhat confident	Confident	Very Confident
1. Programming (any language)	Pre	32.8%	34.5%	13.8%	17.2%	1.7%	0%
	Post	3.4%	13.8%	17.2%	48.3%	17.2%	0%
	Year 1 End	6.9%	3.4%	27.6%	48.3%	13.8%	0%
	Year 2 End	0%	0%	25%	50%	25%	0%
2. Coding in a block language	Pre	37.9%	25.9%	15.5%	15.5%	5.2%	0%
	Post	1.7%	0%	8.6%	56.9%	29.3%	3.4%
	Year 1 End	3.4%	3.4%	17.2%	37.9%	27.6%	10.3%
	Year 2 End	0%	0%	25%	33.3%	41.7%	0%

Note. pre n = 58, post n = 58, year 1 end n = 32, year 2 end n = 12. Each item scored 1-6. Cronbach's α pre = .80, Cronbach's α post = .71, Cronbach's α year-end = .86.[1] *p* values are based on paired t-tests for pre to post, pre to year 1 end, pre to year 2 end.

Table 12. Confidence Programming (Con't)

Rate your confidence with the following:	Group	Not at all confident	Unconfiden t	Somewhat unconfident	Somewhat confident	Confident	Very Confident
3. Coding in a text-based language	Pre	51.7%	34.5%	6.9%	5.2%	1.7%	0%
	Post	24.1%	31.0%	12.1%	27.6%	5.2%	0%
	Year 1 End	20.7%	13.8%	24.1%	37.9%	3.4%	0%
	Year 2 End	8.3%	16.7%	33.3%	33.3%	8.3%	0%
4. Running an "Hour of Code" event	Pre	25.9%	24.1%	15.5%	19.0%	10.3%	5.2%
	Post	6.9%	8.6%	6.9%	37.9%	27.6%	12.1%
	Year 1 End	13.8%	6.9%	10.3%	27.6%	24.1%	17.2%
	Year 2 End	0%	0%	16.7%	25%	8.3%	50%
		Sum of 9 Items Above *M* (*SD*)			[1] *p*		
	Pre	9.0 (4.0)			--		
	Post	14.5 (3.3)			.00		
	Year 1 End	14.6 (4.3)			.001		
	Year 2 End	16.3 (3.4)			.001		

Note. pre n = 58, post n = 58, year 1 end n = 32, year 2 end n = 12. Each item scored 1-6. Cronbach's α pre = .80, Cronbach's α post = .71, Cronbach's α year-end = .86.[1] *p* values are based on paired t-tests for pre to post, pre to year 1 end, pre to year 2 end.

Table 13. Confidence Teaching Programming

Rate your confidence with the following:	Group	Not at all confident	Unconfiden t	Somewhat unconfident	Somewhat confident	Confident	Very Confident
1. Teaching Programming (any language)	Pre	39.7%	29.3%	17.2%	12.1%	1.7%	0%
	Post	5.2%	13.8%	17.2%	48.3%	15.5%	0%
	Year 1 End	6.9%	10.3%	31.0%	34.5%	17.2%	0%
	Year 2 End	0%	0%	16.7%	58.3%	25%	0%
2. Teaching coding in a block language	Pre	41.4%	22.4%	10.3%	22.4%	3.4%	0%
	Post	1.7%	1.7%	13.8%	46.6%	32.8%	3.4%
	Year 1 End	3.4%	10.3%	24.1%	24.1%	27.6%	10.3%
	Year 2 End	0%	0%	16.7%	33.3%	41.7%	8.3%
3. Teaching coding in a text-based language	Pre	51.7%	31.0%	10.3%	5.2%	1.7%	0%
	Post	29.3%	24.1%	25.9%	19.0%	1.7%	0%
	Year 1 End	24.1%	13.8%	37.9%	13.8.%	10.3%	0%
	Year 2 End	8.3%	16.7%	33.3%	33.3%	8.3%	0%
		Sum of 3 items above *M* (*SD*)			[1] *p*		
	Pre	6.1 (3.0)			.001		
	Post	10.1 (2.5)					
	Year 1 End	10.1 (3.3)			.001		
	Year 2 End	11.7(2.2)			.002		

Note. pre n = 58, post n = 58, year 1 end n = 32, year 2 end n = 12. Each item scored 1-6. Cronbach's α pre = .83, Cronbach's α post = .73, Cronbach's α year-end = .85. [1] *p* values are based on paired t-tests for pre to post, pre to year 1 end, pre to year 2 end.

Table 14. Confidence Integrating CS SOLs

Rate your confidence integrating the following into your K-12 instruction:	Group	Not at all confident	Unconfident	Somewhat unconfident	Somewhat confident	Confident	Very Confident
1. The Virginia Computer Science Standards	Pre	8.6%	19.0%	22.4%	31.0%	15.5%	3.4%
	Post	0%	3.4%	1.7%	15.5%	58.6%	20.7%
	Year 1 End	0%	0%	0%	27.6%	48.3%	24.1%
	Year 2 End	0%	0%	0%	8.3%	50%	41.7%
2. Algorithms and programming	Pre	25.9%	24.1%	24.1%	22.4%	3.4%	0%
	Post	1.7%	3.4%	10.3%	19.0%	53.4%	12.1%
	Year 1 End	0%	0%	17.2%	34.5%	34.5%	13.8%
	Year 2 End	0%	0%	0%	8.3%	58.3%	33.3%
3. Information about computer systems	Pre	22.4%	17.2%	25.9%	22.4%	10.3%	1.7%
	Post	1.7%	5.2%	3.4%	32.8%	48.3%	8.6%
	Year 1 End	0%	0%	6.9%	37.9%	37.9%	17.2%
	Year 2 End	0%	0%	8.3%	16.7%	50%	25%
4. Information about cybersecurity	Pre	10.3%	15.5%	24.1%	32.8%	15.5%	1.7%
	Post	5.2%	5.2%	3.4%	24.1%	48.3%	13.8%
	Year 1 End	0%	0%	0%	31.0%	51.7%	17.2%
	Year 2 End	0%	0%	8.3%	16.7%	50%	25%

Note. pre n = 58, post n = 58, year 1 end n = 32, year 2 end n = 12. Each item scored 1-6. Cronbach's α pre = .93, Cronbach's α post = .93, Cronbach's α year-end = .93. [1] *p* values are based on paired t-tests for pre to post, pre to year 1 end, pre to year 2 end.

Table 14. Confidence Integrating CS SOLs (Con't)

Rate your confidence integrating the following into your K-12 instruction:	Group	Not at all confident	Unconfident	Somewhat unconfident	Somewhat confident	Confident	Very Confident
5. Data and analysis	Pre	17.2%	12.1%	27.6%	27.6%	12.1%	3.4%
	Post	3.4%	3.4%	17.2%	25.9%	41.4%	8.6%
	Year 1 End	0%	0%	17.2%	27.6%	41.4%	13.8%
	Year 2 End	0%	8.3%	0%	33.3%	33.3%	25%

		Sum of 6 items above *M* (*SD*)	[1] *p*
	Pre	18.4 (6.8)	.00
	Post	27.3 (5.4)	
	Year 1 End	28.2 (4.3)	.001
	Year 2 End	30.3 (4.5)	<.001

Note. pre n = 58, post n = 58, year 1 end n = 32, year 2 end n = 12. Each item scored 1-6. Cronbach's α pre = .93, Cronbach's α post = .93, Cronbach's α year-end = .93. [1] *p* values are based on paired t-tests for pre to post, pre to year 1 end, pre to year 2 end.

Culturally Responsive Teaching

In the pilot year, culturally responsive teaching confidence and frequency were measured only at the end of the year. Means for all confidence items were greater than 4.0 (out of 6). The overall mean confidence score (sum of 8 items, min 8, max 48) was M = 36.4, SD = 7.2.

Table 15. Culturally Responsive Teaching Confidence

Please indicate how confident you are that you can:	Group	Not at all Confident	Not Very Confident	Somewhat Confident	Confident	Very Confident	Completely Confident	M (SD)
1. Identify ways that the school culture is different from my students' home culture.	Year 1 End	0%	0%	17.2%	34.5%	31.0%	17.2%	4.5 (.97)
	Year 2 End	0%	8.3%	16.7%	16.7%	33.3%	25%	4.5(1.3)
2. Implement strategies to minimize the effects of any mismatch between my students' home culture and the school culture.	Year 1 End	0%	3.4%	20.7%	37.9%	27.6%	10.3%	4.2 (1.0)
	Year 2 End	0%	8.3%	25%	33.3%	25%	8.3%	4.0 (1.1)
3. Develop a community of learners when my class consists of students from diverse backgrounds	Year 1 End	0%	0%	13.8%	24.1%	31.0%	31.0%	4.8 (1.0)
	Year 2 End	0%	0%	16.7%	33.3%	16.7%	33.3%	4.7(1.2)
4. Use my students' cultural background to help make learning meaningful.	Year 1 End	0%	3.4%	13.8%	27.6%	34.5%	20.7%	4.5 (1.1)
	Year 2 End	0%	0%	25%	16.7%	25%	33.3%	4.7(1.2)
5. Use my students' prior knowledge to help them make sense of new information	Year 1 End	0%	0%	13.8%	24.1%	31%	31%	4.8 (1.0)
	Year 2 End	0%	0%	16.7%	33.3%	16.7%	33.3%	4.7(1.2)
6. Revise instructional material to include a better representation of cultural groups.	Year 1 End	0%	0%	10.3%	41.4%	31%	17.2%	4.5 (.90)
	Year 2 End	0%	0%	16.7%	33.3%	25%	25%	4.6(1.1)
7. Critically examine the curriculum to determine whether it reinforces negative cultural stereotypes.	Year 1 End	0%	3.4%	10.3%	34.5%	34.5%	17.2%	4.5 (1.0)
	Year 2 End	0%	0%	16.7%	41.7%	16.7%	25%	4.5(1.1)
8. Use examples that are familiar to students from diverse cultural backgrounds.	Year 1 End	0%	0%	17.2%	27.6%	34.5%	20.7%	4.6 (1.0)
	Year 2 End	0%	0%	16.7%	25%	16.7%	41.7%	4.8(1.2)

Note. year 1 end n = 30, year 2 end n = 12. Each item scored 1-6. Cronbach's α = .97

Table 16. Frequency of Culturally Responsive Teaching

Please indicate how often you do the following:	Group	Never	Very Rarely	Rarely	Occasionally	Frequently	Always
1. Spend time outside of class learning about the cultures and languages of my students.	Year 1 End	0%	0%	13.8%	51.7%	31%	3.4%
	Year 2 End	0%	0%	16.7%	33.3%	33.3%	16.7%
2. Make an effort to get to know my students' families and backgrounds.	Year 1 End	0%	0%	0%	13.8%	65.5%	20.7%
	Year 2 End	0%	0%	8.3%	0%	41.7%	50%
3. Examine class materials for culturally appropriate images and themes.	Year 1 End	0%	0%	0%	24.1%	58.6%	17.2%
	Year 2 End	0%	0%	8.3%	25%	41.7%	25%
4. Encourage students to use cross-cultural comparisons when analyzing material	Year 1 End	0%	0%	6.9%	48.3%	34.5%	10.3%
	Year 2 End	8.3%	0%	16.7%	25%	25%	25%

Note. year 1 end n = 30, year 2 end n = 12. Cronbach's α = .74

Frequency of CS-integrated Instruction

Teacher self-report data indicated that of 40 teachers who completed the frequency of integration survey in late January 2021, 26 (61.9%) reported teaching at least one lesson that explicitly targeted CS SOLs between the beginning of the school year and January. Of the 26 teachers who taught one or more CS lessons, most (88.5%) reported teaching at least one lesson addressing Algorithms and Programming. Few teachers reported teaching CS lessons that explicitly addressed computing systems (38.4%) and data and analysis (38.5%; Table 17).

Table 17. Frequency of CS-Integrated Instruction

SOL Strand	Group	None (%)	1-2 Lessons (%)	3-4 Lessons (%)	5 or more Lessons (%)
Computing systems	Year 1 End	61.5	34.6	3.8	0
	Year 2 End	54.5	27.3	9.1	9.1
Impacts of Computing	Year 1 End	57.7	30.8	11.5	0
	Year 2 End	54.5	36.4	0	9.1
Algorithms and Programming	Year 1 End	11.5	65.4	19.2	3.8
	Year 2 End	18.2	54.5	9.1	18.2
Data and Analysis	Year 1 End	61.5	38.5	0	0
	Year 2 End	54.5	36.4	0	9.1
Networking and the Internet	Year 1 End	46.2	26.9	23.1	3.8
	Year 2 End	54.5	27.3	9.1	9.1
Cybersecurity	Year 1 End	34.6	53.8	11.5	0
	Year 2 End	18.2	72.7	0	9.1

Note. year 1 end n = 26, year 2 end n = 11.

Pilot Cohort Student Outcomes

CS Content Knowledge

Pilot testing during the 2020-21 school year included 149 students: 32 3rd grade (21.5%), 31 4th grade (20.8%), and 86 5th grade (57.7%) from 15 schools. The goal of pilot testing was to establish internal consistency. Pilot testing resulted in the following scores for student content knowledge overall (*M* = 17.9, *SD* = 3.7) and on each hypothesized scale: Computing Systems and Impacts of Computing (*M* = 10.3, *SD* = 2.3), Data and Analysis (*M* = 6.0; *SD* = 1.6), and Cybersecurity (*M* = 1.6; *SD* = .53; Table 18).

Table 18. CS Content Knowledge

	All Grades M (SD)	3rd Grade M (SD)	4th Grade M (SD)	5th Grade M (SD)
Computing Systems and Impacts of Computing [1]	10.3 (2.3)	8.7 (2.0)	11.1 (1.6)	10.7 (2.3)
Data Analysis [2]	6.0 (1.6)	4.8 (1.8)	6.5 (1.2)	6.3 (1.5)
Cybersecurity [3]	1.6 (.53)	1.5 (.5)	1.5 (.5)	1.7 (.5)
Overall Content Knowledge [4]	17.9 (3.7)	14.9 (3.3)	19.0 (2.3)	18.6 (3.7)

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

Dunnett's T post-hoc tests indicate a statistically significant difference between 3rd and 4th grade and 3rd grade and 5th grade, but not between 4th and 5th grades for each scale and the overall content knowledge component (Table 19).

Table 19. CS Content Knowledge Dunnett'st Posthoc

	Grade Level		M difference	SE
Computing Systems and Impacts of Computing	3rd Grade	4th Grade	-2.3***	0.5
		5th Grade	-1.9***	0.4
	4th Grade	5th Grade	0.40	0.4
Data Analysis	3rd Grade	4th Grade	-1.7***	0.4
		5th Grade	-1.5***	0.4
	4th Grade	5th Grade	0.2	0.3

Note. $p < .05$*, $p < .01$**, $p < .001$***

Table 19. CS Content Knowledge Dunnett'st Posthoc (Con't)

	Grade Level	M difference	SE	
Cybersecurity	3rd Grade	4th Grade	-0.047	0.1
		5th Grade	-0.2	0.1
	4th Grade	5th Grade	-0.1	0.1
Overall Content Knowledge	3rd Grade	4th Grade	-4.1***	0.7
		5th Grade	-3.6***	0.7
	4th Grade	5th Grade	0.5	0.6

Note. $p < .05$*, $p < .01$**, $p < .001$***

Affect Toward CS

The overall affective mean for students was 41.6 (SD = 8.9). For each scale, the means were confidence (M = 16.4; SD = 4.9), interest (M = 13.4; SD = 3.8), and utility (M = 11.9; SD = 2.8). There was no statistically significant difference between 3rd, 4th, and 5th grade for each scale and the overall affect component.

Table 20. Affect Toward CS

	All Grades M (SD)	3rd Grade M (SD)	4th Grade M (SD)	5th Grade M (SD)
Confidence [1]	16.4 (4.0)	15.7 (4.8)	15.7 (3.9)	16.9 (3.7)
Interest [2]	13.4 (3.8)	12.4 (3.9)	12.2 (3.9)	14.1 (3.6)
Utility [3]	11.9 (2.8)	10.5 (3.5)	12.3 (2.1)	12.2 (2.6)
Overall Affect [4]	41.6 (8.9)	38.6 (11.4)	40.2 (7.6)	43.2 (8.0)

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.

Although teachers completed the summer PD program prior to students taking the CKACS, no mean student scores approached the maximum score. This suggests there is still an opportunity for students to gain growth in content knowledge and a more positive affect toward CS.

Student Engagement during CS Instruction

Teachers reported on student engagement during CS instruction between September 2020 and November 2020, November 2020 and May 2021, September 2021 and November 2021, and November 2021 and May 2022. Of 39 teachers who completed the mid-year 1 survey and reported on student engagement 37.5% of teachers agreed or strongly agreed their students were more engaged at the end of the first semester than at the beginning of the school year.

Table 21. Student Engagement during CS Instruction

Rate the extent to which you agree with the following	Group	Strongly disagree (%)	Disagree (%)	Somewhat disagree (%)	Somewhat agree (%)	Agree (%)	Strongly agree (%)
My students are more engaged in CS now than at the beginning of the school year.	Year 1 Mid	5.1	0	2.6	53.8	30.8	7.7
	Year 1 End	5.0	0	2.5	55.0	30.0	7.5
	Year 2 Mid	0	6.3	0	37.5	37.5	18.8
	Year 2 End	0	0	9.1	9.1	45.5	36.4

Note. year 1 mid n = 39, year 1 end n = 39, year 2 mid n = 16, year 2 end n = 11.

Table 22. Engagement During Specific SOLs Taught

Describe the general level of engagement during CS SOL strand lessons you implemented in your classroom	Group	Taught SOL-based lesson (n)	Not at all engaged (%)	Slightly engaged (%)	Moderately engaged (%)	Highly engaged (%)
Computing Systems	Year 1 Mid	9	11.1	44.4	44.4	0
	Year 2 Mid	4	0	0	75	25
	Year 2 End	5	20	0	60	20
Impacts of Computing	Year 1 Mid	10	0	20	70	10
	Year 2 Mid	5	0	40	40	20
	Year 2 End	5	0	20	40	40
Algorithms and Programming	Year 1 Mid	21	0	9.5	71.4	19
	Year 2 Mid	10	0	10	20	70
	Year 2 End	9	0	0	33.3	66.7

Table 22. Engagement During Specific SOLs Taught (Con't)

Describe the general level of engagement during CS SOL strand lessons you implemented in your classroom	Group	Taught SOL-based lesson (n)	Not at all engaged (%)	Slightly engaged (%)	Moderately engaged (%)	Highly engaged (%)
Cybersecurity, Data and Analysis	Year 1 Mid	16	0	25	68.8	6.3
	Year 2 Mid	10	10	0	40	50
	Year 2 End	15	20	27	40	13
Networking and the Internet	Year 1 Mid	13	0	38.5	38.5	23.1
	Year 2 Mid	10	0	10	70	20
	Year 2 End	5	0	0	80	20

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 23).

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 microcredentials 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 23. Elementary RCT Cohort 1 Randomization and Retention Data

	Randomized		Completed Year 1		Non-RCT		Completed Microcredentials
	Treatment	Control	Treatment	Control	Applied	Completed Year 1	
Schools	11	12	10	10	11	7	4
Teachers	33	44	29	39	14	9	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 24 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 24. 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. 4 teachers in the treatment group did not provide demographic data.

Table 25. 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

This section describes implementation outcomes for year 2 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 26. ARCS K-5 Coaches Academy Daily Attendance

	Day 1 n	Day 2 n	Day 3 n	Day 4 n	Day 5 n
Treatment Summer 2021 (n = 33 applied)	27	28	28	28	26
Control (delayed treatment) Summer 2022 (n = 37)	[1]20	[1]20	[1]20	[1]19	[1]20

Note. [1] 2 completed the Academy by watching the recordings asynchronously.

Implementation

Overall, the ARCS CODE VA K-5 Coaches Academy Summer PD appeared to be implemented as planned for the 2022 Summer (Cohort 1 Delayed Treatment) teachers. In addition, it appeared that in general, the 2022 ARCS CODE VA K-5 Coaches Academy Summer PD was consistent with the summer 2021 PD, with the few exceptions we describe below. Like the 2020 and 2021 ARCS CODE VA K-5 Coaches Academy Summer PDs, 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.

The following differences were observed between the 2021 and 2022 ARCS CODE VA K-5 Coaches Academy Summer PD. First, on Monday of the PD, more time was spent on pedagogical aspects of the PD. For example, teachers participated in an activity that evaluated what they associate with an ideal academic/instructional coach. The instructors emphasized distinctions between Instructional and CS coaching. Finally, instructors discussed steps of CS coaching, strategies to CS teaching, and pedagogical approaches for children compared to teachers. The teachers were assigned a group activity where they role-played and tackled an obstacle related to coaching and an obstacle related to integrating CS into core content (Monday, Observation).

The focus of Wednesday’s session on coaching was framed as “equity, inclusivity, and accessibility” this year as opposed to “coaching” the previous year. The goal was to develop teachers’ understandings of equity in CS education and instill pedagogical practices that improve accessibility to CS in the classroom. Facilitators began by asking the question “Why shouldn’t specialists push into classrooms to teach all the CS SOLs for me?” Participants responded that CS should be integrated with other subjects to allow students to make connections from CS principles to the world around them. Then, they discussed equity and the digital native. The participants completed a Jamboard activity in which each group illustrated a Digital Native using word phrases and images. Common themes included images of young children with technology and word phrases that indicated technological familiarity. At the end of the activity, the facilitators offered questions intended to encourage participants to think about how their understanding of the digital native may have changed following the activity and to consider their responses from an “equity lens.” The facilitator asked the participants to consider the identities of the digital native including gender, race, ethnicity, disability, and accessibility. Then, the teachers chose one “student persona” to focus on for the session. Teachers considered whether this student was a digital native, as well as their prior knowledge, and access to understand how to best support that student. The activity was intended to prompt teachers to consider student differences while creating lesson plans. Next, participants and facilitators discussed how to create an inclusive computing environment. Participants were assigned breakout rooms to discuss how to create an inclusive culture with the *Impacts of Computing* strand in mind. When they returned, participants shared their responses and facilitators covered how to create lessons that are inclusive. Following this, they reviewed barriers to CS education and discussed various pedagogical strategies for more inclusive learning including universal design for learning. Throughout the session, facilitators had participants think of their chosen “student persona” and consider how they will apply newly learned principles to that student. Facilitators then provided participants with resources to improve accessibility. The collaborative learning lab explored accessible and equitable lesson designs. (Wednesday, observation).

The focus of Friday’s session was “advocacy”. The goal of this day was to develop ways in which teachers can be advocates in their classrooms, schools, and communities for CS based on the number of computing jobs, availability of CS classes, and limited underrepresented students in CS. The facilitators discussed ways teachers could become CS advocates for their school divisions, including listing steps to take and sharing resources to support teachers in convincing stakeholders of the importance of CS. Then, the facilitators challenged teachers to create a pitch for stakeholders that addresses “why CS is beneficial for the school or classroom”. Teachers moved into a breakout room to work in groups and develop an elevator pitch to promote CS. Then, they reviewed a few resources in detail. After exploring resources, they discussed unplugged activities. Facilitators explained why teachers may choose to use unplugged activities. Then, they explained how unplugged activities support plugged activities. Next teachers participated in a model unplugged activity. Finally, teachers go to a breakout room in which they develop an integrated lesson plan using everything they have learned during the week (Friday, observation)

Perceptions of the PD

Of the 35 treatment teachers who completed the ARCS CodeVA K-5 Coaches Academy, 25 treatment teachers completed the post-PD survey in the summer of 2021 and 14 control (delayed treatment) teachers completed the post-PD survey in the summer of 2022. On the Post- Survey, items with Likert scales of 1-6, means over 4.0 were strong indicators, while means below 4.0 indicated potential areas of weakness in program delivery. Overall, participants reported positive perceptions of the PD, with means for all items above 4.0 for all post- items (Table 27). Similar to the pilot cohort, most participants (97%) agreed or strongly agreed that they would recommend the ARCS/Code VA K-5 Coaches Academy Summer PD to their colleagues (97%) and that they would integrate what they learned in the ARCS/Code VA K-5 Coaches Academy Summer PD into their teaching (94%).

Table 27. Post PD Perceptions

How strongly do you agree or disagree with the following statements?	Group	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	Treatment	0	0	4.0 5.9	4.0	92	0	4.9 (.4)
	Delayed Treatment (Control)	0	0	0	14.3	42.9	42.9	5.29 (.73)
2. The ARCS/Code VA K-5 Coaches Academy objectives were clear to me.	Treatment	0	0	4.0	8.0	88	0	4.8 (.5)
	Delayed Treatment (Control)	0	7.1	14.3	14.3	28.6	35.7	5.0 (1.3)
3. The ARCS/Code VA K-5 Coaches Academy provided me with lesson plans that fit state standards.	Treatment	0	0	0	12	88	0	4.9 (.3)
	Delayed Treatment (Control)	21.4	0	0	7.1	50	21.4	4.3 (1.9)
4. The facilitators had adequate knowledge of the subject.	Treatment	0	0	0	4.0	96	0	5.0 (.2)
	Delayed Treatment (Control)	0	0	0	7.1	35.7	57.1	5.5 (.7)
5. The facilitators created an atmosphere of trust and open communication.	Treatment	0	0	0	4.0	96	0	5.0 (.2)
	Delayed Treatment (Control)	0	0	0	14.3	35.7	50	5.4 (.7)
6. I am satisfied with my interactions with the facilitators	Treatment	0	0	0	4.0	96	0	5.0 (.2)
	Delayed Treatment (Control)	0	0	0	28.6	35.7	35.7	5.1 (.8)
7. As needed, the facilitators were available to answer questions and provide direction.	Treatment	0	0	0	4.0	96	0	5.0 (.2)
	Delayed Treatment (Control)	0	0	0	14.3	35.7	50	5.4 (.7)
8. I felt a rapport with other participants.	Treatment	0	0	0	8.0	92	0	4.9 (.3)
	Delayed Treatment (Control)	0	0	7.1	7.1	42.9	42.9	5.2 (.9)

Note. post n = 25, the total number of RCT teachers that completed the summer PD. Delayed treatment (control) teacher n=14. For means, strongly disagree = 1, disagree = 2, somewhat disagree = 3, somewhat agree = 4, agree = 5, and strongly agree = 6.

Table 27. Post PD Perceptions (Con't)

How strongly do you agree or disagree with the following statements?	Group	Strongly disagree (%)	Disagree (%)	Somewhat disagree (%)	Somewhat agree (%)	Agree (%)	Strongly Agree (%)	Mean (SD)
9. I am satisfied with my interaction with my peers.	Treatment	0	0	0	4.0	96	0	5.0 (.2)
	Delayed Treatment (Control)	0	0	7.1	7.1	35.7	50	5.3 (.9)
10. I felt part of a learning community.	Treatment	0	0	0	8.0	92	0	4.9 (.3)
	Delayed Treatment (Control)	0	0	7.1	14.3	35.7	42.9	5.1 (.9)
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.	Treatment	0	0	0	12	88	0	4.9 (.3)
	Delayed Treatment (Control)	7.1	14.3	0	21.4	21.4	35.7	4.4 (1.7)
12. The ARCS/Code VA K-5 Coaches Academy met my needs as a teacher-learner.	Treatment	0	0	0	4.0	96	0	5.0 (.2)
	Delayed Treatment (Control)	14. 3	7.1	0	28.6	50	0	3.9 (1.5)
13. I would recommend the ARCS/Code VA K-5 Coaches Academy to other colleagues.	Treatment	0	0	0	4.0	96	0	5.0 (.2)
	Delayed Treatment (Control)	7.1	7.1	7.1	21.4	21.4	35.7	4.5 (1.6)
14. I will integrate what I learned in the ARCS/Code VA K-5 Coaches Academy in my teaching.	Treatment	0	0	0	8.0	92	0	4.9 (.3)
	Delayed Treatment (Control)	7.1	0	0	14.3	35.7	42.9	5.0 (1.4)

Note. Note. post n = 25, the total number of RCT teachers that completed the summer PD. Delayed treatment (control) teacher n=14. For means, strongly disagree = 1, disagree = 2, somewhat disagree = 3, somewhat agree = 4, agree = 5, and strongly agree = 6.

Useful Components of the PD.

Cohort 1 Treatment (Summer 2021). Participants' open-ended responses (n = 37) of the most useful component of the ARCS CodeVA K-5 Coaches Academy were categorized and closely mirrored those articulated by the pilot cohort at the same time point. These included: learning to integrate CS into their instruction (n = 17), learning about the CS Standards (n = 9), the resources they received (n = 9), better understanding of CS concepts (n = 4), equity (n = 3), learning programming (n = 1), taking information back to the district (n = 1), and collaborating with colleagues (n = 1). Other responses (n = 3) related to how to be effective when using technology (n = 1) and praise for the program (n = 2). Regarding the **value of learning to integrate CS** into their instruction, one participant wrote,

> *I also liked all the different examples of integration we got to see. It is really hard to imagine coding in Language Arts but the examples definitely helped with the big picture.*

Many participants expressed sentiments similar to the following:

> *I think the most useful thing I learned was that you don't have to totally reinvent the wheel and it's easy to adapt my current curriculum to address the CS standards.*

Regarding **learning about the CS Standards**, participants responded with comments such as, "I now understand the CS standards" and "Examining the curriculum framework with other members of the academy to find ways to integrate it."

Regarding **resources**, several participants commented on "unplugged" activities, as exemplified by the following response,

> *One thing I found most useful and not intimidating were the unplugged ideas. I don't have to learn new technologies for them and we explored multiple ways we are already using some of these ideas or how we can easily implement them.*

Others commented on the lesson planning template and programs they can use.

- *I really liked the lesson "spark" mini-lesson planner template.*
- *I learned about several new programs that I can use in the classroom.*

Regarding a better **understanding of CS concepts**, a participant wrote, "I think just getting a better understanding of what computer science is was super helpful! Also actually creating and viewing lessons incorporating CS standards was nice!" About equity, a participant noted, "I learned a lot about inclusivity, which I think is very important in today's world."

Cohort 1 Delayed Treatment (Summer 2022). Participants' open-ended responses (n = 14) of the most useful component of the ARCS CodeVA K-5 Coaches Academy were categorized and closely mirrored those articulated by the pilot cohort and Cohort 1 treatment teachers at the same timepoint. These included: learning about the CS Standards (n = 6), learning to integrate CS into their instruction (n = 4), the resources they received (n = 4), better understanding of CS concepts and instruction (n = 4), and collaborating with colleagues (n = 2).

Regarding the **value of learning about the CS standards**, participants shared:

- *I learned about algorithm in CS and that some CS standards are already been done in my classroom.*
- *Familiarity with the Computer Science SOLs and the framework as well as recommended online resources that can be used to integrate CS with my core teaching.*
- *What are the CS standards and the impacts CS has on a student in making career choices.*

Regarding the value of **learning to integrate CS** into their instruction, one participant wrote,

> *I have learned that as teachers we are all teaching computer science its just for us to be more transparent with the standards and use the terminologies as we teacher our students.*

Another participant commented on the learning of implementing of CS standards into instruction:

> *More insight about the standards and how we can implement.*

Regarding **resources**, participants commented on the CS learning websites and lessons plans provided, as exemplified by the following response,

- *Different websites that are available pertaining to computer science.*
- *The different lesson plans that were provided throughout the course.*

One participant commented that there are many resources available to support CS integration,

> *I learned that there are many resources "out there" that I was unaware of to help me integrate the CS standards into my lessons.*

Regarding a better **understanding of CS concepts** and instruction, a participant wrote, “I learned about algorithm in CS and that some CS standards are already been done in my classroom.” Another one shared his/learning about “What computer science is and how it is integrated into curriculum.”
Regarding **collaborating with colleagues**, one participant commented on the value of building a supportive learning community with colleagues through PD,
I now have a support network of other teachers and mentors within my region and the state of VA. This is powerful.

Perceived Challenges and Additional Supports Needed.

Cohort 1 Treatment (Summer 2021). This year, participants were asked to identify challenges they perceived to integrating the CS standards into their curriculum and additional supports needed to integrate what they learned into their instruction. Challenges converged into seven themes: time (n = 20), buy-in from colleagues and administrators (n = 11), content knowledge (n = 9), confidence (n = 4), access (n = 4), experience (n = 3), and resources (n = 1).
Regarding **time**, participant comments simply responded, “time”. More elaborate responses explained this and included:

- *One of the biggest challenges is convincing classroom teachers to make time and add the standards to their curriculum.*
- *Finding the time to integrate the computer skills into our core curriculum is also challenging.*

Regarding **buy-in from colleagues** and administrators, participants made comments including:

- *My district does not have a lot of support in place for integrating computer science standards.*
- *I feel like the main challenges will be buy in from my colleagues.*

Many comments reflected a **perceived lack of content knowledge, confidence, and experience** as a challenge to integrate.

- *I need to make sure that I take the time to explore the standards in a more detailed manner to make sure I understand what my students should know coming to me and what they are working toward in coming years. I need to explore coding and mediums to use to educate my students on this. I anticipate team members being nervous about implementing the standards- adding something additional to their plates. Fortunately we discussed many ways to make this seem less burdensome.*
- *I still have very limited knowledge of programming, but now I realize there’s a lot I can do without programming with computer science, and there’s a lot of programs that they can work through for coding without me needing to have a ton of background knowledge.*
- *After taking the ARCS class, I feel a little more confident on how to integrate the CS standards in my curriculum.*
- *Learning more and becoming more familiar about the different coding programs. Personal knowledge growth and confidence but I’m working on it.*

Regarding **access**, participants described:

- *Lack of access to some technology that would make it more engaging.*
- *The only challenges I foresee is access to different physical technology items.*
- *All students have chromebooks, but other devices such as iPads, Dash and Dot robots, spheros,*

etc. are shared with the whole school.

Of the 37 respondents, 7 indicated they needed no further supports. Other responses related to developing greater CS content knowledge (n = 14), resources (n = 10), more support (n = 4), and frequent communication/follow up (n = 4).

Most of the comments related to **developing greater CS content knowledge** emphasized a need for learning more about coding, as exemplified in the following responses:

- *I don't think I need anything but I'd like to learn more about programming using scratch and possibly python.*
- *I need to learn more about coding and how to implement events like The Hour of Code.*
- *I would definitely benefit from a better understanding of programming in general, even though that is not necessary to teach the Computer Science Standards.*

Related to **resources**, comments primarily converged on wanting more lesson plan examples and included:

- *Seeing other examples of lesson plans or videos of standards being implemented.*
- *Lesson plans already written for my grade level as a guide to follow*

Related to **support, communication, and follow up**, teachers suggested, "Year-round training and seeing other teachers use it in action", "Meet occasionally for questions", "I will more than likely appreciate some as-needed guidance during the school year as I attempt to integrate the things I have learned in the academy in my school" and "It would be nice to have an occasional check in to see how implementation is going."

Cohort 1 Delayed Treatment (Summer 2022). Similar to the treatment group, participants in the delayed treatment cohort (control) were asked to identify challenges they perceived related to integrating the CS standards into their curriculum and additional supports needed to integrate what they learned into their instruction. Challenges converged into eight themes: time (n = 6), access to resources (n = 4), experience (n = 2), buy-in from colleagues and administrators (n = 2), compatibility of CS standards with content (n = 2), content knowledge (n = 1),

Participants' responses indicate that **not having enough time** is a major concern for integrating CS. They commented that:

- *Ensuring there is time to lesson plan the CS Sols and integrate in the lesson.*
- *Challenges are finding the time, but after completing the ARCS course, I see now how much easier I can integrate it into my lesson in my classroom.*

Regarding the **access to resources**, participants' responses indicate a need for instructional materials and technology to integrate CS. Their comments included:

- *Access to more technology that is strictly geared toward computer science.*
- *Not having resources readily available and accessibility for all students.*
- *My biggest challenge will be exploring and learning about available resources that I can use in my classroom.*

Two of the respondents commented that they **lacked the experience of integrating CS**.

- *Lack of experience may be a barrier in the initial stage.*
- *I need practice and to look at course materials on my own, along with conducting further research to understand the different aspects of computer science.*

Regarding **buy-in from colleagues and administrators,** participants commented that:

- *The biggest challenge I have is teacher by-in. My teachers are not always forthcoming with time to integrate the technology standards (I am a coach).*
- *Time to collaborate with other key stakeholders (teachers) and administrative buy-in that this is teaching critical thinking skills embedded in our reading and math curriculum. The heavy focus on SOL scores inhibits the use of authentic teaching and learning experiences.*

Two participants commented on the **challenges of integrating CS standards** with the core content:

- *Sometimes the standards are difficult to weave together with core content in a way that is authentic and makes strong lessons.*
- *The heavy focus on SOL scores inhibits the use of authentic teaching and learning experiences.*
- *One participant responded that he/she still needed to build up CS content knowledge.*
- *I need practice and to look at course materials on my own, along with conducting further research to understand the different aspects of computer science.*

Of the 14 respondents, 1 indicated no further supports are needed. Other responses related to resources (n = 6), opportunities to collaborate and follow up (n = 5), modeling of teaching (n = 3), developing greater CS content knowledge (n =1), more time to learn (n = 1).
Most of the comments related to **resources** emphasized a need of instructional materials and technology that can be readily used to teach CS, as exemplified in the following responses:

- *More visuals and examples of implementation of CS standards in the classroom.*
- *I would have liked to actually been introduced to some of the different coding programs and how they work. I'm sure there's probably a course for that though! Also, I would have liked to actually see how a lesson would be taught.*
- *Funds for materials.*

Related to **collaboration opportunities and follow up**, comments primarily converged on wanting more opportunities to collaborate with teachers and CS coaches to implement CS:

- *I will need to collaborate with the other teachers from my school who were in attendance to begin implementation.*
- *Additional support will be working with other CS coaches to implement CS at school, and watch videos to understand what CS actually looks like in the classroom.*

Related to **modeling of teaching**, respondents expressed a need for examples and demonstration of how CS instruction can be implemented in class, their comments including:

- *I would love some sample lesson plans or video of teacher actually teaching and integrating computer science in their lesson.*
- *This really didn't share resources and show explicit ways to teach a lesson with CS standards. It focused too much on what is computer science, the standards, and how to get others to be involved. But it did not teach how to actually lead lessons and how to use different resources. No actual examples via video or modeling lessons with us. I would not take an additional course from Code VA because I spent a week on this one and did not get much out of it.*

Related to **developing greater CS content knowledge**, one respondent commented that he/she need to build greater understanding of CS concepts:

> *There are basic computer science concepts that I still don't have a strong grasp of.*

One respondent shared that he/she need **more time to learn** beyond the PD contacting hours:

> *Time to learn them and a place to go to get support to help. But, that is something my school division needs to provide.*

Future PD Topics.

Cohort 1 Treatment and Cohort 1 Delayed Treatment (Control).

Participants identified several areas in which they perceived they would benefit from future PD including programming and coding and integrating CS into remote teaching (Figure 4).

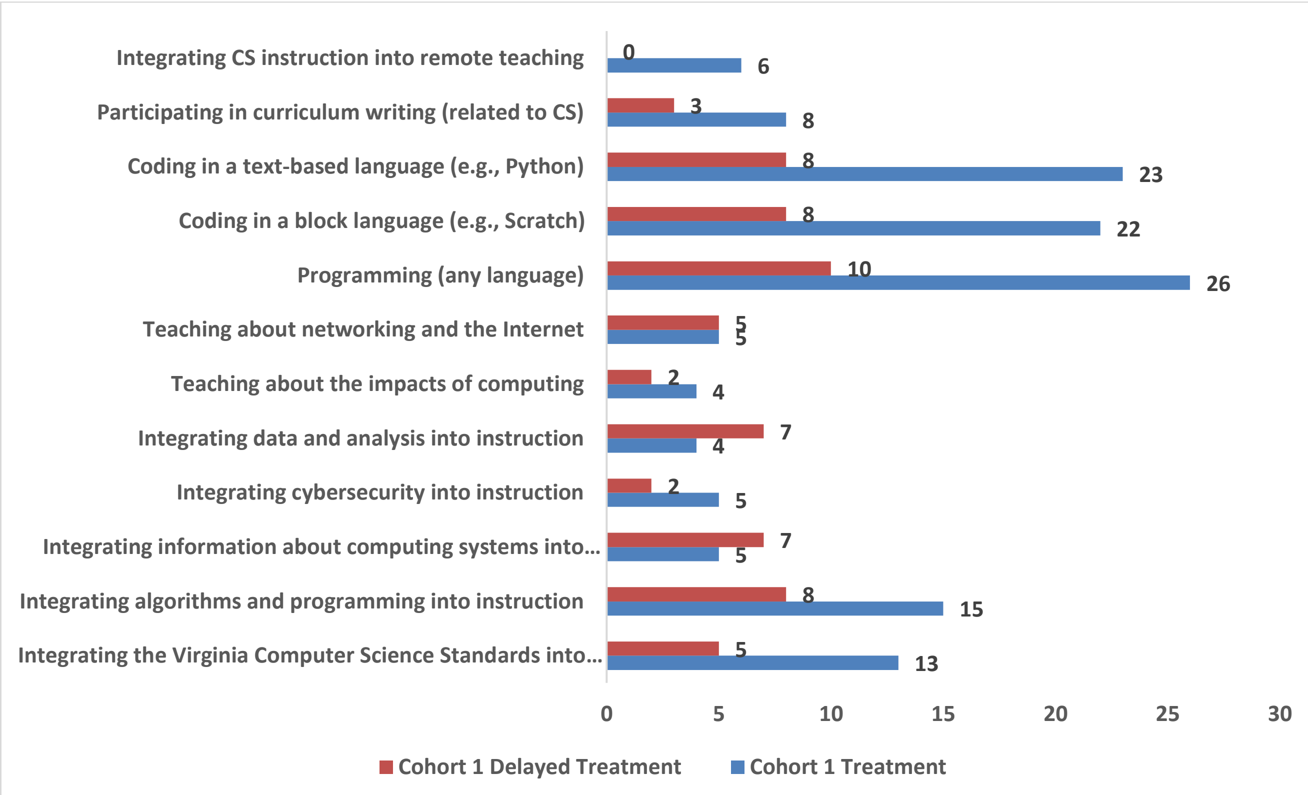

Figure 4. Topics for Future PD

Recommendations.

Cohort 1 Treatment. When asked for recommendations for modifications of the ARCS CodeVA K-5 Coaches academy, 25 of the 37 respondents (67.6%) indicated that they had no recommendations for improvement. The most common recommendations were related to organization (n = 5), content (n = 5), modality (n = 3), and other (n = 1). Unlike with the pilot cohort, no participants commented on the pacing of the ARCS CodeVA K-5 Coaches Academy.

Comments related to the **organization** included:

- *Instead of having so many randomized groups for break-out sessions, I feel that it would be more advantageous to have all break-out sessions in groups of the same grade level (like the first 2 afternoons were). In addition, I think that the task of preparing a PD that we could present to our school is helpful, but it would have been better for me to have more time with actually creating integrated lessons.*
- *I didn't love the morning sessions as much as I liked the work part of the afternoon. That felt more useful.*
- *Thank you for telling us what slide number you were on. That helped tremendously. It also helped to work with the same group through the learning day and then go off with my team in the afternoon.*

Regarding **content**, participant responses converged on a need for more experience coding, as exemplified in the following responses, “I would recommend explaining more about programming language” and “Add a day or two to introduce coding.”
Regarding **modality**, participants indicated that wanted more support throughout the year and an in-person experience as exemplified in the following comments:

- *Provide more workshop and additional support throughout the year.*
- *I would have loved to meet in person for this class...although I understand it was necessary and easier to meet virtually, I think it would have been easier to interact with "strangers" in small groups, etc if we were in person.*

The one other response related to more **clearly identifying the expectations of ARCS** during the application, “Make clear in the application process for ARCS that the participants will become coaches.”

Overall, participants appeared to appreciate the ARCS/CODE VA K-5 Coaches Academy as indicated by the following comments, “I thought it was very well done. I was nervous at first, but the facilitators made me feel comfortable quickly”, “I walked away with valuable resources to help me integrate the CS standards in my lessons and to share them with my peers”, and “The overall course was amazing. Thank you.”

Cohort 1 Delayed Treatment. When asked for recommendations for modifications of the ARCS CodeVA K-5 Coaches academy, 5 of the 14 respondents (35.7%) indicated that they had no recommendations for improvement. The most common recommendations were related to organization (n = 3), content (n = 3), modality (n = 2), and foundational support (n = 1).
Comments related to **organization** included:

- *Have teams from schools participate not just individuals*
- *Spend less time on what is computer science and more of the modeling of lessons and activities and resources.*

Regarding **content,** participant responses converged on a need for lesson examples, as exemplified in the following responses, “Provide more applicable examples in the training.” and “Maybe show us more lessons in action. Also website too.”
Regarding **modality,** participants indicated that wanted more in-person experience, synchronous and asynchronous online sessions, as exemplified in the following comments: “In-person learning.” And “The online sessions could have been both synchronous and asynchronous.”
One participant indicated a need for **more foundational support**: “There will always be teachers who need more foundational support which was not present in this PD.”

Overall, similar to the treatment groups’ responses, participants in the control group appeared to appreciate the ARCS/CODE VA K-5 Coaches Academy as indicated by the comment, “It was a very rewarding experience.”

Networked Improvement Community

All but 1 treatment teacher who completed the Year 1 End survey (n = 14) indicated they used the NIC. That teacher indicated they didn’t have time outside of the standards; 43% indicated using it one or two times and 50% indicated using it about monthly. Ten teachers indicated they participated in CODE VA online training or other events Treatment participants reported on the utility of the NIC the purposes of understanding CS concepts and integrating CS standards into the core curriculum.

Table 28. Participant Use of CodeVA NIC

	Time	Not helpful at all	Not very helpful	Somewhat helpful	Helpful	Very helpful
Knowledge and understanding of CS concepts	Year 1 End (2022)	1 (7.7%)	0 (0%)	4 (30.8%)	7 (53.8%)	1 (7.7%)
Integration of CS standards into your core curriculum	Year 1 End (2022)	1 (7.7%)	0 (0%)	3 (23.1%)	8 (61.5%)	1 (7.7%)

Microcredentials

We will include participation in microcredentials for RCT Cohort 1 Treatment Teachers in the year 4 annual report as they have until June 2023 to complete these. As of September 2022, 4 teachers in the RCT Cohort 1 treatment group have completed the microcredentials.

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 and their results are included below.

CS Content Knowledge

Results of ANCOVA indicated that at the end of the first year of ARCS (spring 2022), treatment teachers' CS content knowledge was significantly greater than control teachers (dark shading), $p = .05$; $R^2 = .3$, after controlling for prescore (light shading), race, gender, prior CS PD experience (Appendix F). Results indicated no significant improvement in treatment teachers' CS knowledge following participation in the Code VA K-5 Coaches Academy (pre/post PD), $t\ (21) = .8$, $p = .4$. In addition, there was no significant difference in treatment teachers' CS knowledge from pre to year-1-end, $t\ (12) = .4$, $p = .7$ (Appendix F).

Table 29. Teacher Content Knowledge

	Treatment			Control (Delayed Treatment)		
Item	[1] Pre Year 1 M (*SD*)	[1] Post PD M (*SD*)	[1] Year 1 End M (SD)	[1] Pre Year 1 M (*SD*)	[1] Year 1 End M (SD)	[1] Post PD M (SD)
1. What is computer science?	2.0 (0.8)	2.1 (0.5)	2.1 (0.5)	2.2 (0.7)	2.0 (0.8)	2.2 (0.8)
2. Describe what a computer programmer does.	2.3 (0.4)	2.2 (0.4)	2.1 (0.5)	2.1 (0.4)	2.1 (0.7)	2.2 (0.6)
3. What makes a device a computer?	1.2 (0.6)	1.4 (0.5)	1.4 (0.6)	1.5 (0.5)	1.3 (0.7)	1.5 (0.5)
4. What is an algorithm?	2.3 (0.7)	2.3 (0.6)	2.5 (0.7)	2.3 (0.7)	1.7 (0.9)	2.1 (1.0)

Note. Each item scored 1-3. [1] Treatment Pre and Post: Summer 2021, Treatment Year 1 End: Spring 2022, Control Pre Year 1: Summer 2021, Control Year 1 End: Spring 2022, Control Post PD: Summer 2022

Table 29. Teacher Content Knowledge (Con't)

	Treatment			Control (Delayed Treatment)		
Item	[1] Pre Year 1 M (*SD*)	[1] Post PD M (*SD*)	[1] Year 1 End M (SD)	[1]Pre Year 1 M (*SD*)	[1]Year 1 End M (SD)	[1]Post PD M (SD)
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)	1.8 (.07)	0.9 (0.9)	1.5 (1.1)
Sum of 5 items, max 15	9.4 (1.9)	9.6 (1.5)	9.4 (2.1)	9.8 (1.9)	8.0 (2.4)	9.6 (2.6)

Note. Each item scored 1-3. [1] Treatment Pre and Post: Summer 2021, Treatment Year 1 End: Spring 2022, Control Pre Year 1: Summer 2021, Control Year 1 End: Spring 2022, Control Post PD: Summer 2022

CS Pedagogical Knowledge

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

Table 30. Experience Programming

	Treatment			Control		
Rate your experience:	Pre M (*SD*)	Post M (*SD*)	Year 1 End M (SD)	Pre M (*SD*)	Year 1 End M (SD)	Post M (SD)
1. Programming (any language)	2.1 (1.2)	2.9 (1.0)	3.6 (1.1)	2.4 (1.4)	2.3 (1.5)	2.5 (1.3)
2. Coding in a block language	2.5 (1.6)	3.4 (1.4)	3.6 (1.2)	2.8 (1.7)	2.9 (1.6)	2.9 (1.5)
3. Coding in a text-based language	1.9 (1.2)	2.6 (1.1)	2.9 (1.3)	1.9 (1.1)	1.9 (1.2)	2.1 (1.4)
4. Running an "Hour of Code" event	2.6 (1.8)	3.4 (1.6)	3.2 (1.7)	3.1 (1.8)	3.3 (1.8)	3.5 (1.9)
Sum of 4 items above	9.0 (5.1)	12.7 (3.4)	13.3 (4.1)	10.3 (5.3)	11.1 (6.3)	12.3 (5.5)

Note. Treatment group (pre n = 25, post n = 25, year 1 end n = 15), control group (pre n = 39, post n = 23, year 1 end n = 14). 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

Table 31. Experience Integrating CS SOLs

	Treatment			Control		
Rate your experience with the following:	Pre M (*SD*)	Post M (*SD*)	Year 1 End M (SD)	Pre M (*SD*)	Year 1 End M (SD)	Post M (SD)
1. The Virginia Computer Science Standards	2.4 (1.4)	4.1 (1.0)	4.0 (0.9)	2.9 (1.4)	3.5 (1.4)	4.8 (1.1)
2. Algorithms and programming	2.0 (1.2)	4.1 (1.0)	3.8 (1.2)	2.3 (1.4)	3.0 (1.5)	4.5 (1.2)
3. Information about computer systems	2.6 (1.1)	4.0 (0.8)	3.6 (1.2)	2.8 (1.4)	3.5 (1.4)	4.6 (1.2)
4. Information about cybersecurity	2.5 (1.2)	4.0 (0.8)	4.0 (1.2)	2.8 (1.5)	3.6 (1.5)	5.0 (0.8)
5. Data and analysis	2.5 (1.4)	4.2 (0.9)	3.9 (1.0)	3.0 (1.5)	3.5 (1.4)	4.57 (1.2)
6. Information about the impacts of computing	2.4 (1.3)	4.2 (0.9)	3.7 (1.0)	2.9 (1.5)	3.3 (1.5)	4.9 (0.7)
Sum of 6 items above	14.5 (6.4)	24.6 (4.9)	23.1 (5.8)	16.7 (8.0)	20.4 (1.6)	23.1 (7.5)

Note. . Treatment group (pre n = 25, post n = 25, year 1 end n = 15), control group (pre n = 39, post n = 23, year 1 end n = 14). Each item scored 1-6. Cronbach's α pre = .94, Cronbach's α post = .97. Scale: very inexperienced = 1, Very experienced = 6

Table 32. Experience Teaching Programming

	Treatment			Control		
Rate your experience:	Pre M (*SD*)	Post M (*SD*)	Year 1 End M (SD)	Pre M (*SD*)	Year 1 End M (SD)	Post M (SD)
1. Teaching Programming (any language)	2.0 (1.2)	2.8 (1.1)	3.4 (1.1)	2.2 (1.4)	2.1 (1.4)	2.6 (1.5)
2. Teaching coding in a block language	2.4 (1.5)	3.4 (1.3)	3.5 (1.2)	2.7 (1.7)	2.7 (1.6)	2.8 (1.6)
3. Teaching coding in a text-based language	1.8 (1.1)	2.5 (1.0)	2.7 (1.1)	1.7 (1.0)	1.8 (1.0)	2.1 (1.4)
Sum of 3 items above	6.3 (3.6)	8.7 (3.1)	9.6 (2.9)	6.6 (3.7)	6.6 (3.8)	7.5 (4.2)

Note. Treatment group (pre n = 25, post n = 25, year 1 end n = 15), control group (pre n = 39, post n = 23, year 1 end n = 14). Each item scored 1-6. Cronbach's α pre = .88, Cronbach's α post = .86. Scale: very inexperienced = 1, Very experienced = 6

Table 33. Other Items Related to Pedagogical Knowledge

	Treatment			Control		
How strongly do you agree or disagree with the following statements?	Pre M (*SD*)	Post M (*SD*)	Year 1 End M (SD)	Pre M (*SD*)	Year 1 End M (SD)	Post M (SD)
1. I understand what computer science is.	4.3 (0.9)	5.2 (0.6)	5.0 (0.5)	4.4 (1.0)	4.3 (1.2)	4.8 (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)	3.7 (1.3)	3.7 (1.5)	3.9 (1.6)
3. I can engage students from rural areas in computer science.	4.3 (1.1)	5.0 (0.8)	4.8 (0.7)	4.3 (1.1)	4.2 (1.2)	4.6 (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)	4.4 (1.1)	4.4 (1.0)	4.6 (0.8)
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)	4.4 (1.2)	4.5 (1.0)	4.6 (1.0)
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)	4.5 (1.0)	4.2 (1.2)	4.7 (0.8)

Note. Treatment group (pre n = 25, post n = 25, year 1 end n = 15), control group (pre n = 39, post n = 23, year 1 end n = 14). Each item scored 1-6. Scale: 1 = strongly disagree, 6 = strongly agree

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 teachers' self-efficacy for teaching CS was significantly greater than control teachers, $p = .001$; $R^2 = .6$, confidence in programming, $p = .002$; $R^2=.5$, confidence in teaching programming, $p = .003$; $R^2=.5$, and confidence in integrating CS SOLs, $p <.001$; $R^2=.4$, after controlling for prescore, race, gender, prior CS PD experience (Appendix F). 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 34. Self Efficacy Scale

	Treatment			Control		
How strongly do you agree or disagree with the following statements	Pre M (*SD*)	Post M (*SD*)	Year 1 End M (SD)	Pre M (*SD*)	Year 1 End M (SD)	Post M (SD)
1. I feel confident using computer technology.	5.0 (0.7)	5.3 (0.6)	5.3 (0.8)	4.9 (0.9)	4.9 (0.8)	4.9 (0.9)
2. I know how to teach programming concepts effectively.	3.1 (1.3)	4.2 (1.0)	4.3 (0.8)	3.1 (1.4)	3.2 (1.5)	3.4 (1.5)
3. I feel confident writing simple programs for the computer.	2.5 (1.3)	3.6 (1.3)	4.1 (1.2)	3.0 (1.5)	2.8 (1.5)	3.1 (1.6)
4. I can promote a positive attitude toward programming in my students.	5.0 (0.8)	5.2 (1.1)	4.9 (0.8)	5.0 (1.0)	4.7 (0.8)	4.7 (1.3)
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)	3.8 (1.5)	3.7 (1.5)	4.1 (1.4)
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)	3.7 (1.6)	3.5 (1.5)	3.7 (1.5)
7. I can adapt lesson plans incorporating programming as an instructional tool.	4.0 (1.3)	4.8 (1.1)	4.6 (0.7)	4.1 (1.4)	3.7 (1.5)	4.1 (1.5)
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)	3.7 (1.4)	3.4 (1.5)	3.6 (1.6)
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)	4.0 (1.3)	3.9 (1.2)	4.2 (1.5)
Sum of 9 items above	34.7 (8.5)	41.7 (8.0)	40.8 (6.2)	35.3 (9.7)	33.7 (10.1)	35.9 (11.5)

Note. Treatment group (pre n = 25, post n = 25, year 1 end n = 15), control group (pre n = 39, post n = 23, year 1 end n = 14). Each item scored 1-6. Cronbach's α pre = .93, Cronbach's α post = .93. Scale: 1 = strongly disagree, 6 = strongly agree

Table 35. Confidence Programming

	Treatment			Control		
Rate your confidence with the following:	Pre M (*SD*)	Post M (*SD*)	Year 1 End M (SD)	Pre M (*SD*)	Year 1 End M (SD)	Post M (SD)
1. Programming (any language)	2.3 (1.2)	3.5 (1.2)	3.9 (0.7)	2.5 (1.4)	2.7 (1.5)	3.1 (1.5)
2. Coding in a block language	2.8 (1.5)	3.8 (1.2)	4.3 (1.3)	3.1 (1.7)	3.3 (1.6)	3.4 (1.8)
3. Coding in a text-based language	2.1 (1.2)	2.9 (1.1)	3.1 (1.2)	2.0 (1.1)	2.2 (1.4)	2.6 (1.7)
4. Running an "Hour of Code" event	2.8 (1.8)	4.1 (1.2)	4.1 (1.2)	3.5 (1.8)	3.6 (1.8)	3.9 (1.8)
Sum of 4 items above	10.0 (5.2)	14.2 (3.8)	15.5 (3.2)	11.0 (5.1)	11.7 (5.4)	12.9 (6.3)

Note. Treatment group (pre n = 25, post n = 25, year 1 end n = 15), control group (pre n = 39, post n = 23, year 1 end n = 14). 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 36. Confidence Teaching Programming

	Treatment			Control		
Rate your confidence with the following:	Pre M (*SD*)	Post M (*SD*)	Year 1 End M (SD)	Pre M (*SD*)	Year 1 End M (SD)	Post M (SD)
1. Teaching Programming (any language)	2.3 (1.4)	3.2 (1.2)	3.8 (0.8)	2.4 (1.6)	2.6 (1.5)	2.9 (1.4)
2. Teaching coding in a block language	2.6 (1.6)	3.7 (1.2)	4.1 (1.3)	3.1 (1.7)	3.0 (1.6)	3.4 (1.5)
3. Teaching coding in a text-based language	2.0 (1.4)	2.6 (1.2)	2.8 (1.2)	1.9 (1.1)	2.0 (1.3)	2.6 (1.4)
Sum of 3 items above	6.8 (4.1)	9.5 (3.2)	10.7 (2.8)	7.4 (3.9)	7.7 (3.9)	9.0 (4.2)

Note. Treatment group (pre n = 25, post n = 25, year 1 end n = 15), control group (pre n = 39, post n = 23, year 1 end n = 14). 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 37. Confidence Integrating CS SOLs

	Treatment			Control		
Rate your confidence integrating the following into your K-12 instruction:	Pre M (*SD*)	Post M (*SD*)	Year 1 End M (SD)	Pre M (*SD*)	Year 1 End M (SD)	Post M (SD)
1. The Virginia Computer Science Standards	2.9 (1.5)	5.0 (.8)	4.6 (0.7)	3.8 (1.2)	3.5 (1.4)	4.8 (1.1)
2. Algorithms and programming	2.4 (1.6)	4.5 (1.1)	4.3 (1.0)	2.9 (1.3)	3.0 (1.4)	4.5 (1.2)
3. Information about computer systems	3.0 (1.4)	4.6 (1.0)	4.4 (1.0)	3.2 (1.4)	3.5 (1.4)	4.6 (1.2)
4. Information about cybersecurity	3.0 (1.4)	4.7 (0.9)	4.5 (1.0)	3.3 (1.5)	3.6 (1.5)	5.0 (0.8)
5. Data and analysis	3.2 (1.5)	4.8 (0.9)	4.3 (0.8)	3.6 (1.5)	3.5 (1.4)	4.6 (1.2)
6. Information about the impacts of computing	3.1 (1.4)	4.8 (0.8)	4.3 (1.0)	3.5 (1.4)	3.3 (1.5)	4.9 (0.7)
Sum of 6 items above	17.6 (7.8)	28.4 (4.8)	26.4 (4.8)	20.3 (7.1)	20.4 (7.9)	28.3 (5.8)

Note. Treatment group (pre n = 25, post n = 25, year 1 end n = 15), control group (pre n = 39, post n = 23, year 1 end n = 14). 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. 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 (Appendix F).

Table 38. Culturally Responsive Teaching Confidence

	Treatment			Control		
Please indicate how confident you are that you can:	Pre M (*SD*)	Post M (*SD*)	Year 1 End M (SD)	Pre M (*SD*)	Year 1 End M (SD)	Post 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)	4.4 (1.0)	4.0 (1.1)	4.9 (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)	4.1 (1.0)	4.0 (1.0)	4.7 (0.8)
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)	4.8 (0.9)	4.6 (1.1)	5.1 (0.7)
4. Use my students' cultural background to help make learning meaningful.	4.6 (0.8)	4.7 (0.8)	4.7 (0.9)	4.7 (0.9)	4.4 (0.9)	5.0 (0.8)
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)	4.8 (0.9)	4.5 (0.9)	5.1 (0.8)
6. Revise instructional material to include a better representation of cultural groups.	4.6 (0.9)	4.6 (0.8)	4.5 (1.1)	4.6 (1.0)	4.5 (1.1)	5.1 (0.9)
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)	4.3 (1.0)	4.3 (1.0)	4.6 (1.0)
8. Use examples that are familiar to students from diverse cultural backgrounds.	4.6 (0.9)	4.6 (0.8)	4.6 (1.1)	4.5 (1.0)	4.5 (1.1)	4.8 (1.1)
Sum of 8 items above (max 48)	36.1 (6.7)	36.6 (.6.3)	36.4 (7.0)	36.2 (6.9)	34.7 (7.6)	39.2 (6.2)

Note. Treatment group (pre n = 25, post n = 25, year 1 end n = 15), control group (pre n = 39, post n = 23, year 1 end n = 14). 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 39. Culturally Responsive Teaching Frequency

	Treatment			Control		
Please indicate how often you do the following:	Pre M (*SD*)	Post M (*SD*)	Year 1 End M (SD)	Pre M (*SD*)	Year 1 End M (SD)	Post 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)	4.3 (0.9)	4.1 (0.9)	4.7 (0.9)
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)	5.1 (0.8)	5.2 (0.8)	5.5 (0.7)
3. Examine class materials for culturally appropriate images and themes.	5.0 (0.6)	4.8 (0.7)	5.1 (0.7)	4.9 (0.8)	4.9 (0.7)	5.1 (0.6)
4. Encourage students to use cross-cultural comparisons when analyzing material	4.6 (1.0)	4.5 (0.8)	4.5 (0.8)	4.5 (0.9)	4.5 (1.0)	5.0 (0.8)

Note**.** Treatment group (pre n = 25, post n = 25, year 1 end n = 15), control group (pre n = 39, post n = 23, year 1 end n = 14). Cronbach's α pre = .76, Cronbach's α post = 77. Scale: 1 = never, 6 = always

Student Outcomes

The CKACKS pre-assessment was administered to students between August 11, 2021 and October 29, 2021 based on their school start date. Students completed the CKACKs post-assessment between March 18, 2022 and April 15, 2022. Students took the assessment during class time or at home. Completion rates for CKACS components are shown in Table 40. Overall for the analytic sample, we were able to match 108 students from 7 treatment schools and 229 students from 8 control schools. Sample attrition and differential attrition will be calculated for the final grant report.

Table 40. Student Assessment

Condition	School Identifier	Target Grade	[1] Number Enrolled in Target Grade	Pre Number Completed Knowledge and Affect	Post Number Completed Knowledge and Affect	Matched
Treatment (n = 9)	Cedar Point	5	98	71	65	15
	Fitzgerald	5	134	89	121	24
	Mullen	3	115	76	63	22
	Magruder	5	100	103	86	27
	Neabsco	5	112	3	0	0
	North	4	110	70	85	11
	River Oaks	5	103	53	10	4
	Ruckersville	4	87	12	7	0
	Swans Creek	5	127	65	26	5
	Total		986	542	463	108

Table 40. Student Assessment (con't)

Condition	School Identifier	Target Grade	[1] Number Enrolled in Target Grade	Pre Number Completed Knowledge and Affect	Post Number Completed Knowledge and Affect	Matched
Control (n = 12)	Antietam	4	131	108	124	28
	Bass Hoover	4	87	71	77	30
	Bel Air	5	67	43	49	8
	Bowser	5	112	0	0	0
	Ellis	5	89	54	0	0
	Loch Lomond	4	99	60	50	9
	Pittsylvania	5	249	197	218	69
	Seaford	5	83	97	79	19
	Spotswood	3	82	15	18	0
	Triangle	5	134	70	71	17
	T. Clay Wood	5	150	135	134	49
	Vaughan	4	94	0	0	0
	Total	--	1377	850	820	229

Note. [1] From 2020-21 VDOE fall membership.

CS Knowledge and Affective Outcomes

Below we provide output for the primary outcomes of interest, content knowledge and affect, after matching student pre- and post-test scores (N = 337). These analyses will be rerun after year 4 of the project when we combine Cohort 1 and Cohort 2 teachers' students. We compared treatment and control student content knowledge post-test scores using pre-test score as the covariate. Controlling for L1 pretest scores, the average treatment school content knowledge mean is .463 points higher than the content knowledge average control school mean of 8.91, $p = .46$. Controlling for L1 pretest scores, the average treatment school affective mean is 1.77 points higher than the content knowledge average control school mean of 14.71, $p = .19$. Of the treatment students in the analytic sample, 75/108 (69%) increased their content knowledge scores pre to post and 63/108 (58%) increased their affective scores pre to post. See Appendix F.

Overall student pre- and post-content knowledge and affective scores are for students in the treatment group are reported in table 41. (Note that this is not the matched sample.)

Table 41. CS Content Knowledge and Affective Scores

	Pre M (SD) (n = 482)	Post M (SD) (n = 409)
Computing Systems and Impacts of Computing [1]	7.0 (1.3)	7.7 (1.8)
Data Analysis [2]	5.8 (1.4)	6.3 (1.4)
Cybersecurity [3]	1.0 (0.0)	1.4 (.49)
Overall Content Knowledge [4]	**13.8 (2.2)**	**15.4 (3.1)**
Confidence [5]	15.5 (3.9)	16.2 (4.1)
Interest [6]	13.3 (3.7)	13.6 (3.9)
Utility [7]	11.3 (2.9)	11.4 (2.7)
Overall Affect [8]	**40.0 (9.0)**	**41.2 (9.5)**

Note. [1] Computing Systems and Impacts of Computing: 4 items, max score: 12; [2] Data Analysis: 3 items, max score: 9; [3] Cybersecurity: 1 item, max score: 3; [4] Overall content knowledge: 8 items, max score: 24.[5] Confidence: 6 items, max score: 24; [6] Interest: 5 items, max score: 20; [7] Utility: 4 items, max score: 16; [8] Overall affect: 15 items, max score: 60.

Frequency of CS-integrated Instruction

Teacher self-report data indicated that of 57 teachers who completed the frequency of integration survey in late January 2022, 43 (75.4%) reported teaching at least one lesson that explicitly targeted CS SOLs between the beginning of the school year and January. Of the 43 teachers who taught one or more CS lessons, most (76.7%) reported teaching at least one lesson addressing Algorithms and Programming. Few teachers reported teaching CS lessons that explicitly addressed data and analysis (39.5% and network and the internet (34.9%, see Table 42).

Of 38 teachers who completed the frequency of integration survey in spring 2022, 21 (55.3%) reported teaching at least one lesson that explicitly targeted CS SOLs at the end of the first academic year following ARCS PD. Of the 21 teachers who taught one or more CS lessons, most (95.2%) reported teaching at least one lesson addressing Algorithms and Programming. Few teachers reported teaching CS lessons that explicitly addressed data and analysis (42.9.5% and computing systems (47.6%, see Table 42).

Table 42. Frequency of CS-Integrated Instruction

SOL Strand	Group	None (%)	1-2 Lessons (%)	3-4 Lessons (%)	5 or more Lessons (%)
Computing systems	Year 1 Mid	44.2	34.9	16.3	4.7
	Year 1 End	52.4	33.3	14.3	0
Impacts of Computing	Year 1 Mid	53.5	39.5	4.7	2.3
	Year 1 End	47.6	47.6	4.8	0
Algorithms and Programming	Year 1 Mid	23.3	51.2	18.6	7.0
	Year 1 End	4.8	52.4	33.3	9.5
Data and Analysis	Year 1 Mid	60.5	23.3	11.6	4.7
	Year 1 End	57.1	38.1	4.8	0
Networking and the Internet	Year 1 Mid	65.1	27.9	4.7	2.3
	Year 1 End	42.9	38.1	14.3	4.8
Cybersecurity	Year 1 Mid	39.5	51.2	7.0	2.3
	Year 1 End	38.1	42.9	14.3	4.8

Note. year 1 mid n = 43, year 1 end n = 21.

Student Engagement during CS Instruction

Teachers reported on student engagement during CS instruction between the beginning of the 2021 school year and January 2022 and January 2022 and May 2022. Of 55 teachers who completed the mid-year 1 survey and reported on student engagement, 50.9% of teachers agreed or strongly agreed their students were more engaged at the end of the first semester than at the beginning of the school year. Of 38 teachers who completed the end-year 1 survey in May 2022 and reported on student engagement, 44.7% of teachers agreed or strongly agreed their students were more engaged at the end of the school year than at the beginning of the school year (Table 43).

Table 43. Student Engagement during CS Instruction

Rate the extent to which you agree with the following	Group	Strongly disagree (%)	Disagree (%)	Somewhat disagree (%)	Somewhat agree (%)	Agree (%)	Strongly agree (%)
My students are more engaged in CS now than at the beginning of the school year.	Year 1 Mid	1.8	7.3	0	40	0	50.9
	Year 1 End	7.9	2.6	7.9	36.8	34.2	10.5

Note. Year 1 mid n = 55, year 1 end n = 38.

Table 44. Engagement During Specific SOLs Taught

Describe the general level of engagement during CS SOL strand lessons you implemented in your classroom	Group	Taught SOL-based lesson (n)	Not at all engaged (%)	Slightly engaged (%)	Moderately engaged (%)	Highly engaged (%)
Computing Systems	Year 1 Mid	22	4.5	27.3	36.4	31.8
	Year 1 End	10	0	30	60	10
Impacts of Computing	Year 1 Mid	10	0	20	70	10
	Year 1 End	11	9.1	54.5	9.1	27.3
Algorithms and Programming	Year 1 Mid	31	0	9.7	29.0	61.3
	Year 1 End	20	0	15	15	70
Cybersecurity	Year 1 Mid	25	8.0	44	36	12
	Year 1 End	13	7.7	7.7	53.8	30.8
Data and Analysis	Year 1 Mid	15	0	46.7	26.7	26.7
	Year 1 End	12	33.3	16.7	33.3	16.7
Networking and the Internet	Year 1 Mid	13	7.7	30.8	38.5	23.1
	Year 1 End	12	8.3	50	16.7	25

Conclusion and Recommendations

From the data presented in this report, it appears clear that the ARCS professional development, which consisted of the CodeVA K-5 Summer Coaches Academy, was implemented as proposed for the pilot cohort and RCT Cohort 1, including both the treatment and delayed treatment (control) groups. Modifications were made to provide the PD through asynchronous and synchronous components to accommodate for the COVID-19 Pandemic and these modifications were retained for the RCT Cohort 1 delayed treatment group. The Networked Improvement Community (e.g., CodeVA NING, Learning Bytes) and Microcredentials were also implemented as proposed, however, with less participation by teachers.

Participant attendance and engagement were high during CodeVA K-5 Summer Coaches Academy for both the Pilot and RCT Cohort 1 teachers. Both pilot cohort teachers and RCT Cohort 1 teachers reported positive perceptions of the ARCS PD on the post-survey. Pilot cohort perceptions of the ARCS PD on the year-end survey also indicated extremely positive perceptions of the ARCS PD (means of all items greater than 4.5).

Key Pilot Cohort Outcomes. Improvements in teacher content knowledge and self-efficacy were retained from pre to year 2-end. However, from year 1 end to year 2 end, participants' CS knowledge significantly decreased, $t(8) = -2.3$, $p = .04$. Overall, this suggests that teachers' CS content knowledge and self-efficacy for teaching CS generally improved across the two years of the ARCS PD. These results should be interpreted with caution given the small number of teachers that completed the year 2 end survey.

Key Cohort 1 RCT Teacher Outcomes. Treatment teacher self-efficacy for teaching CS ($p = .001$; $R^2 = .6$) and CS content knowledge ($p = .05$; $R^2 = .3$) were greater than those of control teachers after controlling for race, gender, prior CS experience, and pre-scores. These results indicate a both statistically and practically meaningful improvement in treatment teachers' self-efficacy and CS content knowledge compared to teachers in the control group following the ARCS CODE-VA K-5 Coaches Academy. There was no significant difference in teacher confidence for implementing culturally responsive teaching for the treatment group compared to the control group, $p = .3$; $R^2=.4$, after controlling for prescore, race, gender, and prior CS PD experience.

Key Cohort 1 RCT Student Outcomes. For the Cohort 1 only matched sample of N = 337 students who completed both the pre- and post-CKACKs assessment, preliminary student results indicated no significant difference between treatment and control school student scores after controlling for student pre-test score. However, the average treatment school content knowledge score was .46 points higher than the average control school mean of 8.9 and the average treatment school affective score was 1.8 points higher than the average control school mean of 14.7.

Recommendations. Two important observations arose from the data that informed our recommendations regarding the Networked Improvement Community component and the Microcredentials Components of ARCS.

Networked Improvement Community. Few teachers in the pilot cohort engaged in the NIC (70% indicated that they engaged with the NIC none to 2 times). Despite changes to the NIC such that teachers were expected to complete 2 Code VA Learning Bytes each semester, 6 treatment teachers have completed at least one Learning Byte and no teacher completed 4 Learning Bytes.

(1) Provide more guidance 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. Pilot participants (n = 67) were eligible to complete the Microcredentials (year 2) component of the PD, which has been available since July 2021. As of June 30, 2022, 12 teachers in the pilot cohort (18%) completed all 5 microcredentials and 4 teachers in the RCT Cohort 1 Treatment group have completed the microcredentials.

(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.

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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						
4. Teaching Programming (any language)						
5. Teaching coding in a block language (e.g. Scratch)						
6. 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
6. The Virginia CS Standards						
7. Algorithms and programming						
8. Information about computer systems						
9. Information about cybersecurity						
10. Data and analysis						
11. 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
12. Programming (any language)						
13. Coding in a block language (e.g. Scratch)						
14. Coding in a text-based language (e.g. Python)						
15. 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 Confident	Completely Confident
41. Identify ways that the school culture (e.g., values, norms, and practices) is different from my students' home culture.						
42. Implement strategies to minimize the effects of any mismatch between my students' home culture and the school culture.						
43. Develop a community of learners when my class consists of students from diverse backgrounds						
44. Use my students' cultural background to help make learning meaningful.						
45. Use my students' prior knowledge to help them make sense of new information						
46. Revise instructional material to include a better representation of cultural groups.						
47. Critically examine the curriculum to determine whether it reinforces negative cultural stereotypes.						
48. Use examples that are familiar to students from diverse cultural backgrounds.						

Culturally Responsive Teaching Frequency.

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

Content Knowledge Items and Rubric

What is computer science?

Met expectations (3)	Partially met expectations (2)	Did not meet expectations (1)	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: Frequency of Implementation Survey

1. Did you teach any lessons that explicitly targeted CS SOLs between the beginning of the school year and the end of January?

Yes

No

2. If yes, approximately how many lessons related to each of the following CS SOL strands did you teach between the beginning of the year and the end of January? If a lesson was designed to target multiple CS SOL strands, count it for each strand.

	None	1-2 lessons	3-4 lessons	5 or more lessons
Algorithms and Programming				
Computing Systems				
Cybersecurity				
Data and Analysis				
Impacts of Computing				
Networking and the Internet				

3. If not, then why?

4. Describe the general level of engagement during CS SOL strand lessons you implemented in your classroom	Not at all engaged	Slightly engaged	Moderately engaged	Highly engaged
Computing Systems				
Impacts of Computing				
Algorithms and Programming				
Cybersecurity				
Data and Analysis				
Networking and the Internet				

5. Describe any CS-related activities you implemented in your classroom that you perceived to be engaging and/or effective for your students.

6. Rate the extent to which you agree with the following	Strongly disagree	Disagree	Somewhat disagree	Somewhat agree	Agree	Strongly agree
My students are more engaged in CS now than at the beginning of the school year.						

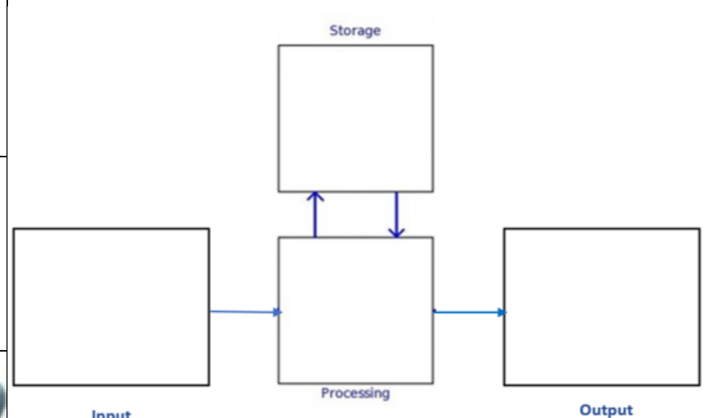
Appendix C: Original Student CS Content Knowledge Performance Tasks and Scoring Rubric (pilot cohort year 1 only)

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.

Inputs	Outputs

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



3. Explain how your computing system works.

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.

4. Which of the technologies listed below are ***computing technologies*** that you could teach the second graders about? (Select all that apply.)

A) Internet search engine
B) Road
C) Desk
D) Smartphone application (software)/App

5. 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.)

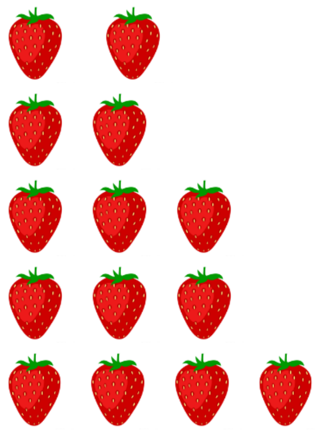
A) I can learn new things by watching YouTube
B) People write letters
C) People can talk on video apps
D) People can buy things online
E) People can find other people easily
F) People can talk on the phone

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.

1. Match the steps that you would take to conduct the experiment with the task in the correct order.

______ Step 1	A. Plant the plants
______Step 2	B. Pick the strawberries
______Step 3	C. Put soil in pots
______Step 4	D. Count the strawberries
______Step 5	E. Water the plants

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



Monday

Tuesday

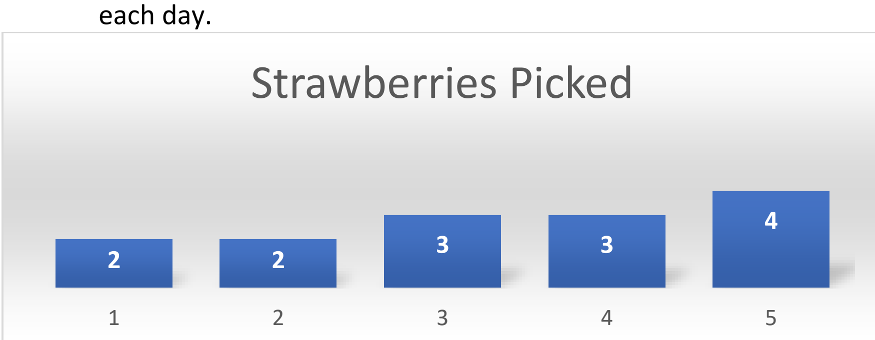
Wednesday

Thursday

Friday

3. How can the computer help you to organize the strawberry data?

4. *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.



Monday Tuesday Wednesday Thursday Friday

5. Based on the pattern of strawberries picked on day 1 through day 5, select the letter for the number of strawberries that most likely will be collected on Saturday, day 6.

A) 1
B) 2
C) 3
D) 4

Explain why you picked this answer.

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.

1. Select words from the list below that can cause cybersecurity problems when using a computer or iPad at home or school.

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

_____ Phishing ____
_____ Riding in a car ____
_____ Cooking ____
_____ Ransomware ____
_____ Hacking ____
_____ Bike riding ____
_____ Online predators ____
_____ Malware ____

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

Proposed Factor	Item	Flesch-Kincaid Grade Level
Confidence	1) I know what computer science is.	2.1
	2) I can learn computer science.[1]	2.9
	3) I am good at computer science.[1,2]	2.1
	4) I can do computer science.[3]	2.9
	5) People like me can do computer science.[2]	3.7
	6) I know a lot about computers.[2]	4.5
Interest	7) I would like to learn more about computer science. [1,2]	3.3
	8) I like computer science.[2,4]	3.7
	9) I would like to get a job in computer science when I get older.[3]	3.6
	10) I think computer science is interesting. [4]	8
	11) It is fun to do computer science. [2]	2.5
CS Utility	12) I can use computer science skills in my life. [2]	2.1
	13) Knowing computer science will help me to meet my goals. [2,3]	3.7
	14) I can use computers to help people and solve problems.[1,2,3]	4.8
	15) I will need to know computer science for my future job.[1]	4

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 Rubric (Pilot Cohort only)

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 and 3.

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 and 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.

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 system; 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.

4.

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

5.

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

6.

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

7.

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, or chart and accurately explains the answer.	Answer correctly identifies computers being useful in constructing at least one of the following: table, graph, or chart but does not accurately explain the answer.	Answer does not identify the computer as being useful in organizing the data.

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.

8 and 9.

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 #8.	Answer does not correctly identify D as the answer **and** the explanation provided is inconsistent with the selected answer for #8.

10.
Phishing: Do not answer suspicious email.
Ransomware/Malware: Do not open email or attachments from people whose name you don't recognize.
Hacking: Do not override security software
Online predators: Do not respond to suspicious questions on social media.

Met expectations (3)	Partially met expectations (2)	Did not meet expectations (1)
Answer correctly identifies all 5 potential security issues and provides accurate explanations of how to avoid each.	Answer correctly identifies at least 2 potential security issues **and** provides accurate explanations of how to avoid each and may identify non-cybersecurity problems as well. Or Answer correctly identifies at least 3 potential security issues but one explanation is not accurate, and may identify non-cybersecurity problems as well.	Answer correctly identifies fewer than 2 potential security issues with accurate explanations and may identify non-cybersecurity problems as well.

Appendix D: Microcredentials Evaluation Survey

1. Which microcredentials have you completed to date? (Select all that apply)

DIDC – Introduction to Computers, Digital Impact, and Digital Citizenship
SNIC – Computing Systems, Networks and the Internet, and Cybersecurity
ALPR – Algorithms and Programming
DTAN – Data and Analysis
CSLI – Computer Science Lesson Integration

2. Rate the extent to which you found each microcredential useful.

Item	Strongly Disagree	Disagree	Somewhat Disagree	Somewhat Agree	Agree	Strongly Agree
DIDC – Introduction to Computers, Digital Impact, and Digital Citizenship						
SNIC – Computing Systems, Networks and the Internet, and Cybersecurity						
ALPR – Algorithms and Programming						
DTAN – Data and Analysis						
CSLI – Computer Science Lesson Integration						

3. Please provide feedback (positive and negative) about the **DIDC – Introduction to Computers, Digital Impact, and Digital Citizenship** microcredential.

4. Please provide feedback (positive and negative) about the **SNIC – Computing Systems, Networks and the Internet, and Cybersecurity** microcredential.

5. Please provide feedback (positive and negative) about the **ALPR – Algorithms and Programming** microcredential.

6. Please provide feedback (positive and negative) about the **DTAN – Data and Analysis** microcredential.

7. Please provide feedback (positive and negative) about the **CSLI – Computer Science Lesson Integration** microcredential.

8. Are there any microcredential topics that you would like to learn more about?
   (Select all that apply)
   DIDC – Introduction to Computers, Digital Impact, and Digital Citizenship
   SNIC – Computing Systems, Networks and the Internet, and Cybersecurity
   ALPR – Algorithms and Programming
   DTAN – Data and Analysis
   CSLI – Computer Science Lesson Integration
   I do not wish to learn more about any of the topics

9. Rate the extent to which you agree with the following statements

Item	Strongly Disagre e	Disagree	Somewh at Disagree	Somewh at Agree	Agree	Strongly Agree
I liked being able to complete the microcredentials at my own pace/on my own time.						
I liked the staggered opening of the microcredential sessions (e.g., that a new session opened every few weeks).						
Completing the microcredentials allowed me to build on my knowledge and understanding of the Virginia Computer Science Standards.						
After completing the microcredentials, I can effectively teach the Virginia Computer Science Standards for my grade.						
Completing the microcredentials will help me to better integrate the Virginia Computer Science Standards into my classroom instruction.						

10. Did you take advantage of the office hours that were offered?
    Yes
    No

11. If yes, how helpful were the office hours?
    Very helpful
    Somewhat helpful
    Not Very helpful
    Not at all Helpful

12. You indicated that you did not complete the following microcredentials. Why did you not complete these microcredentials?

13. Please share other comments about the micocredentialing process and how it might be improved.

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

Content Knowledge Items

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

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

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

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

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

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

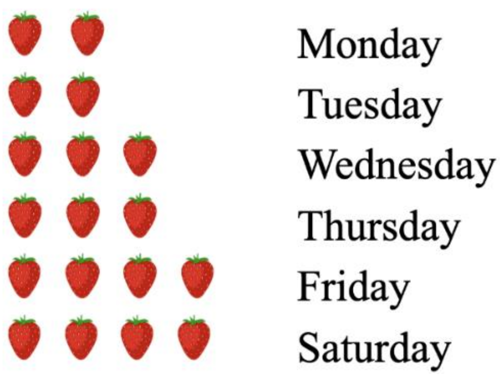
5. Which of the technologies listed below are ***computing technologies*** that you could teach the second graders about? (Select all that apply.)
   Internet search engine
   Light up sneakers
   Fidget spinner
   Smartphone application (software)/App

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

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

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

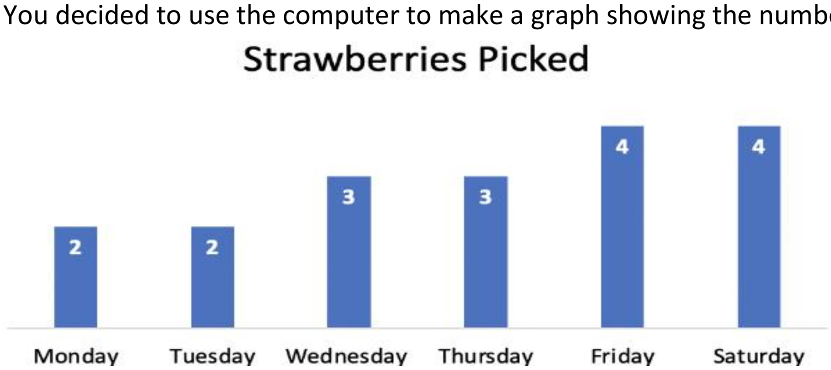
Once the plants have grown and strawberries appear, you pick them every day for six days. The following picture shows the number of strawberries that you picked each day.



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

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

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



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

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

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

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

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

Affective Items

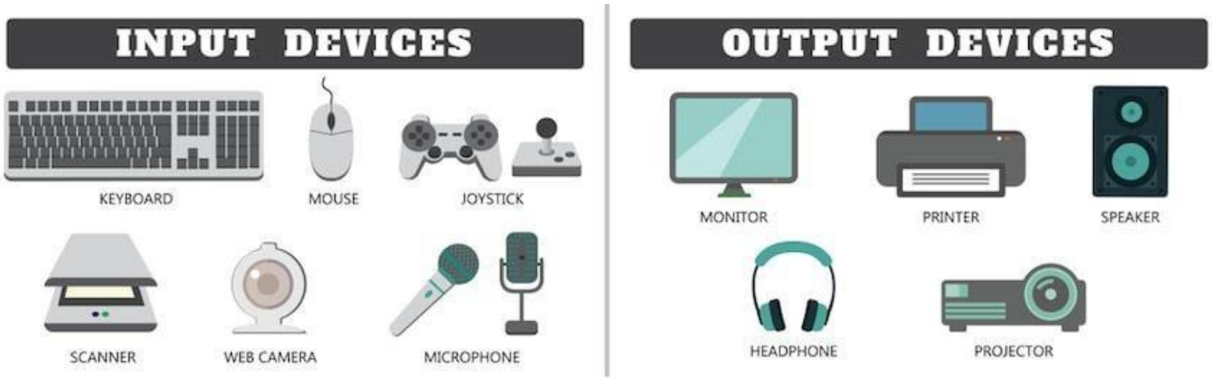
Respond to the following items using this 4-pt Likert scale: Strongly disagree (1), Disagree (2), Agree (3), Strongly agree (4)

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

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

Student Content Knowledge Scoring Rubric

1.



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

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

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

5.

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

6.

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

7.

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

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

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

9 and 10.

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

11 and 12.

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

Appendix F: T-test, ANCOVA, and Student Outcome Results

Paired sample t-test of treatment teachers' CS content knowledge (Pre to Post)

Paired Samples Test

		Paired Differences							Significance	
					95% Confidence Interval of the Difference					
		Mean	Std. Deviation	Std. Error Mean	Lower	Upper	t	df	One-Sided p	Two-Sided p
Pair 1	POST Knowledge Score - PRE Knowledge Score	.31818	1.78316	.38017	-.47243	1.10879	.837	21	.206	.412

Paired sample t-test of treatment teachers' CS content knowledge (Pre to Year-end)

Paired Samples Test

		Paired Differences							Significance	
					95% Confidence Interval of the Difference					
		Mean	Std. Deviation	Std. Error Mean	Lower	Upper	t	df	One-Sided p	Two-Sided p
Pair 1	Year end knowledge score - PRE Knowledge Score	.30769	3.03822	.84265	-1.52828	2.14367	.365	12	.361	.721

ANCOVA test result of teachers' year-end CS content knowledge between treatment group and control group.

Tests of Between-Subjects Effects

Dependent Variable: Year end knowledge score

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	55.315[a]	5	11.063	2.293	.072	.291
Intercept	6.812	1	6.812	1.412	.245	.048
PREKNOWSC	14.747	1	14.747	3.057	.091	.098
GENDERCODE	2.243	1	2.243	.465	.501	.016
RACECODE	12.453	1	12.453	2.582	.119	.084
PRIORPDCS	2.283	1	2.283	.473	.497	.017
RCTGROUP	21.258	1	21.258	4.407	.045	.136
Error	135.067	28	4.824			
Total	2681.000	34				
Corrected Total	190.382	33				

a. R Squared = .291 (Adjusted R Squared = .164)

ANCOVA test result of teachers' year-end self-efficacy of teaching CS between treatment group and control group.

Tests of Between-Subjects Effects

Dependent Variable: YESESCALE

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	1956.447[a]	5	391.289	9.624	<.001	.601
Intercept	208.603	1	208.603	5.131	.030	.138
PRESESCALE	1168.871	1	1168.871	28.750	<.001	.473
GENDERCODE	83.676	1	83.676	2.058	.161	.060
PRIORPDCS	18.843	1	18.843	.463	.501	.014
RACECODE	1.041	1	1.041	.026	.874	.001
RCTGROUP	524.356	1	524.356	12.897	.001	.287
Error	1301.027	32	40.657			
Total	53956.000	38				
Corrected Total	3257.474	37				

a. R Squared = .601 (Adjusted R Squared = .538)

ANCOVA test result of teachers' year-end confidence in programming between treatment group and control group.

Tests of Between-Subjects Effects

Dependent Variable: YECONFPROSCALE

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	450.330[a]	5	90.066	6.125	<.001	.489
Intercept	36.768	1	36.768	2.501	.124	.072
PRECONFPROSCALE	211.683	1	211.683	14.396	<.001	.310
GENDERCODE	.006	1	.006	.000	.983	.000
PRIORPDCS	.037	1	.037	.003	.960	.000
RACECODE	31.994	1	31.994	2.176	.150	.064
RCTGROUP	167.703	1	167.703	11.405	.002	.263
Error	470.538	32	14.704			
Total	7579.000	38				
Corrected Total	920.868	37				

a. R Squared = .489 (Adjusted R Squared = .409)

ANCOVA test result of teachers' year-end confidence in teaching programming between treatment group and control group.

Tests of Between-Subjects Effects

Dependent Variable: YECONFTEACHSCALE

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	263.449[a]	5	52.690	6.445	<.001	.502
Intercept	21.404	1	21.404	2.618	.115	.076
PRECONFTEACHSCALE	151.370	1	151.370	18.516	<.001	.367
GENDERCODE	.133	1	.133	.016	.899	.001
PRIORPDCS	2.773	1	2.773	.339	.564	.010
RACECODE	3.119	1	3.119	.381	.541	.012
RCTGROUP	85.184	1	85.184	10.420	.003	.246
Error	261.603	32	8.175			
Total	3496.000	38				
Corrected Total	525.053	37				

a. R Squared = .502 (Adjusted R Squared = .424)

ANCOVA test result of teachers' year-end confidence in integrating confidence in integrating CS SOLs between treatment group and control group.

Tests of Between-Subjects Effects

Dependent Variable: YECONFINTEGCSSOLSCALE

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	854.955[a]	5	170.991	4.701	.002	.423
Intercept	142.157	1	142.157	3.908	.057	.109
PRECONFINTEGCSSOLSCALE	298.805	1	298.805	8.215	.007	.204
GENDERCODE	1.539	1	1.539	.042	.838	.001
PRIORPDCS	73.828	1	73.828	2.030	.164	.060
RACECODE	2.936	1	2.936	.081	.778	.003
RCTGROUP	588.674	1	588.674	16.185	<.001	.336
Error	1163.913	32	36.372			
Total	21709.000	38				
Corrected Total	2018.868	37				

a. R Squared = .423 (Adjusted R Squared = .333)

Paired sample t-test of teachers' confidence Culturally Responsive Teaching (Pre to Year-end)

Paired Samples Test

		Paired Differences							Significance	
					95% Confidence Interval of the Difference					
		Mean	Std. Deviation	Std. Error Mean	Lower	Upper	t	df	One-Sided p	Two-Sided p
Pair 1	End of year CRT Confidence Score (sum of 8 items) - WHAT IS THIS? CRT Confidence or CRT FREQ	11.40000	7.40463	1.91187	7.29945	15.50055	5.963	14	<.001	<.001

ANCOVA test result of teachers' year-end confidence in implementing culturally responsive teaching between treatment group and control group.

Tests of Between-Subjects Effects

Dependent Variable: YECONFCULTURESCALE

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	829.462[a]	5	165.892	4.659	.003	.421
Intercept	30.643	1	30.643	.861	.361	.026
PRECONFCULTURESCALE	703.938	1	703.938	19.770	<.001	.382
RACECODE	12.927	1	12.927	.363	.551	.011
PRIORPDCS	11.648	1	11.648	.327	.571	.010
GENDERCODE	23.875	1	23.875	.671	.419	.021
RCTGROUP	38.420	1	38.420	1.079	.307	.033
Error	1139.380	32	35.606			
Total	49504.000	38				
Corrected Total	1968.842	37				

a. R Squared = .421 (Adjusted R Squared = .331)

Student Outcomes

Model 1: Student Post Content Knowledge Scores with Pretest Score as Covariate (N = 337)

Random Effects (Groups, n =15)	Variance	Standard Deviation		
Post School Coded (intercept)	1.076	1.037		
Residual	3.862	1.965		

Fixed Effects	Estimate	Std. Error	df	t-value	*p*
Intercept	8.91	.881	187.1	10.11	<.001
RCT Group	.0462	.603	15.61	.767	.455
PreCK Score	.448	.0564	335.6	7.94	<.001

R^2 = .015

Model 2: Student Post Affective Knowledge Scores with Pretest Score as Covariate (N = 337)

Random Effects (Groups, n = 15)	Variance	Standard Deviation		
Post School Coded (intercept)	2.00	1.42		
Residual	65.3	8.08		

Fixed Effects	Estimate	Std. Error	df	t-value	*p*
Intercept	14.71	2.29	203.65	6.41	<.001
RCT Group	1.77	1.25	11.02	1.41	.185
PreCK Score	.636	.0559	333.63	11.19	<.001

R^2 = .0285