ARCS External Evaluation
Year 2 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.

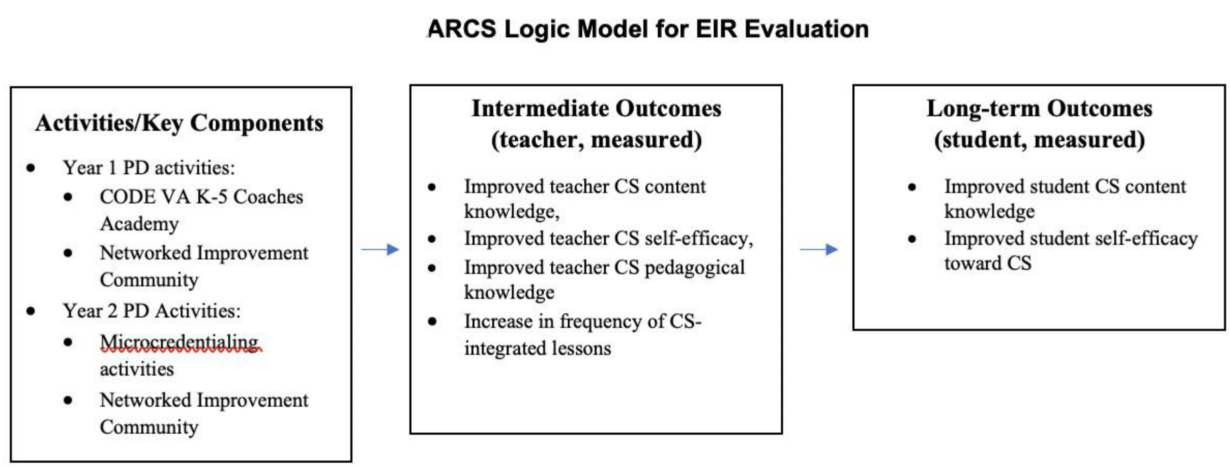

Figure 1. ARCS Logic Model

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 (CodeVA NING PLC) 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.

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 drawn to date for October 1, 2020 to September 30, 2021 grant year.

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

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

Exploratory research questions include:

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

Implementation questions include:

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

Year 2 Evaluation Activities

1. Coordinated with Old Dominion University to update IRB approval for research and evaluation activities.

2. Submitted evaluation design summary, contrast tables, and fidelity matrix and worked with ABT liaison to respond to and integrate feedback into the registered design.
3. Revised teacher assessment in conjunction with ODU research team.
4. Administered student content knowledge instrument (CKACS) to students in pilot cohort classrooms.
5. Analyzed student pilot cohort data and revised CKACS in conjunction with the ODU research team.
6. Revised scoring rubrics for CKACS.
7. Documented recruitment, attrition, and summer PD attendance of RCT Cohort 1 teachers.
8. Analysis of demographic data for elementary teachers in RCT Cohort 1.
9. Documented year 2 summer PD for RCT Cohort 1.
10. Documented implementation of microcredentials for the pilot cohort.
11. Administered and analyzed end-of-year assessments for pilot cohort teachers.
12. Administered and analyzed pre- and post-summer PD assessments to RCT Cohort 1 teachers.
13. Administered pre-CKACS to students in RCT Cohort 1 teacher classrooms.
14. Developed school level report for CKACS
15. Presented paper at the 2021 Annual NARST conference in conjunction with ODU research team.
16. Submitted proposal to 2021 Annual EIR project directors and evaluators TA meeting.
17. Submitted proposal to 2022 Annual NARST conference in conjunction with ODU research team.

Acknowledgments and Recommended Citation

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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.

Like in 2020, due to the COVID-19 pandemic, sessions were not able to be held in person. 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 2021 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 2.5-hour synchronous sessions beginning June 21, 2021 and ending June 25, 2021 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 Session and Breakouts	Live Session and Breakouts	Live Session and Breakouts	Live Session and Breakouts	Live Session and Breakouts
1:30 – 3:30 Asynchronous	Learning Lab	Learning Lab	Learning Lab	Learning Lab	Learning Lab

Figure 2. 2021 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.

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 only), at the end of year 1, and at the end of year 2.

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 2020-21 classroom environment. Another 6 questions asked only on the year-end survey asked about experiences participating in the Networked Improvement Community - the CodeVA NING PLC.

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 Results

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

Recruitment, Attrition, and Analytic Sample

Elementary teachers (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 1. PILOT ELEMENTARY STUDY RANDOMIZATION AND RETENTION DATA

	Applied n	Started ARCS n (%)	Completed Year 1 n (%)	Registered for Microcredentials
Schools	38	34	28 (82.4%)	--
Teachers	78	70	67 (95.7%)	38

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 2 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 2. 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

Year-End Perceptions of the PD

On Post- and Year-end PD Survey, 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 3). 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 3. 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-end	0	0	0	6.9	62.1	31.0	5.2 (0.6)
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-end	0	0	3.4	20.7	48.3	27.6	4.9 (0.9)
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-end	0	0	0	20.7	51.7	27.6	5.0 (0.8)
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-end	0	0	0	3.4	55.2	41.4	5.3 (0.6)
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-end	0	0	0	3.4	51.7	44.8	5.4 (0.6)
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-end	0	0	0	13.8	41.4	44.8	5.3 (0.7)

TABLE 3 (CON'T). 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)
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 (.7)
	Year-end	0	3.4	0	6.9	41.4	48.3	5.3 (.8)
8. I felt a rapport with other participants.	Post	0	0	0	12.1	44.8	43.1	5.3 (.7)
	Year-end	0	3.4	0	24.1	48.3	24.1	4.9 (.8)
9. I am satisfied with my interaction with my peers.	Post	0	0	0	8.6	48.3	43.1	5.3 (.9)
	Year-end	0	3.4	3.4	6.9	65.5	20.7	5.0 (.9)
10. I felt part of a learning community.	Post	0	0	0	13.8	37.9	48.3	5.3 (.7)
	Year-end	0	3.4	3.4	10.3	55.2	27.6	5.0 (.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.	Post	0	15.5	3.4	13.8	37.9	29.3	5.3 (.7)
	Year-end	0	6.9	10.3	13.8	37.9	34.5	4.8 (1.3)
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-end	0	3.4	10.3	13.8	41.4	34.5	4.8 (1.2)
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 (.8)
	Year-end	0	3.4	0	13.8	43.1	41.4	5.2 (.8)
14. I will integrate what I learned … in my teaching.	Post	0	0	1.7	3.4	31.0	63.8	5.6 (.7)
	Year-end	0	0	6.9	10.3	43.1	41.4	5.1 (1.1)

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

Useful Components of the PD. 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 resources, 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.*"

Recommendations for Modification. 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!*"

Networked Improvement Community: Code VA NING PLC.

ARCS participants (n = 35) joined the CodeVA NING ARCS page. Participants (n = 30) completing the year -end survey were asked about ARCS. These respondents 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 reported on the utility of the NING for the purposes of understanding CS concepts and integrating CS standards into the core curriculum (Table 4).

TABLE 4. PARTICIPANT USE OF CODEVA NING PLC

	Not helpful at all	Not very helpful	Somewhat helpful	Helpful	Very helpful
Knowledge and understanding of CS concepts	0 (0%)	2 (7.7%)	7 (26.9%)	18 (69.3%)	5 (19.2%)

Integration of CS standards into your core curriculum	0 (0%)	1 (3.8%)	10 (38.5%)	14 (43.9%)	5 (19.2%)

Participants also reported how they used the CodeVA NING PLC for the ARCS project this school year (Figure 3).

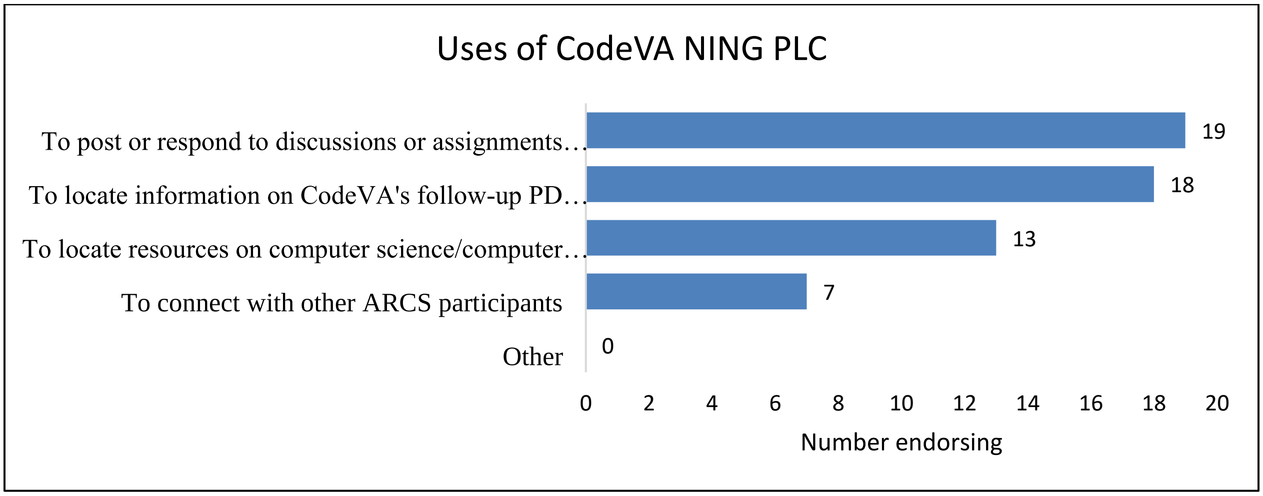


Figure 3. Participant use of the CodeVA NING PLC.

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 Microcredentialing.

As of October 26, 2021, 67 teachers were eligible and have had access to complete the Microcredentials on a rolling schedule since July 1, 2021. As of September 30, 2021 (the end of year two of the project), 2 teachers have completed all 5 microcredentials (Table 5).

TABLE 5. MICROCREDENTIAL COMPLETION

Microcredential	Number registered	Number started	Number completed
Introduction to Computer Science Principles, Digital Impact, and Digital Citizenship;	38	24	6
Computing Systems, Networks and the Internet, and Cybersecurity	38	15	3
Algorithms and Programming	37	9	1
Data and Analysis	38	8	2
Lesson Integration	36	27	7

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.

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-end, t (29) = .88, p = .39 (Table 6).

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)
	End	0%	16.7%	53.3%	30%	2.1 (0.7)
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)
	End	0%	10%	70%	20%	2.1 (0.6)
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)
	End	0%	16.7%	70%	13.3%	2.0 (0.6)
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)
	End	7.4%	0%	70.4%	22.2%	2.1 (0.5)
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)
	End	13.8%	3.4%	58.6%	24.1%	2.1 (0.7)
		Sum of 5 items above *M* (*SD*)			[2]*p*	
	Pre	8.2 (1.5)			—	
	Post	10.6 (1.9)			< .001	
	End	10.4 (1.6)			< .001	

Note. pre n = 58, post n = 58, year-end n = 30; 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 and pre to year-end.

CS Pedagogical Knowledge

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

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%
	End	10.3%	10.3%	31.0%	37.9%	10.3%	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%
	End	6.9%	10.3%	24.1%	27.6%	27.6%	3.4%
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%
	End	24.1%	6.9%	37.9%	27.6%	3.4%	0%
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%
	End	13.8%	13.8%	20.7%	24.1%	10.3%	17.2%

Group	Sum of 4 items above *M* (*SD*)	[1] *p*
Pre	8.5 (4.3)	.00
Post	12.7 (4.0)	
End	13.3 (4.5)	.001

Note. 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 and pre to year 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%
	End	10.3%	27.6%	24.1%	13.8%	24.1%	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%
	End	10.3%	27.6%	20.7%	13.8%	17.2%	10.3%
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%
	End	24.1%	31.0%	31.0%	10.3%	3.4%	0%
		Sum of 3 items above *M* (*SD*)			**[1] *p***		
	Pre	5.6 (3.0)			.00		
	Post	8.4 (2.9)					
	End	8.8 (3.7)			.001		

Note. 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 and pre to year-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%
	End	3.4%	0%	0%	65.5%	27.6%	3.4%
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%
	End	3.4%	6.9%	20.7%	48.3%	13.8%	6.9%
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%
	End	3.4%	3.4%	17.2%	58.6%	10.3%	6.9%
4. 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%
	End	3.4%	3.4%	3.4%	72.4%	6.9%	10.3%
5. 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%
	End	6.9%	6.9%	20.7%	51.7%	6.9%	6.9%
6. 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%
	End	3.4%	10.3%	24.1%	44.8%	10.3%	6.9%

		Sum of 6 items above *M* (*SD*)	[1] *p*
	Pre	15.4 (7.1)	.00
	Post	21.7 (6.0)	
	End	23.4 (5.6)	.001

Note. 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 and pre to year-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%
	End	0%	0%	0%	13.8%	62.1%	24.1%
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%
	End	0%	6.9%	17.2%	44.8%	24.1%	6.9%
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%
	End	0%	0%	0%	24.1%	65.5%	10.3%
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%
	End	0%	0%	0%	24.1%	55.2%	20.7%
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%
	End	0%	0%	0%	23.3%	56.7%	20%
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%
	End	0%	3.4%	10.3%	24.1%	44.8%	17.2%

Note. 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-end (all *p*'s < .05).

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%
	End	0%	0%	0%	27.6%	34.5%	37.9%
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%
	End	3.4%	6.9%	10.3%	44.8%	24.1%	10.3%
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%
	End	3.4%	13.8%	24.1%	27.6%	13.8%	17.2%
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%
	End	0%	0%	0%	17.2%	41.4%	41.4%
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%
	End	0%	3.4%	10.3%	41.4%	27.6%	17.2%
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%
	End	0%	6.0%	13.8%	41.4%	20.7%	17.2%
7. 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%
	End	0%	6.9%	3.4%	48.3%	24.1%	17.2%
8. 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%
	End	0%	3.4%	13.8%	41.4%	31.0%	10.3%
9. 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%
	End	0%	3.4%	3.4%	37.9%	31.0%	24.1%
		Sum of 9 Items Above *M* (*SD*)			**[1] *p***		
	Pre	32.3 (8.8)			.001		
	Post	42.7 (6.4)					
	End	40.5 (7.7)			.001		

Note. 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 and pre to year-end.

TABLE 12. CONFIDENCE PROGRAMMING

Rate your confidence with the following:	Group	Not at all confident	Unconfident	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%
	End	6.9%	3.4%	27.6%	48.3%	13.8%	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%
	End	3.4%	3.4%	17.2%	37.9%	27.6%	10.3%
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%
	End	20.7%	13.8%	24.1%	37.9%	3.4%	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%
	End	13.8%	6.9%	10.3%	27.6%	24.1%	17.2%
		Sum of 4 items above *M* (*SD*)			**[1] *p***		
	Pre	9.0 (4.0)			--		
	Post	14.5 (3.3)			.00		
	End	14.6 (4.3)			.001		

Note. 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 and pre to year-end.

TABLE 13. CONFIDENCE TEACHING PROGRAMMING

Rate your confidence with the following:	Group	Not at all confident	Unconfident	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%
	End	6.9%	10.3%	31.0%	34.5%	17.2%	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%
	End	3.4%	10.3%	24.1%	24.1%	27.6%	10.3%
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%
	End	24.1%	13.8%	37.9%	13.8.%	10.3%	0%
		Sum of 3 items above *M* (*SD*)			***P***		
	Pre	6.1 (3.0)			.001		
	Post	10.1 (2.5)					
	End	10.1 (3.3)			.001		

Note. 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 and pre to year-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%
	End	0%	0%	0%	27.6%	48.3%	24.1%
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%
	End	0%	0%	17.2%	34.5%	34.5%	13.8%
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%
	End	0%	0%	6.9%	37.9%	37.9%	17.2%
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%
	End	0%	0%	0%	31.0%	51.7%	17.2%
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%
	End	0%	0%	17.2%	27.6%	41.4%	13.8%
6. Information about the impacts of computing	Pre	13.8%	19.0%	22.4%	31.0%	10.3%	3.4%
	Post	0%	3.4%	3.4%	24.1%	56.9%	12.1%
	End	0%	0%	6.9%	27.6%	48.3%	17.2%
		Sum of 6 items above *M* (*SD*)			***P***		
	Pre	18.4 (6.8)			.00		
	Post	27.3 (5.4)					
	End	28.2 (4.3)			.001		

Note. 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 and pre to year-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:	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.	0%	0%	17.2%	34.5%	31.0%	17.2%	4.5 (.97)
2. Implement strategies to minimize the effects of any mismatch between my students' home culture and the school culture.	0%	3.4%	20.7%	37.9%	27.6%	10.3%	4.2 (1.0)
3. Develop a community of learners when my class consists of students from diverse backgrounds	0%	0%	13.8%	24.1%	31.0%	31.0%	4.8 (1.0)
4. Use my students' cultural background to help make learning meaningful.	0%	3.4%	13.8%	27.6%	34.5%	20.7%	4.5 (1.1)
5. Use my students' prior knowledge to help them make sense of new information	0%	0%	13.8%	24.1%	31%	31%	4.8 (1.0)
6. Revise instructional material to include a better representation of cultural groups.	0%	0%	10.3%	41.4%	31%	17.2%	4.5 (.90)
7. Critically examine the curriculum to determine whether it reinforces negative cultural stereotypes.	0%	3.4%	10.3%	34.5%	34.5%	17.2%	4.5 (1.0)
8. Use examples that are familiar to students from diverse cultural backgrounds.	0%	0%	17.2%	27.6%	34.5%	20.7%	4.6 (1.0)

Note. Each item scored 1-6. Cronbach's α = .97

TABLE 16. FREQUENCY OF CULTURALLY RESPONSIVE TEACHING

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

Note. 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 (N = 26)

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

Teachers who indicated they did not integrate lessons that explicitly targeted CS SOLs into instruction were asked to explain why. All of the teachers (n = 14) indicated that they did not respond that it was due to pandemic-related teaching constraints such as virtual teaching, feeling overwhelmed, or lack of time. Representative responses included:

> *I feel like with this year being as crazy as it is, it is hard to squeeze in extra time to do other assignments. My students are hybrid so I am only having half the time with them in person as I would in a normal school year.*

> *with covid and teaching remotely, my students, parents, and I have all been a bit overwhelmed. We return to in-person next week and I will begin doing some then.*

> *Due to COVID and seeing students only two days a week, I was limited to focus on core subjects. I did use technology, however, it was not on CS SOLS.*

Many indicated that despite the challenges of the pandemic and remote teaching, they were still attempting to integrate CS into instruction, as exemplified by the following response:

> *My school district is still virtual. This has make it hard to create assignments for just CS. However, I have included CS and CS vocabulary into my reading lessons.*

Pilot Cohort Student Outcomes

CS Content Knowledge

Pilot testing 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: 5 items, max score: 15; [2] Data Analysis: 4 items, max score:12; [3] Cybersecurity: 1 item, max score: 3; [4] Overall content knowledge: 10 items, max score: 30.

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
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 effect toward CS.

Student Engagement during CS Instruction

Teachers reported on student engagement during CS instruction between the beginning of the school year and January 2021. Of 40 teachers who completed the mid-year 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 (N = 40)

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.	5.0	0	2.5	55.0	30.0	7.5

TABLE 22. ENGAGEMENT DURING SPECIFIC SOLS TAUGHT

Describe the general level of engagement during CS SOL strand lessons you implemented in your classroom	Taught SOL-based lesson (n)	Not at all engaged (%)	Slightly engaged (%)	Moderately engaged (%)	Highly engaged (%)
Computing Systems	10	10	40	50	0
Impacts of Computing	11	0	18.2	72.7	9.1
Algorithms and Programming	22	0	9.1	68.2	22.7
Cybersecurity, Data and Analysis	17	0	23.5	70.6	5.9
Networking and the Internet	14	0	35.7	35.7	28.6

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. 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%). In the control group, 39 teachers from 12 schools completed the pre-assessment and are currently actively participating in the project.

Table 23. Elementary RCT Cohort 1 Randomization and Retention Data

	Randomized		Retained		Non-RCT	
	Treatment	**Control**	**Treatment**	**Control**	**Applied**	**Retained**
Schools	11	12	10	12	11	7
Teachers	33	44	29	39	14	9

Rural teacher participation

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

TABLE 24. COHORT 1 DEMOGRAPHICS

	Treatment (n = 25)[1] n (%)	Control (n = 39) n (%)	Non-RCT (n = 9) n (%)
Gender			
Male	3 (12.0%)	4 (10.3%)	0 (0%)
Female	22 (88.0%)	35 (89.7%)	9 (100%)
Race/Ethnicity			
White	23 (92.0%)	30 (76.9%)	9 (100%)
Black	1 (4.0%)	8 (20.5%)	0 (0%)
Asian	1 (4.0%)	0 (0%)	0 (0%)
Other	0 (0%)	1 (2.6%)	0 (0%)
Hispanic	0 (0%)	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 (%)	Non RCT (n = 9) n (%)
Has Ed Degree	25 (100%)	25 (100%)	25 (100%)
Elementary	22 (88%)	31 (79.5%)	88.9%
Secondary	1 (4%)	0 (0%)	0 (0%)
SPED	2 (8%)	2 (5.1%)	0 (0%)
Ed Tech	2 (8%)	0 (0%)	0 (0%)
Other[2]	2 (8%)	3 (7.7%)	0 (0%)
Has STEM Degree	1 (4%)	3 (7.7%)	1 (11.1%)

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 (June 21) n	Day 2 (June 22) n	Day 3 (June 23) n	Day 4 (June 24) n	Day 5 (June 25) n
Treatment (n = 33 applied)	27	28	28	28	26
Non-RCT (n = 14 applied)	9	8	9	9	9

Implementation

Overall, the ARCS CODE VA K-5 Coaches Academy Summer PD appeared to be implemented as planned. Below, we use examples from observation field notes to characterize the content and structure of the PD, and illustrate teacher engagement. Finally, we identify a few differences between the PD as implemented in Summer 2020 with the pilot cohort of teachers compared to the summer 2021 with the first cohort of treatment teachers.

Content. The ARCS CODE VA K-5 Coaches Academy Summer PD appeared to address goals related to improving teacher pedagogical knowledge and self-efficacy. The vignettes below from Monday, Wednesday, and Friday of the CODE VA K-5 Coaches Academy Summer PD demonstrate how facilitators introduced CS to teachers over the course of the week:

> *On Monday, the facilitators led the participants in a discussion to answer the question "What is Computer Science?" Participants were placed in breakout rooms and completed a JamBoard slide with their ideas. After 8 minutes, they return to the main Zoom room and a leader from each group shared their group's responses. Participants then discussed "Why Teach CS?" and shared ideas related to equity, digital citizenship, and debunking myths about CS.*
>
> *Later in the session, teachers explained what they thought computational thinking was using the chat. Teachers responded with answers including: "it's an approach to solve problems in a way that can be implemented with a computer but does not have to be", "it's a way to think logically", and "abstraction, iteration".*
>
> *After this, facilitators led a discussion of the CS SOLs. While discussing the computing systems SOL, the facilitator asked the teachers to think about other systems they teach about. Teachers*

responded with statements including: food webs, ecosystems, a computer needs input, output, processing, and storage, being able to trouble shoot basic problems. (Monday, Observation)

This example demonstrates how facilitators activated teachers' initial content knowledge and elicited their ideas about CS and then built on this initial knowledge to help teachers develop a more formal understanding of CS based on the SOLs.

The focus of Wednesday's session was "coaching". The goal of this day was to develop teachers' capacity as coaches and teacher-leaders of CS within their schools. The vignette below illustrates how facilitators began developing teacher understandings of how to coach others in CS.

Facilitators began by asking teachers what a good coach is and can do. Then, they asked teachers to share how adults learn differently from children. Finally, the facilitators discussed the characteristics of a good coach. To reinforce these ideas, teachers then completed an activity in which they entered words that they associated with the qualities of a good coach. For examples, teachers entered words like knowledgeable, patient, and helpful.

Next, the participants practiced coaching in small group. During this breakout session, teachers were asked to respond to a scenario in which they help a teacher overcome a problem. One group was given the scenario of helping a kindergarten teacher on a K-6 computing systems. The group debriefed that they focused on helping the kindergarten teacher understand input, output, and storage. They suggested that the teacher go use the math standard of putting something in, something happening in the processor, and something comes out. Their example for explaining that storage was limited was related to when a phone or computer sends a notification that that ask the teacher to clean up their storage on a phone or computer. Another group had an example in which they had to coach a teacher about networking and the internet. They shared that they would guide a teacher to introduce younger kids to the social media, have them email authors and illustrators, brainstorm an anchor chart on how to communicate with friends and family, write in a shared journal online or making flipgrids.

Later in the session, the facilitators engaged teachers in a discussion about barriers in teaching CS that focused on resistant learners. To help teachers think about how they might coach a colleague when they encountered resistant learners, teachers did a role play activity with two scenarios. One scenario was content-based and the other was an interpersonal challenge.

*The content-based scenario stemmed around the "third grade algorithms and programming". Suggestions for their colleague to address this challenge included: begin with something that they know like creating a recipe for peanut butter and jelly, model that it is the same as building code, show examples with Scratch or another software, relate the vocabulary to things they already know and use. The scenario related to an interpersonal challenge was that teachers did not have adequate PD time and are therefore resistant to learning CS. During the role play, teachers suggested, as a coach, that the person they were coaching: offer morning or afternoon meetings, create a collaborative folder, be willing to video yourself modeling concepts or providing implementation ideas. (*Wednesday, observation).

The theme of coaching extended to Friday's synchronous instruction as well.

Teachers completed a CS lesson plan analysis in breakout rooms addressing: strands present in the lesson, equity, accessibility, and the coaching process. Later, teachers present their *collaborative learning lab activity from previous days: a CS PD plan. Many of the plans reflect the structure of the PD following the subsequent order: connect technology to personal life, introduce CS standards, explore plugged and unplugged activities with heavy emphasis on collaboration, complete a final reflection.* (Friday, 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. To achieve teacher understanding of what it means to advocate for CS instruction in a school, teachers participated in an activity in which they created a pitch to stakeholders that answered the question, "why CS is beneficial for the school or classroom" as described in the following vignette.

On Friday, the facilitator shared information regarding marginalization of CS in high schools. 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. Lastly, using Canva, the participants designed a poster to advocate for CS and shared them with the entire group. Group 2 used their pitch to briefly describe what CS is and how it can benefit students. Group 3 took a different approach and focused on the number of CS jobs available, the importance of increasing diversity in the field, and pointed out that teachers are already teaching many CS principles in their pitch. Group 6 felt it was important to have an example like a student project on their phone and used that to engage in conversation about how they integrate CS into core content. Group 7 began by explaining how easy it is to integrate CS into the core curriculum and then said that CS would make their school the "it" school (Friday, observation)

From the elevator pitches, it appeared clear that participants in the ARCS CODE VA K-5 Coaches Academy Summer PD could articulate the importance of integrating CS instruction for students.

Structure.

Similar to the summer of 2020 of ARCS CODE VA K-5 Coaches Academy Summer PD, 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. The following excerpt from observation notes illustrates how facilitators set the tone for the week of PD and attempted to build rapport with and among the teachers:

The facilitators led an optional morning meeting via Air Meet for teachers to get to know one another and network. (Monday, observation)

This platform allowed for teachers to interact with each other and one-on-one engagement. At the beginning of the formal synchronous PD time, facilitators went over norms for creating a positive online community via Zoom, the components of ARCS outside of the PD, and program objectives.

The facilitator shared technology norms, engagement norms, and then introduced the structure of the program (5 online summer session, content specific activities in PLCs, 4 follow-up sessions during the academic year, and opportunities to collaborate). Then the facilitator share the guiding questions for the session: What is CS?, What are the Virginia Standards of Learning CS Strands?, How do I teach computational thinking skills in my own classroom?, and How can each strand be integrated into core content? (Monday, observation)

Each day of the ARCS CodeVA K-5 Coaches Academy Summer PD had a similar structure.

> *To begin the session, the facilitator would share reflections from previous day's activities. After an opportunity for participants to respond, the facilitator introduced the theme for the day as well as the goals. After providing background knowledge and/or statistics related to the theme, the facilitator introduced an activity. The second facilitator placed the participants in 8 breakout rooms and give them approximately 8 to 10 minutes to complete the task. Participants typically used Jamboards to display their responses. After the time ended, participants returned to the main session and one leader from each group would share their findings or decisions around why they decided on a certain response. Other participants would chime in and give feedback or add to the chat. During this time the facilitator served as a guide and related the responses back to the overall theme. This same structure was repeated across the session typically for two more activities. At the end of each session, groups worked in grade-level teams or K-2 and 3-5 to connect their pedagogical understandings to CS content through tasks such as lesson planning or analysis. During these sessions, participants were given more time (approximately 20 minutes) in their breakout rooms.* (Observations)

Maintaining the same structure throughout the course of the week likely facilitated teacher engagement and allowed for clear expectations of participation.

Engagement. The facilitators supported teacher engagement by asking if they had questions, trying to help teachers feel more comfortable with asking questions and not knowing an answer, and using the affordances of Zoom including breakout rooms and the chat feature. For example, teachers kept their cameras on since they were told it is easier to connect with real faces during the day 1 technology norms session. Teachers were also actively engaged in the main session and in the breakout rooms; they often unmuted themselves and communicated with each other and actively used the chat, too. Facilitators also used the chat and breakout room features to engage teachers as evidenced by the following examples:

> *Facilitators asked teachers to identify some of the positives and negative of impacts of computing after using a TikTok example. Teachers responded in the chat with comments like: Creativity, learning, community building, expressing themselves, encouraging movement; TikTok allows kids to see people of different ethnicities and backgrounds; [During COVID with social distancing] kids get to use TikTok to be a part of something bigger than themselves; and Follow trends, build awareness on social issues. Later in the session, the facilitator shared slides that were aligned with some of these points.* (Monday, observation)

Another example of how the facilitators tried to support teacher engagement using the chat occurred during the Friday elevator pitch presentations when facilitators asked participants to provide feedback in the chat (Friday, observation). This seemed to help encourage teachers to be more proactive viewers and to practice their coaching skills during this session. In another example of how facilitators engaged teachers, during the research dig, teachers looked for CS resources to include in a PD plan:

> *When prompted by the facilitator, a teacher from one group would unmute themself or respond in the chat that they had a similar idea to another group. Teachers described small changes they*

> *would make based on grade level needs. One teacher then shared her group's PD plan. It involved showing how easy CS is. They proposed using an unplugged robot game with a grip carpet and having teams give direction to their robot to navigate to a safe space. They said they planned to connect that activity to the algorithms strand. Their goal was to get teachers to see how important it is for students to be technology literate. The facilitator asked if this was like anyone else's plan. Teachers responded that they wanted to make sure the activities were connected to personal life, school events, or aspects of teaching that teachers enjoyed.* (Friday, observation)

Comparison to Pilot Cohort PD. We noted several differences between the pilot cohort PD (summer 2020) and the summer 2021 PD. Fundamentally, the program was modified between the pilot cohort and the RCT Cohort 1 from a 6-day to a 5-day program. In terms of content, in the summer 2021, a member of the ODU team shared findings from the pilot cohort that had moved on to microcredentialing at the beginning of the first day (Monday, observation). This seemed to appear to encourage RCT participants to engage in the program because the pilot cohort experienced positive results. there was a greater emphasis on accessibility and equity (Friday, observation), which is a very important part of "why" of CS that was missing in the summer 2020 PD. Addressing this may have supported teacher buy in for integrating CS into instruction.

In terms of structure, compared to last year, there was a more equal distribution of speaking time/engagement between the various facilitators. In summer 2020 PD, Facilitator 1 (who was not present in the summer of 2021) spoke for the majority of the first session.

Regarding engagement, the teachers in this group appeared more confident with synchronous and asynchronous platforms for PD. The teachers seemed more familiar with the Zoom space (Monday, observation). It is likely that since they had been using Zoom for over a year on Zoom at this point, they were more comfortable with the technology and interacting with each other in a virtual setting. It is also possible that because there were fewer facilitators in the summer of 2021 the teachers may have been less intimidated and more willing to participate.

Perceptions of the PD

Of the 35 treatment and non-RCT teachers who completed the ARCS CodeVA K-5 Coaches Academy, 25 treatment and 9 non-RCT teachers completed the post-PD survey. 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?	Strongly disagree (%)	Disagree (%)	Somewhat disagree (%)	Somewhat agree (%)	Agree (%)	Strongly Agree (%)	Mean (SD)
1. Communications regarding the ARCS/Code VA K-5 Coaches Academy were received in a timely manner	0	0	5.9	5.9	88.2	0	4.8 (.7)
2. The ARCS/Code VA K-5 Coaches Academy objectives were clear to me.	0	0	2.9	5.9	91.2	0	4.9 (.6)
3. The ARCS/Code VA K-5 Coaches Academy provided me with lesson plans that fit state standards.	0	0	0	11.8	88.2	0	4.9 (.3)
4. The facilitators had adequate knowledge of the subject.	0	0	0	2.9	26.5	70.6	5.7 (.5)
5. The facilitators created an atmosphere of trust and open communication.	0	0	0	2.9	20.6	76.5	5.7 (.5)
6. I am satisfied with my interactions with the facilitators	0	0	0	2.9	17.6	79.4	5.8 (.5)
7. As needed, the facilitators were available to answer questions and provide direction.	0	0	0	2.9	26.5	70.6	5.7 (.5)
8. I felt a rapport with other participants.	0	0	2.9	8.8	41.2	47.1	5.3 (.9)
9. I am satisfied with my interaction with my peers.	0	0	2.9	5.9	44.1	47.1	5.3 (.8)
10. I felt part of a learning community.	0	0	2.9	8.8	29.4	58.8	5.4 (.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.	0	0	0	8.8	35.3	55.9	5.5 (.7)

TABLE 27 (CON'T). POST PD PERCEPTIONS

How strongly do you agree or disagree with the following statements?	Strongly disagree (%)	Disagree (%)	Somewhat disagree (%)	Somewhat agree (%)	Agree (%)	Strongly Agree (%)	Mean (SD)
12. The ARCS/Code VA K-5 Coaches Academy met my needs as a teacher-learner.	0	0	0	2.9	44.1	52.9	5.5 (.6)
13. I would recommend the ARCS/Code VA K-5 Coaches Academy to other colleagues.	0	0	0	2.9	35.3	61.8	5.6 (.6)
14. I will integrate what I learned in the ARCS/Code VA K-5 Coaches Academy in my teaching.	0	0	0	5.9	29.4	64.7	5.6 (.6)

Note. post n = 34, includes both RCT and non-RCT teachers that completed the summer PD. For means, strongly disagree = 1, disagree = 2, somewhat disagree = 3, somewhat agree = 4, agree = 5, and strongly agree = 6.

Useful Components of the PD. 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 timepoint. 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 really liked the lesson "spark" mini-lesson planner template. 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 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.

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.”

Perceived Challenges and Additional Supports Needed***.*** 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:

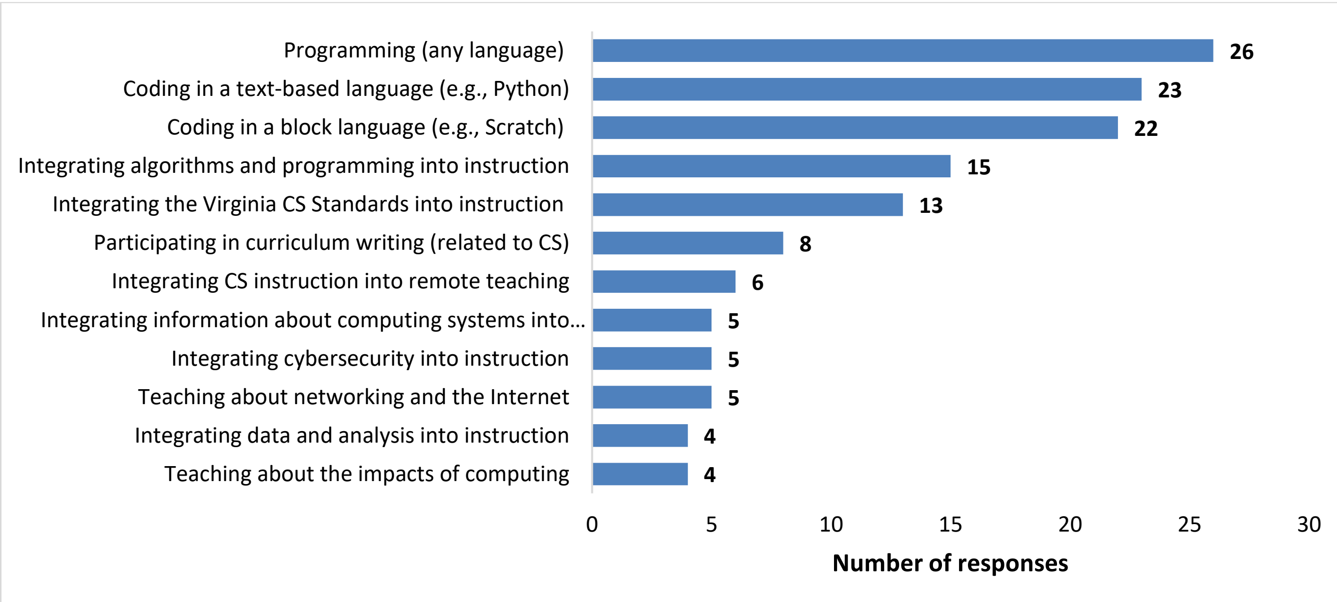
Seeing other examples of lesson plans or videos of standards being implemented.

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."

Future PD Topics. Participants also 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. 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 identify 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."

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 indicated no difference in treatment teachers' CS knowledge following participation in the Code VA K-5 Coaches Academy, $t\ (21) = .42$, $p = .68$.

TABLE 28. TEACHER CONTENT KNOWLEDGE

	Treatment		Control	Non-RCT	
Item	Pre M (*SD*)	Post M (*SD*)	Pre M (*SD*)	Pre M (*SD*)	Post M (*SD*)
1. What is computer science?	2.0 (0.8)	2.1 (0.5)	2.2 (0.7)	2.3 (0.7)	1.9 (0.8)
2. Describe what a computer programmer does.	2.3 (0.4)	2.2 (0.4)	2.1 (0.4)	1.9 (.33)	2.0 (0.5)
3. What makes a device a computer?	1.3 (0.5)	1.4 (0.5)	1.5 (0.5)	1.0 (0.0)	1.3 (0.5)
4. What is an algorithm?	2.3 (0.7)	2.3 (0.6)	2.3 (0.7)	2.1 (0.9)	2.3 (0.7)
5. In what ways is the term "variable" used differently in computer science than in math and science?	1.9 (0.8)	1.8 (0.4)	1.8 (.07)	1.3 (0.5)	1.8 (0.8)
Sum of 5 items, max 15	9.8 (1.6)	9.8 (1.3)	9.8 (1.9)	8.7 (1.9)	9.8 (1.3)

Note. Each item scored 1-3.

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 (all *p*'s < .05).

TABLE 29. EXPERIENCE PROGRAMMING

	Treatment		Control	Non-RCT	
Rate your experience:	**Pre M (*SD*)**	**Post M (*SD*)**	**Pre M (*SD*)**	**Pre M (*SD*)**	**Post M (*SD*)**
1. Programming (any language)	2.1 (1.2)	2.9 (1.0)	2.4 (1.4)	1.3 (0.7)	1.9 (0.9)
2. Coding in a block language	2.5 (1.6)	3.4 (1.4)	2.8 (1.7)	1.7 (1.3)	2. 6 (1.5)
3. Coding in a text-based language	1.9 (1.2)	2.6 (1.1)	1.9 (1.1)	1.2 (0.4)	1.6 (0.5)
4. Running an "Hour of Code" event	2.6 (1.8)	3.4 (1.6)	3.1 (1.8)	1.3 (0.7)	1.8 (0.7)
Sum of 4 items above	9.0 (5.1)	12.3 (4.2)	10.3 (5.3)	5.6 (2.8)	7.8 (2.3)

Note. Each item scored 1-6. Cronbach's α pre = .91, Cronbach's α post = .83.

TABLE 30. EXPERIENCE INTEGRATING CS SOLS

	Treatment		Control	Non-RCT	
Rate your confidence with the following:	**Pre M (*SD*)**	**Post M (*SD*)**	**Pre M (*SD*)**	**Pre M (*SD*)**	**Post M (*SD*)**
1. The Virginia Computer Science Standards	2.4 (1.4)	4.1 (1.0)	2.9 (1.4)	2.9 (1.4)	3.3 (1.3)
2. Algorithms and programming	2.0 (1.2)	4.1 (1.0)	2.3 (1.4)	1.2 (0.4)	3.1 (1.4)
3. Information about computer systems	2.6 (1.1)	4.0 (0.8)	2.8 (1.4)	2.1 (1.05)	3.6 (1.4)
4. Information about cybersecurity	2.5 (1.2)	4.0 (0.8)	2.8 (1.5)	2.0 (1.3)	3.4 (1.5)
5. Data and analysis	2.5 (1.4)	4.2 (0.9)	3.0 (1.5)	2.6 (1.1)	3.7 (1.4)
6. Information about the impacts of computing	2.4 (1.3)	4.2 (0.9)	2.9 (1.5)	1.9 (1.2)	3.2 (1.4)
Sum of 6 items above	14.5 (6.4)	24.6 (4.9)	16.7 (8.0)	12.7 (5.1)	20.3 (8.0)

Note. Each item scored 1-6. Cronbach's α pre = .94, Cronbach's α post = .97.

TABLE 31. EXPERIENCE TEACHING PROGRAMMING

	Treatment		Control	Non-RCT	
Rate your experience:	Pre M (*SD*)	Post M (*SD*)	Pre M (*SD*)	Pre M (*SD*)	Post M (*SD*)
1. Teaching Programming (any language)	2.0 (1.2)	2.8 (1.1)	2.2 (1.4)	1.2 (0.7)	2.0 (1.2)
2. Teaching coding in a block language	2.4 (1.5)	3.4 (1.3)	2.7 (1.7)	1.4 (1.3)	2.2 (1.4)
3. Teaching coding in a text-based language	1.8 (1.1)	2.5 (1.0)	1.7 (1.0)	1.0 (0.0)	1.4 (0.5)
Sum of 3 items above	6.3 (3.6)	8.7 (3.1)	6.6 (3.7)	3.7 (2.0)	5.7 (2.6)

Note. Each item scored 1-6. Cronbach's α pre = .88, Cronbach's α post = .86.

TABLE 32. OTHER ITEMS RELATED TO PEDAGOGICAL KNOWLEDGE

	Treatment		Control	Non-RCT	
How strongly do you agree or disagree with the following statements?	Pre M (*SD*)	Post M (*SD*)	Pre M (*SD*)	Pre M (*SD*)	Post M (*SD*)
1. I understand what computer science is.	4.3 (0.9)	5.2 (0.6)	4.4 (1.0)	4.1 (0.9)	5.0 (0.5)
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)	3.7 (1.3)	3.0 (1.1)	3.3 (1.2)
3. I can engage students from rural areas in computer science.	4.3 (1.1)	5.0 (0.8)	4.3 (1.1)	4.0 (1.2)	4.8 (0.7)
4. I can engage students from low socioeconomic backgrounds in computer science.	4.4 (1.2)	5.1 (0.7)	4.4 (1.1)	4.6 (1.4)	5.1 (0.6)
5. I can engage students who are traditionally underrepresented in STEM in computer science	4.4 (1.2)	5.2 (0.7)	4.4 (1.2)	4.4 (1.4)	5.1 (0.6)
6. I can address issues of access to computer technologies for students in my school.	4.0 (1.2)	4.7 (0.9)	4.5 (1.0)	4.0 (1.7)	4.8 (0.8)

Note. 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 > .8). Results indicated significant improvement in treatment teacher self-efficacy for teaching CS, confidence programming, confidence teaching programming, and confidence integrating CS SOLs from pre- to post- and pre- to year-end (all *p*'s < .05).

TABLE 33. SELF EFFICACY SCALE

	Treatment		Control	Non-RCT	
How strongly do you agree or disagree with the following statements	**Pre M (*SD*)**	**Post M (*SD*)**	**Pre M (*SD*)**	**Pre M (*SD*)**	**Post M (*SD*)**
1. I feel confident using computer technology.	5.0 (0.7)	5.3 (0.6)	4.9 (0.9)	4.6 (1.2)	4.9 (0.8)
2. I know how to teach programming concepts effectively.	3.1 (1.3)	4.2 (1.0)	3.1 (1.4)	2.1 (1.3)	4.2 (0.4)
3. I feel confident writing simple programs for the computer.	2.5 (1.3)	3.6 (1.3)	3.0 (1.5)	2.1 (1.3)	3.3 (1.3)
4. I can promote a positive attitude toward programming in my students.	5.0 (0.8)	5.2 (1.1)	5.0 (1.0)	4.9 (1.2)	5.1 (0.6)
5. I can guide students in using programming as a tool while we explore other topics.	4.0 (1.5)	4.7 (1.2)	3.8 (1.5)	3.6 (2.0)	4.4 (1.4)
6. I feel confident using programming as an instructional tool within my classroom.	3.6 (1.4)	4.5 (1.3)	3.7 (1.6)	2.7 (1.8)	4.0 (1.0)
7. I can adapt lesson plans incorporating programming as an instructional tool.	4.0 (1.3)	4.8 (1.1)	4.1 (1.4)	2.7 (1.7)	4.6 (0.7)
8. I can create original lesson plans incorporating programming as an instructional tool.	3.8 (1.4)	4.7 (1.0)	3.7 (1.4)	2.7 (1.7)	4.7 (0.5)
9. I can identify how programming concepts relate to the Virginia Standards of Learning.	3.8 (1.2)	4.8 (1.1)	4.0 (1.3)	2.8 (1.6)	5.0 (0.5)
Sum of 9 items above	34.7 (8.5)	41.7 (8.0)	35.3 (9.7)	28.0 (11.9)	40.2 (5.6)

Note. Each item scored 1-6. Cronbach's α pre = .93, Cronbach's α post = .93.

TABLE 34. CONFIDENCE PROGRAMMING

	Treatment (n = 25)		Control (n = 39)	Non-RCT (n = 9)	
Rate your confidence with the following:	**Pre M (*SD*)**	**Post M (*SD*)**	**Pre M (*SD*)**	**Pre M (*SD*)**	**Post M (*SD*)**
1. Programming (any language)	2.3 (1.2)	3.5 (1.2)	2.5 (1.4)	1.3 (0.5)	3.3 (0.9)
2. Coding in a block language	2.8 (1.5)	3.8 (1.2)	3.1 (1.7)	1.4 (1.0)	3.0 (1.3)
3. Coding in a text-based language	2.1 (1.2)	2.9 (1.1)	2.0 (1.1)	1.0 (.00)	2.0 (0.9)
4. Running an "Hour of Code" event	2.8 (1.8)	4.1 (1.2)	3.5 (1.8)	1.4 (0.7)	3.0 (0.9)
Sum of 4 items above	10.0 (5.2)	14.2 (3.8)	11.0 (5.1)	5.2 (2.0)	11.3 (2.4)

Note. 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.

TABLE 35. CONFIDENCE TEACHING PROGRAMMING

	Treatment		Control	Non-RCT	
Rate your confidence with the following:	**Pre M (*SD*)**	**Post M (*SD*)**	**Pre M (*SD*)**	**Pre M (*SD*)**	**Post M (*SD*)**
1. Teaching Programming (any language)	2.3 (1.4)	3.2 (1.2)	2.4 (1.6)	1.2 (0.7)	3.1 (1.1)
2. Teaching coding in a block language	2.6 (1.6)	3.7 (1.2)	3.1 (1.7)	1.4 (1.3)	3.2 (1.5)
3. Teaching coding in a text-based language	2.0 (1.4)	2.6 (1.2)	1.9 (1.1)	1.0 (0.0)	1.9 (0.9)
Sum of 3 items above	6.8 (4.1)	9.5 (3.2)	7.4 (3.9)	3.7 (2.0)	8.2 (2.7)

Note. Each item scored 1-6. Cronbach's α pre = .89, Cronbach's α post = .81.

TABLE 36. CONFIDENCE INTEGRATING CS SOLS

	Treatment		Control	Non-RCT	
Rate your confidence integrating the following into your K-12 instruction:	**Pre M (*SD*)**	**Post M (*SD*)**	**Pre M (*SD*)**	**Pre M (*SD*)**	**Post M (*SD*)**
1. The Virginia Computer Science Standards	2.9 (1.5)	5.0 (.8)	3.8 (1.2)	2.6 (1.4)	4.9 (0.8)
2. Algorithms and programming	2.4 (1.6)	4.5 (1.1)	2.9 (1.3)	1.4 (0.5)	4.3 (0.9)
3. Information about computer systems	3.0 (1.4)	4.6 (1.0)	3.2 (1.4)	2.1 (1.1)	4.7 (0.9)
4. Information about cybersecurity	3.0 (1.4)	4.7 (0.9)	3.3 (1.5)	2.2 (1.5)	4.8 (0.7)
5. Data and analysis	3.2 (1.5)	4.8 (0.9)	3.6 (1.5)	2.6 (1.1)	4.9 (0.6)
6. Information about the impacts of computing	3.1 (1.4)	4.8 (0.8)	3.5 (1.4)	1.9 (1.2)	4.9 (0.8)
Sum of 6 items above	17.6 (7.8)	28.4 (4.8)	20.3 (7.1)	12.8 (6.1)	28.4 (3.9)

Note. Each item scored 1-6. Cronbach's α pre = .94, Cronbach's α post = .93.

Culturally Responsive Teaching

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

TABLE 37. CULTURALLY RESPONSIVE TEACHING CONFIDENCE

	Treatment		Control	Non-RCT	
Please indicate how confident you are that you can:	**Pre M (*SD*)**	**Post M (*SD*)**	**Pre M (*SD*)**	**Pre 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)	4.4 (1.0)	3.8 (0.7)	4.6 (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)	3.7 (0.7)	4.2 (1.0)
3. Develop a community of learners when my class consists of students from diverse backgrounds.	4.6 (1.0)	4.8 (0.9)	4.8 (0.9)	4.7 (0.7)	4.8 (0.8)
4. Use my students' cultural background to help make learning meaningful.	4.6 (0.8)	4.7 (0.8)	4.7 (0.9)	4.1 (1.1)	4.6 (0.7)
5. Use my students' prior knowledge to help them make sense of new information.	4.7 (0.9)	4.7 (0.8)	4.8 (0.9)	4.7 (1.0)	4.8 (0.7)
6. Revise instructional material to include a better representation of cultural groups.	4.6 (0.9)	4.6 (0.8)	4.6 (1.0)	4.1 (1.5)	4.7 (0.9)
7. Critically examine the curriculum to determine whether it reinforces negative cultural stereotypes.	4.4 (0.9)	4.5 (0.9)	4.3 (1.0)	3.8 (1.3)	4.7 (0.7)
8. Use examples that are familiar to students from diverse cultural backgrounds.	4.6 (0.9)	4.6 (0.8)	4.5 (1.0)	4.0 (1.1)	4.7 (0.7)
Sum of 8 items above (max 48)	36.1 (6.7)	36.6 (.6.3)	36.2 (6.9)	32.8 (7.1)	36.9 (5.4)

Note. Each item scored 1-6. Cronbach's α pre = .96, Cronbach's α post = .96.

TABLE 38. CULTURALLY RESPONSIVE TEACHING FREQUENCY

	Treatment		Control	Non-RCT	
Please indicate how often you do the following:	Pre M (*SD*)	Post M (*SD*)	Pre M (*SD*)	Pre 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)	4.3 (0.9)	4.0 (0.5)	4.2 (0.4)
2. Make an effort to get to know my students' families and backgrounds.	5.1 (0.7)	5.0 (0.7)	5.1 (0.8)	5.1 (0.8)	5.4 (0.5)
3. Examine class materials for culturally appropriate images and themes.	5.0 (0.6)	4.8 (0.7)	4.9 (0.8)	4.7 (1.0)	4.8 (0.4)
4. Encourage students to use cross-cultural comparisons when analyzing material	4.6 (1.0)	4.5 (0.8)	4.5 (0.9)	4.2 (1.1)	4.3 (0.7)

Note**.** Cronbach's α pre = .76, Cronbach's α post = 77.

Student Outcomes

Students from the RCT were administered the CKACS from August 11, 2021 to October 29, 2021 based on their school start date. Students took the assessment during class time or at home. Completion rates for CKACS components are shown in Tables 38 and 39.

TABLE 39. STUDENT OUTCOMES

Condition	School Identifier	Number of Teachers	Target Grade	[1] Number Enrolled in Target Grade	Number Started	Number Completed Knowledge	Number Completed Affective
Treatment (n = 10)	1	4	5	98	74	72	71
	2	2	5	134	113	93	89
	3	3	5	115	86	79	75
	4	5	3	100	126	101	101
	5	1	4	112	115	105	105
	6	1	5	112	22	6	3
	7	4	4	110	92	71	70
	8	2	5	103	68	52	52
	9	2	3	87	19	13	11
	10	4	5	127	80	67	65
	Total	28	--	1098	795	659	645
Control (n = 12)	11	5	4	131	124	114	110
	12	2	4	87	81	74	71
	13	1	5	67	52	45	41
	14	24	--	272	249	226	218
	15	2	5	89	59	56	52
	16	5	5	112	0	0	0
	17	1	4	99	60	60	59
	18	3	5	83	108	100	98
	19	1	3	82	14	14	14
	20	2	5	150	141	133	133
	21	5	5	134	99	77	72
	22	1	4	94	0	0	0
	Total	52	--	1400	987	899	868

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

CS Knowledge

We are currently coding student pre-content knowledge data and will report these outcomes in the year 3 annual report.

Affect Toward CS

TABLE 40. AFFECT TOWARD CS

	Treatment M (SD) (n = 645)	**Control M (SD) (n = 868)**	***F (p)***
Confidence[1]	15.3 (3.9)	14.9 (3.6)	2.7 (.098)
Interest[2]	13.0 (3.8)	12.8 (3.6)	.8 (.37)
Utility[3]	11.0 (3.0)	10.8 (2.9)	2.1 (.14)
Overall Affect	39.3 (9.3)	38.6 (8.5)	2.4 (.12)

Note: [1] Confidence: 6 items, max score: 24; Cronbach's α = 0.78; [2]Interest: 5 items, max score: 20, Cronbach's α = 0.83; [3]Utility: 4 items, max score: 16, Cronbach's α = 0.75, Overall Affect, sum of 15 items, max score: 60, Cronbach's α = 0.89.

ANOVA indicated no significant difference between means for students in the treatment and control conditions for any of the sub-scales or the overall affective measure.

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, Networked Improvement Community (e.g., CodeVA NING PLC), and Microcredentials, was implemented successfully for the pilot cohort and RCT cohort. Modifications were made to provide the PD through asynchronous and synchronous components to accommodate for the COVID-19 pandemic. Modifications, informed by pilot cohort year 1 implementation, also informed instrument modification, implementation of CodeVA K-5 Summer Coaches Academy, and the Networked Improvement Community.

Participant attendance and engagement were high during CodeVA K-5 Summer Coaches Academy for both the Pilot and RCT Cohort 1 teachers. At the end of year 1, pilot participants appeared to understand the expectations for their continued participation in the second year of the program (e.g., Microcredential completion, Networked Improvement Community participation).

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). Pilot participant CS content knowledge, pedagogical knowledge, self-efficacy, and confidence, all improved significantly pre- to post-PD, and changes were generally retained on the year-end surveys. Similar improvements were seen in RCT treatment teacher CS content knowledge, pedagogical knowledge, self-efficacy, and confidence following the CodeVA K-5 Summer Coaches Academy. Comparison between treatment and control teachers on these outcomes for the RCT Cohort will be reported on the Year 3 report after the end of the 2021-22 academic year as well student outcomes.

Two important observations arose from the data that informed our recommendations below. First, of teachers who responded to the pilot year-end survey (approximately half of the pilot cohort completers), 70% indicated that they engaged in the Networked Improvement Community component of ARCS none or only one or two times. Second, participants ($n = 67$) were eligible to complete the Microcredentials (year 2) component of the PD, which has been available since July 2021. To date, approximately half of the eligible teachers have registered for at least one course and to date, two teachers have completed all 5 microcredentials.

Based on these data, we recommend the following improvements for future iterations of the ARCS PD for RCT Cohort 1 teachers (and future RCT Cohort 2 teachers). These recommendations are informed by both pilot cohort results and RCT Cohort 1 results.

(1) Provide more guidance to teachers on accessing the NIC 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 through the NIC.
(3) Open Microcredential registration mid-June so teachers can begin this work immediately after

the school year ends.

(4) 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.

(5) 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.

Other Evaluation Activities

Paper Presentation for NARST 2021

ARCS presented at the 2021 NARST Virtual Conference (Brobst, Maeng, & Garner, 2021). This explanatory mixed methods study examined whether rural elementary teachers' experience and confidence related to computer science differed according to instructional type (self-contained, specialized/departmentalized, elective) prior to and following a 6-day professional development program, and why those variations may exist. Data were drawn from a group of 58 elementary teachers in a mid-Atlantic state who participated in a summer PD program designed to support their computer science integration.

Findings indicated that, prior to PD, specialized/departmentalized and elective teachers scored higher than self-contained teachers on confidence and experience items related to computer science integration. After PD, specialized/departmentalized and elective teachers scored significantly higher on several items related to confidence and experience, even after controlling for pre-PD scores and years of experience teaching computer science content. Qualitative data suggested that, regardless of teacher type, time and resource constraints were perceived as a significant challenge to computer science integration. However, time issues were more frequently mentioned by self-contained teachers, suggesting that the reduced number of subject area responsibilities for specialized/departmentalized and elective teachers offer them increased time for computer science integration. Implications for professional development and teacher support related to computer science integration are discussed.

Development of the Content Knowledge and Affective Instrument for Computer Science (CKACS)

The development of the CS content knowledge performance assessment was informed by the state CS Standards and Curriculum Framework documents for grades 3-5, the grade 3-5 CS Performance Task Common Rubric, and the grade 3-5 science, math, English, social studies standards (core content standards). The CS Standards include 6 strands: algorithms and programming, computing systems, cybersecurity, data and analysis, impacts of computing, and networking and the Internet. *Algorithms and programming* involves efficiently using sequencing, loops, if-then statements, and debugging to solve problems. *Computing systems* involves understanding the interactions people have with a wide variety of computer devices and how the system communities and processes information. *Data and Analysis* addresses how data is generated rapidly, stored, and analyzed to make accurate predictions. *Cybersecurity* involves information technology security and the protection of systems. *Impacts of Computing* involves an understanding of the positive and negative impacts of the pervasiveness of computers and computing in daily life. Finally, *Networking and the Internet* addresses the difference between local networks and a worldwide network and cites examples of how these are used within the school or community.

To design items for the instrument, first, the knowledge and skills in the CS curriculum framework were cross-referenced with grade level-appropriate core content standards using a *Computer Science Curriculum Alignment* document. Four strands emerged as most emphasized in the grades 3-5 CS standards and integration documents and were targeted for the content items. These were: computing systems, data and analysis, cybersecurity, and impacts of computing. Then, core content standards in which to integrate the corresponding CS concepts were selected based on the natural fit of the concepts and contextualized within a real-world scenario. This resulted in three sections of the assessment: computing systems and impacts of computing, data and analysis, and cybersecurity.

Then, multiple-choice, drag-and-drop, and open-ended items within each of these strands and scenarios were developed. The five computer systems and impacts of computing items were contextualized within the scenario of teaching a lesson about computers, how they work, and why they are important. These items also integrated literacy (communicating with clarity, using appropriate language) and math and science components (discussion of inputs and outputs). The four data and analysis items were contextualized within a task about experimental design and integrated aspects of math (patterns, tables, data organization), literacy (communicating with clarity, using appropriate language), and science (experimental design, interpreting data). The cybersecurity item was contextualized within the scenario of sharing what was learned with a grown-up at home to keep the family safe, and integrated aspects of social studies (respect for community rules and laws) and literacy (using vocabulary to communicate ideas).

Support for face and content validity was established through an iterative process. The initial items were reviewed and modified based on feedback from an expert panel and then re-reviewed by the panel. The panel consisted of a faculty member in CS, the state CS coordinator, and two STEM education faculty with expertise in assessment and instrument design. The revised instruments incorporated feedback from the panel of experts to modify questions and improve language based on student pilot responses. Table 41 contains examples of how items were modified based on revision and pilot testing.

The affective component of the instrument was developed from existing validated instruments including the Elementary Student Coding Attitudes Survey (Mason & Rich, 2019), Programming Empowerment Survey (Kong et al., 2018), STARS Outreach Computer Attitude Survey (BPC Evaluation Toolkit, 2015), and Hour of Code Attitudes Toward and Self-efficacy with CS survey (Phillips & Brooks, 2017). The items selected from these existing instruments comprised three potential scales using a 4-point Likert scale (1-strongly disagree, 4-strongly agree): CS Confidence, CS Interest, and CS Utility.

Items from the existing instruments were then adapted to be language appropriate for elementary students and Flesch-Kincaid Grade Level was calculated using an online calculator (https://goodcalculators.com/flesch-kincaid-calculator/).

Similar to the content knowledge items, support for face and content validity was established through an iterative process. The initial items were reviewed and modified based on feedback from an expert panel and then re-reviewed by the panel. The panel consisted of a faculty member in CS, the state CS coordinator, an expert in elementary reading education, and two STEM education faculty with expertise in assessment and instrument design. This process resulted in the 15-item measure that was pilot tested in the spring of 2021 to establish test-retest reliability and internal consistency.

TABLE 41.

	Original wording	Expert Feedback	Rationale for modifications	Final Item
CK Computer Systems and Impacts of Computing 1: Item 5	Which of the technologies listed below are computing technologies that you could teach the second graders about? a) Internet search engine b) Road c) Desk d) Smartphone application (software)/App	Desk and Road were not selected by anyone. May need to increase difficulty.	Increased difficulty of the non-computing technology choices. Changed from desk and road to fidget spinner and light-up sneakers	Which of the technologies listed below are computing technologies that you could teach the second graders about? a) Internet search engine b) Light up sneakers c) Fidget spinner d) Smartphone application (software)/App
CK Data and Analysis: Item 7	How can you use the computer help you to organize the strawberry data?	Most students referred to a pattern or counting. They did not mention graphing	Modified rubric for students that indicate a pattern and modified wording to provide clarity	How can you use a computer to show your findings for the strawberry data?
CK Cybersecurity: Item 10	Which of the following can cause cybersecurity problems when using a computer or iPad at home or schools and how could you avoid or deal with the problems? For the items, you selected, describe what your family could do to avoid or deal with each of the cybersecurity problems you identified.	Bike riding, riding in a car, and cooking were not selected by anyone. May need to increase difficulty	Increased difficulty of the non-cyber security issue choices from riding in a car and cooking to emailing a family member, following people on social media, cyberbullying, and strong passwords And separated into two questions	Which of the following 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 or deal with each of the cybersecurity problems you identified.

The final version of the CKACS instrument (Appendix D) will be implemented with students in the RCT.

Paper Proposal for NARST 2022

The ARCS team contributed to a paper that was submitted to the annual NARST conference to address the need for valid and reliable tools that can measure changes in students' computer science (CS) knowledge and attitudes (McCoy, Maeng, Loney, Brobst, Moots, & Garner, submitted). This study describes the development and validation of the Content Knowledge and Affective Instrument for Computer Science (CKACS). The CKACS consists of ten content knowledge questions (Cronbach's α = .79) with subscales in computing systems and impacts of computing (α = .72), data and analysis (α = .60), and cybersecurity. The affective component of the instrument (Cronbach's α = .89) included confidence (α = .80), interest (α = .85), and utility (α = .76) scales. Students demonstrated moderate levels of understanding about CS content knowledge and moderately positive attitudes toward CS. The CKACS instrument was modified based on the results of pilot testing and expert panel feedback. The final version of the instrument will be implemented in a randomized control trial. The CKACS instrument may assist us in better supporting teachers, school leaders, researchers, and policymakers in integrating and measuring CS content knowledge and affect in elementary settings.

References

Bean, N., Weese, J., Feldhausen, R., & Bell, R. S. (2015, October). *Starting from scratch: Developing a pre-service teacher training program in computational thinking.* In 2015 Frontiers in Education Conference (FIE) (pp. 1-8). IEEE.

Bogdan, R. C. & Biklen, S. K. (2007). *Qualitative research for education: An introduction to theories and methods* (5th Ed). Boston, Massachusetts: Pearson Education, Inc.

BPC Evaluation Toolkit. (2015, August 18). *STARS Outreach Computer Attitude Survey for Secondary Students*. Retrieved from https://csedresearch.org/wp-content/uploads/Instruments/Computing/PDF/MS_HSoutreach_survey_UNCC.pdf

Kong, S. C., Chiu, M. M., & Lai, M. (2018). A study of primary school students' interest, collaboration attitude, and programming empowerment in computational thinking education. *Computers & Education, 127,* 178-189.

LeMahieu, P. (2015). *Why a NIC? Carnegie Commons Blog.* Retrieved from https://www.carnegiefoundation.org/blog/why-a-nic/Mason & Rich, 2019

McKay, S. (2017). *Five essential building blocks for a successful networked improvement community.* Retrieved from https://www.carnegiefoundation.org/blog/five-essential-building-blocks-for-a-successful-networked-improvement-community/

Miles, M. B. & Huberman, A. M. (1994). *Qualitative Data Analysis* (2nd Ed). Thousand Oaks, California: Sage Publications.

Phillips, R. S., & Brooks, B. P. (2017). *The hour of code: Impact on attitudes towards and self-efficacy with computer science.* Technical Report. https://code.org/files/HourOfCodeImpactStudyJan2017.pdf

Rhodes, C. M. (2016). Validation of the Culturally Responsive Teaching Survey. *Universal Journal of Educational Research*, *5*(1), 45-53.

Siwatu, K. O. (2007). Preservice teachers' culturally responsive teaching self-efficacy and outcome expectancy beliefs. *Teaching and teacher education, 23*(7), 1086-1101.

Yadav, A. & Berges, M. (2019). Computer science pedagogical content knowledge: Characterizing teacher performance. *ACM Transactions on Computing Education (TOCE), 19*(3), 1-24.

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**
7. The Virginia CS Standards						
8. Algorithms and programming						
9. Information about computer systems						
10. Information about cybersecurity						
11. Data and analysis						
12. 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
13. Programming (any language)						
14. Coding in a block language (e.g. Scratch)						
15. Coding in a text-based language (e.g. Python)						
16. 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

1. What is computer science?

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

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

2. Describe what a computer programmer does.

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

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

3. What makes a device a computer?

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

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

4. What is an algorithm?

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

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

5. 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)
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.

[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

6. What challenges do you face integrating the Computer Science SOLS into your curriculum?

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) ____

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

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

18. 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?

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				

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

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

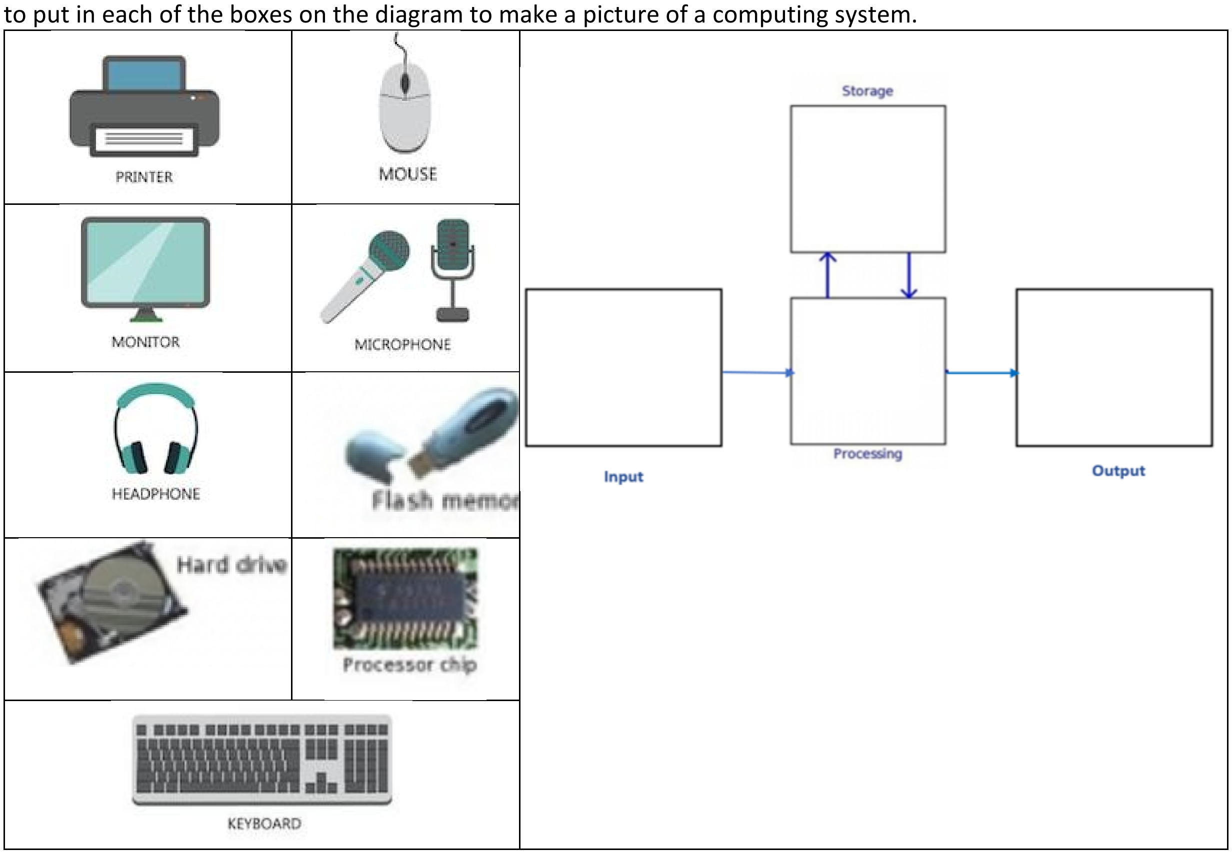
Appendix C: Original Student CS Content Knowledge Performance Tasks and Scoring Rubric (pilot cohort only)

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.)

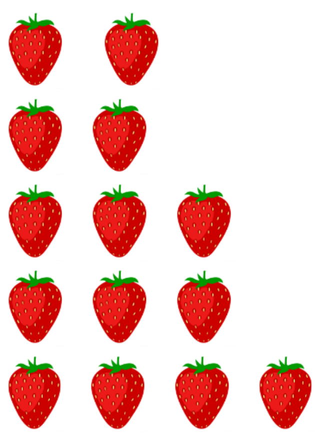
A) I can learn new things by watching YouTube
B) People write letters
C) People can talk on video apps
D) People can buy things online
E) People can find other people easily
F) People can talk on the phone

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.

6. 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

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

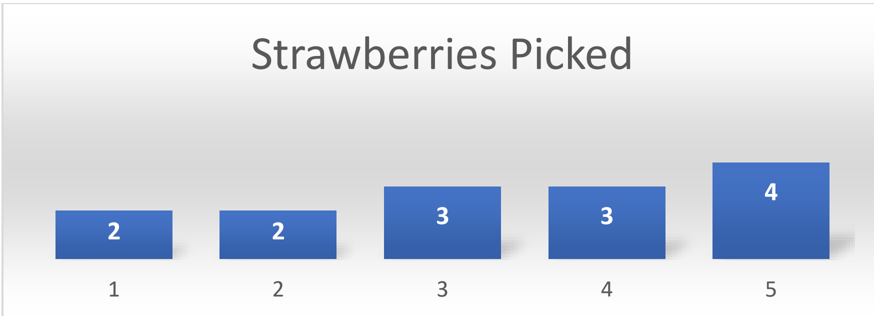
Wednesday

Thursday

Friday

7. How can the computer help you to organize 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.



Monday Tuesday Wednesday Thursday Friday

8. 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

9. 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.

10. 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 ____

Respond to the following items using this 4-pt Likert 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 Disagree**	**Disagree**	**Somewhat Disagree**	**Somewhat 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

Content Knowledge Items

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

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

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

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

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

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

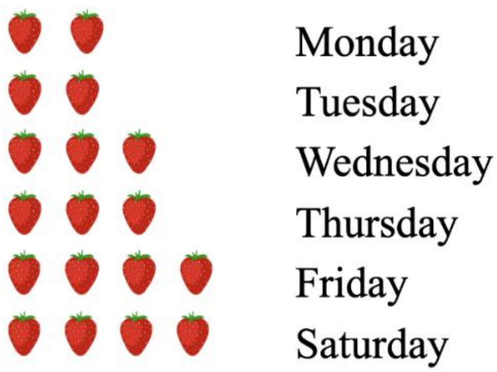
5. Which of the technologies listed below are ***computing technologies*** that you could teach the second graders about? (Select all that apply.)
   Internet search engine
   Light up sneakers
   Fidget spinner
   Smartphone application (software)/App

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

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

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

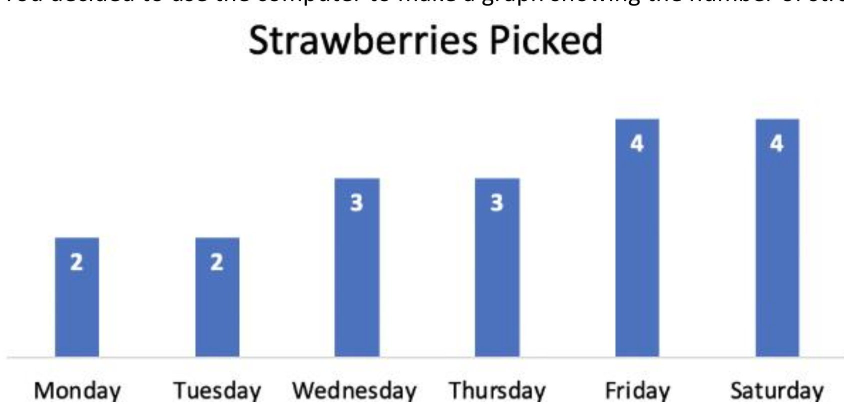
Once the plants have grown and strawberries appear, you pick them every day for six days. The following picture shows the number of strawberries that you picked each day.



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

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

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



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

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

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

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

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

Affective Items

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

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

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

Student Content Knowledge Scoring Rubric

1.

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

2 - 4.

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.

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.

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.

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.

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.

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.