Thinking Globally, Acting Locally:

Increasing CS Capacity and Equity by Developing a Regional CS Teacher Community

National Science Foundation Computer Science for All (CSforAll) grant to Siena College.

Research Practice-Partnership External Evaluator Report

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Section1: Executive Summary.

Thinking Globally, Acting Locally: Increasing CS Capacity and Equity by Developing a Regional CS Teacher Community is a project conducted by computer science and education faculty at Siena College with Dr. Robin Flatland as Principal Investigator. The three-year project was funded by the National Science Foundation as part of its Computer Science for All (CSforAll) initiative. The primary goal of this multi-faceted project was to increase the number and diversity of students taking high school computer science courses in Upstate New York through initiatives including providing professional development for teachers, continuing revisions of computer science curriculum, and creating a regional professional learning community. Together, these activities provided support for teachers certified in other subject areas who were offering foundational computer science courses at their high schools.

Beginning in August 2019, the project leveraged an existing research-practice partnership consisting of five Siena faculty and four high school teachers. Over the course of the three-year grant, the partnership grew to 35 teachers from 29 high schools in 29 different school districts. More than half of these high schools were offering no foundational computer science classes prior to joining the project and their teachers had little or no formal background in the subject. The project provided teachers with comprehensive support in offering two courses: a college-level dual enrollment course called *Introduction to Computer Science* (CS110) and a new high school-level course called *Discovering Computer Science* (DCS) that was developed as part of the grant. The project also provided in-service teachers with tuition scholarships to take Siena College courses that can qualify them for an additional New York State teaching certificate in computer science. By the end of the grant in December 2022, 23 teachers will have completed 38 college computer science courses (127 credits).

The project also focused on broadening participation in computer science to include more students from traditionally under-represented groups (females, racial/ethnic minorities, those attending rural schools, and economically disadvantaged students). This goal was achieved in part by strategically seeking out partnerships with high-needs schools in urban and rural areas. Three of the participating schools were large, urban high-needs schools and 14 were rural schools (with six also classified as high-needs). The professional development provided teachers with research-based strategies for recruiting females and racial/ethnic minorities into their computer science classrooms and covered teaching practices for engaging females and racial/ethnic minorities. In addition, the computer science course curriculums were designed to welcome a diverse group of students with components on computer science diversity, societal impact, and hands-on projects that allow them to creatively express their individualities. The number of high school students in participating teachers' CSforAll classes grew from around 220 in 2019-20 school year, to around 380 in 2020-21, to over 500 in the final year. Thus, the number of high school students being introduced to computer science each year basically doubled over the three years of the project.

An important component of this project was an external evaluation, which was overseen by Dr. Kathryn Schiller with the assistance of her graduate research assistant Stacey Hansen. Designed

in collaboration with the Siena College CSforAll team, the evaluation had two major components that are featured in this report. First, student surveys were conducted twice during each of the academic years of 2019-20, 2020-21, and 2021-22 with the first in early fall and the second in late spring. Second, teacher focus groups were conducted in May and June 2022. Details of participants and methodology are given in each section.

The student survey analysis highlights overall trends across and between the two CSforAll courses. First, students in both courses were more likely to be male, but DCS was more ethnically diverse than CS110. Consistent with being a college-level course, CS110 tended to have academically higher performing students than the introductory DCS. Second, responses to the two surveys indicated students in both courses grew in their confidence with computers and computer science. Students in CS110 also appeared to increase their sense of belonging in the field more than their DCS counterparts. Finally, although higher among CS110 students than their peers in DCS, responses from students in both courses indicated positive assessments of both the class and their teacher.

Key findings from teacher focus group interviews center around five themes that inform the evaluation, lessons learned, and refinement of CSforAll objectives. First, focus group discussions highlighted the effectiveness of the CSforAll professional development model for developing confident, competent, and engaged computer science teachers in a vibrant learning community. Second, comments during the interviews not only suggested a rising interest in computer science course offerings but also highlighted challenges related to course scheduling that present a real barrier to increasing the number of courses like CS110 and DCS. Third, some participants attributed increasing computer science enrollments with school-wide recruitment and involvement. Teachers' efforts to diversify student enrollments focused on female students while limited attention was given to recruiting underrepresented minority groups even in schools with diverse student populations. Fourth, focus group discussions indicated that CSforAll materials offer appropriate rigor and teachers use a variety of approaches to increase student learning in the CS courses. Fifth, teachers also expressed commitment to overcoming the challenges to expand opportunities of scaling CSforAll to attract more students. Finally, throughout the focus groups, teachers indicated appreciation for and benefits of participating in a research-practice partnership, especially the ability to contribute to refining of the curriculum and developing strategies for increasing diversity in computer science.

The final section of this report draws upon both the student survey responses and teacher focus group discussions to explore issues created by the COVID-19 pandemic that forced dramatic shifts to remote instruction in the latter part of the 2019-20 school year and most of the following 2020-21 school year. Recognizing the challenges of remote instruction, the CSforAll team and their research-practice partnership members spent the summer of 2020 developing additional curricular materials and implemented a new coding platform for the courses. In the focus groups, teachers credited these new materials and coding platform for making the transition to remote learning "easy." They added that lasting benefits include schools' adoption of individual networked devices for students, a platform that allows simultaneous viewing of coding drafts, and curriculum materials that assist students in becoming independent learners. The students' responses to the post-course survey showed

consistently positive assessments of their CSforAll course and teacher across all three years. Generally, differences between years were observed among students in DCS courses when comparing 2020-21 and 2021-22, when students were returning to classrooms. Hence, the CSforAll team's efforts to adjust for remote instruction appear to have mitigated potential negative effects of the pandemic on both teachers and students.

The rich data collected for this evaluation inspired ideas for further research and analysis. Conducted collaboratively between Siena College and UAlbany team members, these activities could result in conference presentations and peer-reviewed publications. Some topics, research questions, and data sources include:

- Impact of COVID on CSforAll Courses – what differs by year? Mixed methods using information from teacher focus groups, student surveys, and document analysis of professional development materials and curriculum.
- Development of CSforAll indicators – How can student surveys be used to provide measures of individual change, course quality, and teacher performance? Statistical analysis of student survey data.
- Gender differences in CSforAll – longer papers for journals in computer science, education, sociology, and gender studies. Mixed methods using information from teacher focus groups, student surveys, and student focus groups.
- Reasons for decline in interest – Could learning and development not be linear? How are demographic and academic differences related to loss of interest? Statistical analysis of student survey data.
- School type differences in CSforAll – How do the challenges offering computer science courses differ between rural, suburban, and urban schools? How do students' perceptions of computer science change over time and what are their perceptions of these courses and instructors? Mixed methods using information from the focus groups, student surveys, and document analysis of professional development materials and curriculum.
- Enrollment choice differences – What differences might we see between those assigned to or choosing to enroll in the CSforAll courses? What differences are related to who – teachers, counsellors, parents, or peers – encourages a student to enroll in computer science? Statistical analysis of student survey data.
- Course function differences – What differences might we see between those using the CSforAll course as a math requirement compared to an elective? Mixed methods using information from teacher focus groups and student surveys.
- Developing teachers' capacity to teach computer science – How do teachers' experience and perception of their CSforAll course change with experience? How do students' perceptions of the course and instructor differ by teacher experience? Mixed methods using information from teacher focus groups and student surveys.

Section 2: Student CSforAll Survey Results.

This part of the evaluation report provides an overview of the student survey component of the Siena College CSforAll project (referred to here as simply "CSforAll") evaluation and some key results from each section of the questionnaires distributed during each year of the project. Due to the rich nature of the data collected from the six surveys over the span of three years (i.e., 2019-20, 2020-21, and 2021-22), this section contains examples of the types of analyses possible with these data. All the analyses draw upon the two student survey datasets – one consisting of all valid responses to the pre-and post-course surveys and the second containing a subset of cases where a student's response on the pre-course survey could be matched to their post-course response – provided to the CSforAll Principal Investigator as a component of this evaluation. The next part of this section describes the methodology for collecting the survey data, matching the pre- and post-course responses, and provides an overview of response rates. Subsequent parts of this section explore three components of the data collected – characteristics of students responding to the pre-course survey, changes in students' responses to questions on both the pre-course and post-course surveys, and students' feedback on the course and instructor from the post-course survey.

A. Overview of Survey Methodology, Data Preparation, and Response Rates.

Students enrolled in *Introduction to Computer Science* (CS110) or *Discovering Computer Science* (DCS) in schools participating in CSforAll were invited to complete two anonymous surveys – a pre-course survey administered in September and a post-course survey usually administered in May or June. The surveys were developed by the CSforAll team in collaboration with the UAlbany evaluator to be consistent with prior projects, align with current research questions, and improve pre-to-post survey matching methodology. The 2020-21 version of the pre-course can be found in Appendix A and post-course survey in Appendix B.

The survey data was collected electronically through a link to Siena's Qualtrics account. Each links was specific to the school and course. The files were provided annually to UAlbany as SPSS files downloaded from Qualtrics by the CSforAll Principal Investigator.

To facilitate comparisons across the three years and two surveys, a "merged" sample file was created. In this merged file, the variables' names were standardized and indicator variables included to denote in which year and from which survey a response was received. For consistency, question numbering for all three years was aligned with the 2020-21 survey and to the pre-course instrument for post-course responses.

To allow direct comparisons of individual students' responses across time, a "matched" sample of pre-to-post responses was also created. Both the pre- and post-course surveys included five student identifier items to be used in matching responses. These items were selected as being likely that students would have consistent responses across time (e.g., the day of the month that they were born). These items were adjusted in the second year to increase variability (e.g., the third letter instead of second letter of their middle name) to reduce the potential for two students to have the same responses to all five questions (creating duplicate ids). In the latter two years, questions concerning students' gender and grade levels were also included on both

surveys, which allowed comparisons of responses across survey to confirm that the matching process was reliable.

Response Rates across Courses by Year

The distribution of responses for the pre- and post-course surveys and for the matched sample across years and courses is shown in Table 1. The steady increase in number of responses reflects continued expansion of courses being offered and schools participating in CSforAll across the three years of the project. In the first year, pre-course responses were almost evenly divided between CS110 and DCS. By the third year, the number of responses from DCS students outnumbered those from students in CS110, which is a trend consistent with the expanded offerings of the introductory course that also tended to have larger class sizes.

Table 1: Counts of Student Survey Responses by Course and Year

		Course		
Sample	Year	CS110	DCS	Total
Pre-course	AY19_20	112	116	228
	AY20-21	166	249	415
	AY21-22	187	325	512
	Total	465	690	1155
Post-course	AY19_20	107	76	183
	AY20-21	142	180	322
	AY21-22	151	232	383
	Total	400	488	888
Matched	AY19_20	78	45	123
	AY20-21	99	118	217
	AY21-22	109	141	250
	Total	286	304	590

For all years and courses, fewer responses were received to the post-course survey (middle panel of Table 1). Such declines in response rates are common in longitudinal research, although to what extent the trend reflects attrition from course enrollment or other reasons for non-responses, such as student absences or reluctance to participate, cannot be determined from the anonymous survey.

The process of matching responses across the pre-course and post-course surveys resulted in an even smaller sample for a variety of reasons. First, some students may have completed only one of the surveys. Second, students may have changed the information provided in the five identification items (e.g., entered a different number of pets). Overall, however, 51% (590/1155) of pre-course responses and 66% (590/888) of post-course responses are included in the matched sample. For comparison purposes, results are shown for both the merged and matched samples.

Response Rates across Courses and School Types.

An important goal of Siena's CSforAll project is to increase course offerings in high-need urban and rural school districts. To allow exploration of differences by school location, a variable indicating school type was created. This variable was based on information provided by the Principal Investigator concerning the schools that participated at some point in the project. Table 2 shows the distribution of survey responses by school type. The relatively low number of responses from CS110 students in high-need urban districts reflects that this course was not offered in these types of schools in the first year of the project. Hence, analyses comparing differences across school type by year are not included in this descriptive report.

Table 2: Student Survey Responses by Course and School Type

		Course		
survey	School Type	CS110	DCS	Total
Pre-course	High-Need Urban	49	269	318
	Rural	88	137	225
	Suburban / Other	328	284	612
	Total	465	690	1155
Post-course	High-Need Urban	43	191	234
	Rural	70	111	181
	Suburban / Other	287	186	473
	Total	400	488	888
Matched	High-Need Urban	28	104	132
	Rural	46	76	122
	Suburban / Other	212	124	336
	Total	286	304	590

Overall, CS110 students responding to the survey were predominantly from suburban schools, in contrast to greater diversity in the type of schools that DCS students were attending. Just over 70% (49/465) of CS110 responses to the pre-course survey were from students in suburban schools compared to 41% of responses for DCS. The ratios for the matched sample are similar, with 74% of CS110 students attending suburban schools compared to just over 40% of DCS students. The small number of responses from CS110 students in both high-need urban and rural schools for the matched sample also makes analyses of CS110 problematic.

Tests of Statistical Significance

Results presented in this report draw upon both the "merged" and "matched" samples depending on the variables being used or the purpose of the analysis. All differences noted are statistically significant at $p < .05$ using one of the following tests:

- Comparisons of percentages are tested with a pairwise comparison of column proportions using the Bonferroni correction. In addition, a Pearson chi-square is used to determine whether the two variables are statistically associated with each other.
- Comparisons between two group averages are tested using two-sample t-test of means.
- Comparisons of changes between the pre-course to post-course surveys are tested using paired-sample t-tests of individual differences.

B. Characteristics of Students by CSforAll Courses.

This section examines demographic and academic characteristics of students responding to the CSforAll surveys overall and between courses. These items are drawn from the pre-course survey, with consistency trends in both the merged and matched samples examined.

Student Demographic Characteristics

One goal of CSforAll is to encourage under-represented groups to enroll in computer science courses while in high school. Table 3 shows the percentages of students responding to the pre-course survey by key demographic characteristics. Patterns are remarkably similar between the two samples, suggesting that attrition resulted in minor changes in relative demographic composition.

The rates at which students self-identified as either male or female did not differ across the courses. The question allowed non-binary gender identification, but the counts were too small to include in a statistical report. For both CS110 and DCS, around three quarters of the respondents self-identified as male (around 74% in CS100 and around 77% in DCS). These group percentages differed by less than 2% between the two samples.

In contrast to gender, the two courses differed in the extent of racial/ethnic diversity. While students could select multiple ethnic categories, the sample is divided into two groups for the purpose of this report – those over-represented in computer science (i.e., white and/or Asian) and those under-represented (i.e., African American, Latinx, and/or mixed race). Around 80% of students in CS110 reported being either white or Asian, while around 40% of DCS students indicated that they were from an under-represented group. The rates for CS110 again differed by less than 2% but were closer to 4% for DCS. This difference in racial/ethnic diversity between the two courses most likely reflects a larger number of responses from high-need urban districts more likely to be offering DCS.

Table 3: Demographic Characteristics of Students Responding to CSforAll Surveys.

	Merged Sample				Matched Sample			
	Course				Course			
Gender	CS110	sig	DCS	Total	CS110	sig	DCS	Total
Male	74.2%		77.4%	76.1%	73.0%		77.8%	75.4%
Female	25.8%		22.6%	23.9%	27.0%		22.2%	24.6%
Race/Ethnicity								
White/Asian	79.8%	*	59.6%	67.8%	80.7%	*	63.9%	72.1%
African American / Latinx / Mixed	20.2%	*	40.4%	32.2%	19.3%	*	36.1%	27.9%
Grade Level								
Freshman/Sophomore	17.2%	*	45.3%	33.9%	18.1%	*	56.8%	38.1%
Junior	30.9%	*	25.0%	27.4%	34.8%	*	22.9%	28.6%
Senior	51.9%	*	29.8%	38.7%	47.2%	*	20.3%	33.3%

* Percentage in CS110 is statistically significantly different from DCS at $p < .05$

Reflecting differences in the targeted populations of students, the two courses differed significantly in the grade levels of students. Around half of students responding from CS110 courses were seniors, reflecting that this course could be taken for college credit, while around 18% were freshmen or sophomores. In contrast, close to half of the DCS students reported being freshmen or sophomores while between 20-30% were seniors. These differences in students' grade levels are consistent with CS110 being an advanced-level course for high school students while DCS is designed as an introductory computer science course.

Student Academic Characteristics

The pre-course survey included questions concerning students' not only students' prior academic performance and computer science courses but also why they are in the current CSforAll course. Table 4 shows respondents' self-reported grade point average (GPA), whether they had taken a prior computer science course, whether they were assigned to the CSforAll course, and who encouraged them to enroll in it. As before, percentages are shown for both the merged and matched samples.

Table 4: Academic Characteristics of Students Responding to CSforAll Surveys.

	Merged Sample				Matched Sample			
	Course				Course			
Self-reported GPA	CS110	sig	DCS	Total	CS110	sig	DCS	Total
90-100 (A)	65.2%	*	37.3%	48.8%	71.7%	*	50.5%	60.8%
80-89 (B)	29.2%	*	37.5%	34.1%	23.7%	*	33.4%	28.7%
79 or lower (C-F)	5.6%	*	25.2%	17.1%	4.7%	*	16.0%	10.5%
Taken Prior Computer Science Courses	31.3%	*	14.5%	21.6%	32.3%	*	15.9%	24.2%
Reason Taking CSforAll Course^								
I did not choose to take it, but I was put into it anyway	3.3%	*	15.6%	10.5%	1.4%	*	13.3%	7.5%
A teacher encouraged me	25.3%	*	13.6%	18.4%	25.6%	*	12.7%	19.0%
A counselor encouraged me	15.7%		13.8%	14.6%	16.1%		14.3%	15.2%
My parents encouraged me	32.8%	*	17.9%	23.9%	35.4%	*	24.0%	29.6%
My friends encouraged me	16.4%	*	7.6%	11.2%	19.3%	*	10.7%	14.9%

* Percentage in CS110 is statistically significantly different from DCS at $p < .05$

^ % do not sum to 100% because students could select more than one option.

Consistent with earlier trends related to grade levels, students responding from the two courses reported very different GPAs. Over two thirds of CS110 students reported receiving grades in the A-range and fewer than 6% reported receiving average grades of C or below. In contrast, DCS students were almost evenly divided between As, Bs, and Cs or below. Again, these GPA trends most likely reflect differences in course goals – CS110 could be taken for college credit while DCS is designed as an introductory course suitable for a wide variety of students.

Similarly, students in the two courses differed in their prior coursework in computer science. Over 30% of CS110 students had enrolled in a prior computer science course compared to less than 15% of those enrolled in DCS. A similar percentage of DCS students also reported that they were placed into, rather than choose, the course. In contrast, virtually all (i.e., over 95%) of CS110 students reported having chosen to enroll in their course. Regardless, a large majority of students in both courses indicated that they had chosen to enroll in their CSforAll course.

When examining who encouraged students to choose their course, responses from those in CS110 tended to differ from those in DCS. Students in CS110 are more likely to report being encouraged to enroll by their parents (around a third), teachers (around a quarter) and friends (between 16-20%) than students in DCS (respectively, around 20%, 13% and 10%). Interestingly, the percentages reporting being encouraged by a school counsellor did not differ significantly between CS110 and DCS students.

C. Changes in Student Attitudes between Pre-course and Post-course.

One purpose of the student survey is to estimate the impact of CSforAll courses by examining changes over time in responses to items included on both the pre-course and post-course questionnaires. While comparing trends using all responses to both surveys is possible, the findings reported here are for the matched sample, which allows examining individual changes over time.

This section of the report focuses on three sets of attitudinal items most aligned with the goals of the project. A principal component factor analysis exploring relationships between 35 attitudinal items identified five factors. A substantive examination of the items suggested substantive interpretations of these scales, which were also confirmed by a reliability analysis indicating that all composite scales had satisfactory Cronbach's alphas above .77. The scales were created by calculating the mean of the component items, which keeps the scaling the same as in the original questions (i.e., "strongly disagree" = 1 and "strongly agree" = 5).

Overall Changes in Student Responses

Table 5 shows the results from the pre-course and post-course surveys for the items that make up three of the scales – computer skills, future in computer science, and a sense of belonging in computer science. (The other two scales estimated students' perceptions of their skills with technology and skills with problem solving, neither of which showed much change over time.)

The largest changes in students' attitudes were in their self-perceptions of their computer skills. In September, students on average indicated "neither agree/disagree" (3) or "agreed" (4) with statements like "*I am able to solve basic problems through computer programming*." Approximately nine months later, students were on average clearly "agreeing" (4) with the statements. The exception was a small decline in "*Computer science is interesting to me*" but students were still on average "agreeing" with the statement. These changes suggest that students were growing in their confidence working with computers and understanding of computer science.

Another goal of CSforAll is helping students develop a sense of belonging in computer science. A comparison of pre-course and post-course survey responses indicate statistically significant increases in students' agreement with statements such as "*I have role models in computer science who are women*." Initially, students on average tended to "disagree" (2) or "neither agree/disagree" (3) in September, but by May or June were less likely to "disagree" on average. These changes suggest that students in the CSforAll courses were developing a social connection with computer science and a greater awareness of diversity in the field.

Table 5: Changes in Students' Attitudes between Pre- and Post-Course Surveys

	Pre-Course		Post-Course		Pre-Post	
Please rate your level of agreement with the following statements	Mean	Std. Deviation	Mean	Std. Deviation	Change	Sig
Computer Skills Scale (Mean of 5 items; α = .778)	**3.55**	**0.714**	**3.94**	**0.713**	**0.386**	***
I am able to solve basic problems through computer programming (Q13_3).	3.06	1.071	3.93	0.911	0.869	***
I have a basic understanding of the discipline of computer science (Q21_5).	3.53	0.934	3.98	0.826	0.451	***
I can explain what computer science is to my friends (Q21_1).	3.43	1.003	3.98	0.830	0.553	***
I am a sophisticated computer user (Q13_2).	3.57	0.977	3.73	0.974	0.161	***
Computer science is interesting to me (Q27_3).	4.18	0.800	4.07	1.005	-0.103	*
Future in CS Scale (Mean of 7 items; α = .884)	**3.80**	**0.779**	**3.77**	**0.905**	**-0.033**	
I am aware of career opportunities in computer science (Q13_4).	4.29	0.823	4.37	0.784	0.080	*
I see examples of how computer science applies to my everyday life (Q13_1).	4.00	0.875	4.05	0.943	0.052	
I will need to utilize my computer programming skills for my future job (Q21_8).	3.60	1.005	3.57	1.174	-0.032	
I am considering a career path in computer science (Q13_5).	3.52	1.180	3.35	1.322	-0.165	**
I am considering a college major related to computer science Q13_6).	3.41	1.225	3.28	1.370	-0.134	*
I am considering taking additional courses in computer science (Q13_7)	3.67	1.090	3.64	1.317	-0.032	
I will need to utilize technology for my future job (Q21_9).	4.14	0.891	4.11	1.004	-0.027	
Belonging in CS Scale (Mean of 5 items; α = .755)	**3.25**	**0.699**	**3.37**	**0.734**	**0.114**	***
I feel I am a part of a community of students who are interested in computer science (Q27_11).	3.27	0.994	3.38	1.045	0.103	*
I know a lot of students like me who are interested in computer science (Q27_8).	3.20	1.035	3.30	1.082	0.095	*
I have role models in computer science who are people of color (Q27_10).	2.86	1.062	2.99	1.063	0.125	**
I have role models in computer science who are women (Q27_9).	2.80	1.079	3.01	1.113	0.208	***
Computer science can be used to solve problems facing society (Q27_7).	4.13	0.776	4.16	0.832	0.027	

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

In contrast, students' plans to pursue a future in computer science changed little over the course of the school year. Given that a large majority were choosing to enroll in the CSforAll course, students' tendencies to "agree" (4) with statements about their future in computer science are not surprising. The decline in agreement with statements like "*I am considering a*

career path in computer science" may reflect some students reconsidering those plans or some aspects of their futures. Whether those changes are temporary or what factors might be related to them is beyond the scope of this report.

Differences in Attitudes across CSforAll Courses.

As noted in prior sections of this report, students in the two CSforAll courses tend to differ in many ways that might also be related to their attitudes about computers, their future in computer science, and sense of belonging. This section examines the extent that students' attitudes differ between the two courses and changes in those attitudes over time. As before, Table 6 shows the average responses for the same three scales and their component items broken out by CS110 and DCS.

Given that CS110 is a college-level course, students in this course would be expected to express greater confidence in their computer skills and knowledge of computer science than those in DCS. In September, CS110 students were on average closer to "agree" (4) than those in DCS (i.e., respectively 3.66 compared to 3.45 on the overall computer skill scale). Differences between the two courses were also observed in students' average responses to the same items the following spring. However, students' responses for both courses suggested increasing levels of agreement concerning their computer skills over time. The greatest growth in both courses was in students' agreement with "*I am able to solve basic problems through computer programming*." However, DCS students on average had a slight decline in their agreement that "*computer science is interesting*." As before, reasons for this decline in interest, given students' increase in confidence with computers, are difficult to determine from analyses for this report.

Trends related to a sense of belonging in computer science suggest one possible reason for some students losing interest in the subject. In September, responses related to items indicating a sense of belonging were relatively similar (i.e., means were not statistically significantly different). The except was students' level of agreement with "*I know a lot of students like me who are interested in computer science*" being higher in CS110 than for DCS. This difference is consistent with CS110 students being more likely to report that their friends encouraged them to enroll in their course. By spring, responses from students in these two courses indicated differing levels of agreement with the sense of belonging items. CS110 students tended to agree more on average with items like "*I feel I am a part of a community of students who are interested in computer science*" than DCS students. These results suggest that increased computer skills did not result in a greater sense of belonging in computer science for students in DCS but did for CS110 students.

Table 6: Differences between CSforAll Courses and Changes from Pre- to Post-Course Surveys.

	Pre-Course					Post-course								
	CS110		DCS			CS110		DCS			Pre-Post Change			
Please rate your level of agreement with the following statements	Mean	Std. Deviation	Mean	Std. Deviation	Sig	Mean	Std. Deviation	Mean	Std. Deviation	Sig	CS110	Sig	DCS	Sig
Computer Skills Scale (Mean of 5 items)	**3.66**	**0.698**	**3.45**	**0.715**	***	**4.08**	**0.691**	**3.81**	**0.710**	***	**0.417**	***	**0.359**	***
I am able to solve basic problems through computer programming (Q13_3).	3.10	1.137	3.02	1.005		4.10	0.863	3.76	0.926	***	1.001	***	0.746	***
I have a basic understanding of the discipline of computer science (Q21_5).	3.68	0.901	3.39	0.943	***	4.14	0.799	3.84	0.827	***	0.453	***	0.451	***
I can explain what computer science is to my friends (Q21_1).	3.55	0.937	3.31	1.049	**	4.06	0.791	3.91	0.861	*	0.503	***	0.600	***
I am a sophisticated computer user (Q13_2).	3.66	0.949	3.49	0.996	*	3.87	0.937	3.61	0.993	**	0.208	***	0.119	*
Computer science is interesting to me (Q27_3).	4.30	0.668	4.06	0.893	***	4.23	0.914	3.93	1.065	***	-0.071		-0.132	*
Future in CS Scale (Mean of 7 items)	**4.00**	**0.720**	**3.62**	**0.789**	***	**4.00**	**0.838**	**3.56**	**0.914**	***	**0.000**		**-0.064**	
I am aware of career opportunities in computer science (Q13_4).	4.39	0.793	4.20	0.842	**	4.46	0.771	4.29	0.788	**	0.076		0.085	
I see examples of how computer science applies to my everyday life (Q13_1).	4.07	0.830	3.93	0.911		4.22	0.870	3.89	0.980	***	0.152	**	-0.040	
I will need to utilize my computer programming skills for my future job (Q21_8).	3.78	0.962	3.44	1.019	***	3.86	1.084	3.29	1.190	***	0.086		-0.145	*
I am considering a career path in computer science (Q13_5).	3.80	1.133	3.25	1.163	***	3.60	1.317	3.12	1.286	***	-0.197	**	-0.129	
I am considering a college major related to computer science Q13_6).	3.71	1.183	3.13	1.199	***	3.57	1.360	3.01	1.324	***	-0.138		-0.125	
I am considering taking additional courses in computer science (Q13_7)	3.93	1.046	3.43	1.076	***	3.90	1.199	3.40	1.376	***	-0.029		-0.031	
I will need to utilize technology for my future job (Q21_9).	4.33	0.775	3.97	0.958	***	4.35	0.866	3.89	1.074	***	0.024		-0.073	
Belonging in CS Scale (Mean of 5 items)	**3.31**	**0.661**	**3.20**	**0.729**	*	**3.49**	**0.702**	**3.25**	**0.745**	***	**0.179**	***	**0.053**	
I feel I am a part of a community of students who are interested in computer science (Q27_11).	3.33	0.933	3.22	1.047		3.53	0.979	3.23	1.086	***	0.195	**	0.017	
I know a lot of students like me who are interested in computer science (Q27_8).	3.38	1.013	3.04	1.031	***	3.51	1.065	3.10	1.061	***	0.133		0.061	
I have role models in computer science who are people of color (Q27_10).	2.84	1.056	2.88	1.069		2.99	1.037	2.98	1.088		0.157	*	0.095	
I have role models in computer science who are women (Q27_9).	2.83	1.090	2.77	1.070		3.13	1.094	2.89	1.120	*	0.300	***	0.121	
Computer science can be used to solve problems facing society (Q27_7).	4.20	0.736	4.07	0.809		4.31	0.805	4.02	0.835	***	0.112	*	-0.051	

As with computer skills, students' responses concerning their future in computer science differ consistently between courses both in September and in Spring. "*I see examples of how computer science applies to my everyday life*" was the only item associated with this scale for which responses did not differ significantly between CS110 and DCS in September but did so in spring. The apparent decline in plans to pursue a career in computer science is only statistically significant among the CS110 students. Overall, however, students in both courses had little change in attitudes related to a future in computer science.

D. Students' Assessment of CSforAll Courses and Teachers.

A series of questions that appeared only on the post-course survey concerned students' perception of their CSforAll course and teacher. They were asked to indicate their level of agreement on a five-point scale to questions such as "*I found this class to be interesting*" and "*The teacher for this class was well organized*." Table 7 shows the average responses for both courses combined and separately for the merged and matched samples. Comparisons of the mean ratings on all the items showed extremely small differences (i.e., less than .056 on a five-point scale) between the merged and matched samples.

In general, students' responses indicated positive feelings about their CSforAll courses. On average, students tended to "agree" (4) with the statements about their course. The lowest mean rating (3.666) was for "*I found this class to be challenging*," but still well over "neither agree/disagree" (3). The rating for the course overall was the highest at over "agree" (4). While still over "neither agree/disagree" (3), students' ratings for DCS tended to be lower on average than those for CS110 on all items except finding the class challenging. These findings suggest that students overall had positive experiences in both CSforAll courses, but more so for the more advanced course.

Overall, students' responses indicate that they had even more positive feelings about their teachers. The average level of agreement was above "agree" (4) for all the teacher items, both overall and for each course. As with ratings for their course, CS110 students tended to agree more strongly than those in DCS with the statements about their teachers, with average ratings approaching "strongly agree" (5). Regardless, as with their assessment of the courses overall, students in both courses also appeared to think highly of their CSforAll teachers.

Table 7: Differences in Perception of Course and Teacher by CSforAll Course

Please rate your level of agreement with the following statements (Q36 & Q30).		Merged Sample				Matched Sample			
		CS110	DCS	Sig	Total	CS110	DCS	Sig	Total
I found this class to be interesting.	Mean	4.309	3.962	***	4.117	4.342	3.963	***	4.146
	Std. Dev.	0.877	1.063		0.998	0.859	1.068		0.990
I found this class to be challenging.	Mean	3.621	3.703		3.666	3.614	3.693		3.654
	Std. Dev.	1.159	1.129		1.143	1.157	1.148		1.152
I would recommend this class to fellow students.	Mean	4.119	3.812	***	3.949	4.158	3.814	***	3.981
	Std. Dev.	0.902	1.035		0.989	0.869	1.025		0.967
This class increased my interest in computer science.	Mean	3.968	3.681	***	3.809	3.996	3.696	***	3.841
	Std. Dev.	1.080	1.193		1.152	1.072	1.168		1.132
I felt my opinions were valued in this class.	Mean	4.148	3.826	***	3.970	4.165	3.840	***	3.998
	Std. Dev.	0.860	0.910		0.902	0.855	0.896		0.891
I felt comfortable asking questions in this class.	Mean	4.269	4.011	***	4.126	4.277	4.057	***	4.164
	Std. Dev.	0.843	0.945		0.909	0.836	0.902		0.877
Overall, I was satisfied with my experience in this class.	Mean	4.354	4.068	***	4.196	4.371	4.051	***	4.206
	Std. Dev.	0.892	1.020		0.975	0.860	1.032		0.965
The teacher for this class…									
displayed an interest in student learning.	Mean	4.602	4.231	***	4.398	4.623	4.243	***	4.428
	Std. Dev.	0.665	0.884		0.813	0.629	0.881		0.791
encouraged my participation in the class.	Mean	4.564	4.270	***	4.402	4.560	4.302	***	4.428
	Std. Dev.	0.713	0.842		0.799	0.699	0.825		0.776
made sure students understood the material	Mean	4.408	4.092	***	4.234	4.442	4.151	***	4.293
	Std. Dev.	0.849	0.969		0.930	0.782	0.927		0.871
presented material at a level that I could understand.	Mean	4.504	4.102	***	4.283	4.540	4.155	***	4.342
	Std. Dev.	0.796	0.953		0.908	0.759	0.917		0.865
was knowledgeable about the subject matter of this	Mean	4.507	4.308	***	4.398	4.533	4.348	**	4.438
	Std. Dev.	0.737	0.865		0.815	0.700	0.880		0.802
was well organized.	Mean	4.447	4.162	***	4.291	4.484	4.208	***	4.342
	Std. Dev.	0.788	0.941		0.886	0.737	0.946		0.861
was enthusiastic about the subject matter of this class.	Mean	4.668	4.280	***	4.456	4.696	4.336	***	4.512
	Std. Dev.	0.643	0.864		0.795	0.586	0.830		0.743
made me feel welcomed in this class.	Mean	4.653	4.352	***	4.488	4.664	4.393	***	4.525
	Std. Dev.	0.676	0.899		0.819	0.644	0.879		0.785

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

Section 3: Teacher Focus Group Results.

This part of the evaluation report provides an overview of the teacher focus group component of the CSforAll evaluation and key results related to the program's objectives. The first part of this section describes the methodology for the teacher focus groups. Subsequent components of this section explore findings related to professional development, course offerings and schedule, student enrollment and recruitment, course content and student engagement, and future challenges and opportunities. This section ends with an overview of teachers' reflections on participating in a research-practice partnership.

A. Overview of Focus Group Methodology.

To solicit qualitative feedback from participating teachers, the Principal Investigator invited a representative sample CSforAll teachers to join one of three focus groups – a DCS focus group, a CS110 focus group, and a research-practice partnership focus group. A total of 12 teachers participated in these focus groups held between May 17 and June 6, 2022. Each group had between three and five participants representing various levels of prior experience with computer science and different types of school districts (rural, city, and suburban). Each interview lasted approximately one hour on Zoom and was recorded to facilitate transcription and analysis. The interview protocols (see Appendix C) were tailored for each group to facilitate exploring their areas of expertise in a particular course or as a research partner. Focus group questions and discussion explored teachers' becoming involved in CSforAll, implementing CSforAll at their schools, and observations of the impact of CSforAll.

The initial coding framework was developed from the CSforAll project goals outlined in the proposal funded by the National Science Foundation, with subsequent coding based on frameworks for assessing research-practice partnerships. These eight stated objectives guiding this analysis were:

1. Develop and evaluate an in-service computer science teacher PD model that can be adopted by other colleges/universities to establish a workforce of confident, competent, and engaged computer science teachers.
2. Increase the number of rigorous, conceptual college and high school level courses being offered at Tech Valley high schools.
3. Increase the total number of high school students taking a college or high school level computer science course at the participating high schools from 77 per year to at least 300 students per year.
4. Increase the percentage of females enrolled in a computer science class at the participating high schools from approximately 20% to 40%. This goal is 12% higher than the national percentage of females that took an advanced placement computer science exam in 2018.
5. Increase the enrollment of underrepresented minority groups in the computer science classes of participating high schools to reflect the population of each school.

6. Increase the enrollment of rural students in the computer science classes of participating high schools.
7. Create in-service and pre-service teacher pathways for obtaining initial and second teaching computer science certification in New York.
8. Increase participation in our vibrant and sustainable professional learning community of computer science educators.

B. Professional Development.

CSforAll objectives #1 & #8: Develop confident, competent, and engaged computer science teachers participating in a vibrant and sustainable learning community.

Focus group participants included self-starters who advocated for CSforAll at their school and those who joined a school initiative, either by volunteering or being recruited. Recruits included teachers who were already teaching in the school as well as teachers pulled up from middle schools in the district and new hires. These teachers expressed personal interest in computer science and/or a willingness to try something new. Teachers' prior experience with computer science ranged from none, to having a computer science minor, to having professional programming experience. Focus group participants had been teaching in CSforAll for one to six years. Despite such a diversity of knowledge and experience, feedback regarding CSforAll professional development was remarkably consistent.

Summer workshops and Siena College courses are effective

Professional development offered via summer workshops and Siena College courses were very effective. Teachers reported finding it helpful to review and work through the course materials that they would be teaching. Doing so enhanced their personal understanding of computer science, familiarity with how to teach the topic, and comfort teaching a new subject. One teacher described their initial anxiety: *"[I'm] teaching a brand new course I've never taught before - that no one's taught. Alone. This is going to be a disaster."* The teacher continued, *"It was not a disaster…the summer was very helpful for ameliorating my existential dread teaching the course…being able to do some of the labs was really good."*

Some teachers enrolled in CS110 at Siena College while concurrently teaching it at their high school. *"That was probably the most beneficial - I took [CS110] actually while I was teaching, so … I was just a little bit ahead and it was so fresh."* Another teacher commented that *"when I was teaching it, I was actually taking it and the students really thought that that was kind of cool … that I was doing it right along with them."*

The teachers noted the value of these professional development opportunities and intend to continue participating in the future, saying *"as much contact as possible is good."*

CSforAll teacher network provides help and belonging

CSforAll teachers described having formed a community that provides support, assistance, and sense of belonging. This network is forged through involvement in summer workshops, Siena

College coursework, CSforAll monthly meetings, and the CSforAll executive committee. Focus group participants report that this network is helpful for discussing challenges as well as sharing ideas and resources. Several teachers indicated that they communicate with other CSforAll teachers on an ad hoc basis: *"there's someone that works [at a nearby school] and we have each other's number. Now we talk all the time, like 'hey we're struggling on this - what'd you do? What'd I do?'"* The teachers noted that these connections are a source of support and assistance:

> *since I am like the only one - the solo person - it's just been really nice to have, like, a support group. Someone to talk to. …I literally text another teacher like right in class to be like, 'can you check my Replit?' … I have a Replit shared with another teacher, so we can, like, send each other code and check and try to help each other out.*

Strong trust in and support from Siena College partners

Focus group participants spoke very highly of the Siena College faculty partners in CSforAll.

> *The support is just overwhelming. Like today, I had an issue …and I emailed I don't know, maybe like 10:00 and at 10:08 I had three emails back. …Eight minutes … you don't get that anywhere else, so that was the biggest thing that got me to just switch totally was they're so supportive.*

Teachers repeatedly commented that Siena College faculty respond very quickly and are a reliable and trustworthy source for computer science information and technical problem-solving. One teacher commented that *"the team at Siena is so incredibly responsive. …it just boggles the mind how helpful they are."* Other teachers described Siena's support as *"priceless"* and the partners as *"very welcoming - open, supportive, helpful. Like I said, I can't say enough about it. It's an unbelievable, um, department that they have there. It's, like, unparalleled in my opinion. … we should give them sainthood."*

C. Course Offerings & Schedule.

CSforAll objective #2: Increase the number of conceptual college and high school level courses offered at high schools in the region.

Schools adopt CSforAll in lieu of other options

As described previously, focus group participants included teachers who agreed to join school's computer science initiative and those who encouraged their school to offer computer science. While personal interest motivated most teachers to advocate for computer science, one person cited a local employers' needs as the impetus for creating a course. About half of the focus group participants described having computer science at their school prior to joining CSforAll.

Two of the teachers had been using a commercially available product for teaching computer science and credited the quality of Siena College's materials and support for their decisions to switch to CSforAll. One teacher switched curriculum mid-term, stating that the school had

> *assigned me to do [a commercially available course] … And at the time they also sent me up to Siena because … they wanted to see what I thought about it and to be completely honest with you, I just stopped teaching the [commercial] class and just started teaching Discovering.*

Self-created computer science offerings were largely replaced with CSforAll courses. In only one instance a teacher continues to offer their own course to complement Siena College's *Introduction to Computer Science* (CS110) dual-enrollment course.

Scheduling struggles

Focus group participants identified course scheduling as the most significant challenge. They described the master schedule being influenced by teacher availability, competing time slots for electives, and space constraints. Many CSforAll teachers also teach required math courses, which restricts availability for when they can teach CSforAll courses. Additionally, CSforAll courses are often scheduled at the same time as other lucrative electives.

These challenges manifest in students' schedules and course selection: *"I do have some girls that keep telling me every year that they really want to be in my class, but they can't fit it into their schedule."* A focus group participant described a notable drop in enrollment because entry-level DCS was scheduled at the same time as the freshman lunch period. A teacher from a smaller rural school noted concern from the principle that interest in CSforAll could cannibalize other electives, while a teacher from a larger suburban school noted competing opportunities for students, saying *"we have so many electives and the kids typically want to take extra bio, chem, physics, forensics … the list goes on and on."*

D. Student Enrollment & Recruitment.

CSforAll objectives #3, #4, #5, & #6: Increase the total number of high school students taking a college or high school level CS, including in rural areas. Increase the percentage of females and underrepresented minority groups in CS courses.

Focus group participants expressed interest in increasing participation in computer science and, while acknowledging challenges, conveyed optimism about doing so.

School-wide involvement is important

Focus group participants indicated that, overall, their schools and administrators are supportive of CSforAll and teachers' participation. Focus group participants further identified administrators, guidance counselors, math teachers, and students as critical partners for promoting and facilitating students' enrollment. One teacher said, *"I've been, um, kind of infiltrating the math classes trying to get my fellow math teachers to recruit for me."* Other examples of school-wide involvement include CSforAll teachers teaming with administrators to promote computer science through class visits, and guidance counselors promoting the classes to their students.

Importantly, the lack of school-wide involvement is an impediment. After hearing another focus group participant talk about hosting Hour of Code, one teacher said *"I couldn't do the Hour of Code again because I needed that support of the math people."* Another described struggling to find committed partners amid competing priorities:

> *I almost feel like the one-man marching band … just trying to drum up the interest, trying to you know get everything running. And we have like nine principles at the school so it's also hard to really find a strong [partner]. I have one principle I often go to help rally this up, but he's also in charge of a lot of other things.*

Enrollment increases

Overall, teachers reported an increase in enrollment. However, they also cited unmet student interest due to the aforementioned scheduling challenges.

The teachers did not always know how students become enrolled in their classes. They indicated that some students selected the courses while others were assigned to them. DCS teachers in particular noted variation in students' interest in computer science; some are simply pursuing math credit or unfamiliar with computer science before taking the course.

Two teachers highlighted creative approaches to their struggles with meeting minimum enrollment requirements. One explained aligning the CSforAll course to her school's effort to increase upper-level and college credit course enrollment; she is permitted to run CS110 with fewer students than typically required. The other teacher offers computer science through distance learning to enroll students from multiple schools. This allowed her to run the course and the school to make some money.

Variety of approaches to recruitment

The most commonly cited recruitment activities were teachers promoting CSforAll to their current students and computer science students' word-of-mouth. Some teachers showcase students' work and encourage their students to promote the class. Others described students' inclination to share their experiences with peers:

> *word has spread organically between … the high-flyers that are currently taking it, who have done nothing but speak incredibly highly of the class because they've enjoyed it. They've been so incredibly frustrated at times, and then they, you know, they have that Eureka moment when they solve the problem. And it's made it really, really fun and they've clearly told their friends and, you know, the underclassmen.*

Other approaches include visiting study hall and math classes, participating in elective fairs, posting flyers, and publishing information on the school's website. One teacher described hosting an Hour of Code event as a strategy for engaging a larger number of potential students:

> *I did Hour of Code with the entire secondary level where I went to our high school - the main campus high school and to another off campus high school that we have - and did Hour of Code with every single student from ninth to twelfth grade to really help promote the idea of computer science, give everybody an opportunity to do it. …I made,*

> *like, a website and they had like a list of different activities they could pick from. …I tried to do, like, three to five classrooms at a time and I'd have them come to, like, our library or some other large area. And then I'd have them try it out and if they did try it out, I gave out raffle tickets and they won prizes, they got stickers, … and key chains and stuff like that for just for doing it*.

A couple teachers discussed focusing on sparking interest among younger students at the middle school level with presentations, activities, and interactions with role models. They also engaged parents: *"I reached out to the eighth-grade parents of the accelerated math students and I just sent them a letter and was just saying how they were recommended by their math teacher to take the course."*

Attention to participation of females

Focus group participants reported low numbers of females in their classes with instances of entirely male enrollment across all school types. Some teachers are seeing increases in girls' interest and enrollment, yet one remarked, *"I always have two girls in my Discovering class and then they do not pursue. So, I just see that as a general trend from seventh grade all the way up I get fewer and fewer girls, as we get higher and higher."*

Several teachers indicated that their efforts to diversify CSforAll enrollment focused on girls. One teacher hoped that being a female computer science teacher would implicitly inspire more girls to enroll. A male teacher suggested including personal interactions with female role models, such as local professionals or the Siena faculty, in the classroom. Two teachers leveraged their roles as coaches to encourage the girls on their sports teams to sign up. One of the teachers described hosting a Women in STEAM day at the middle school; companies and professionals were invited to interact with students and about 1000 people attended.

Limited focus on participation of underrepresented racial/ethnic groups

Consensus among focus group participants is that, while desired, participation of underrepresented racial/ethnic groups is a significant challenge. A couple teachers specifically referenced having very limited diversity in their school/district, indicating little opportunity for growth. In contrast, two teachers indicated that they are involved in CSforAll, in part, because their schools do have a more diverse student population.

Nine of the twelve schools represented in the focus group enroll 2% - 12% Black or Hispanic students. A teacher whose school falls on the higher end of that range shared their aspiration to have diversity in CSforAll classes reflect that of the school: "*yes, I'd love the diversity, I would love it to be equivalent to the diversity of my school, but that's a goal. That's a growth goal.*"

None of the focus group participants reported efforts or strategies to engage with this goal.

E. Course Content & Student Engagement.

CSforAll objective #2: Increase the rigor and student learning in conceptual college and high school level courses being offered at participating high schools in the region.

Course materials are easy to use

Focus group participants spoke highly about the quality and value of curricular materials provided by CSforAll. Teachers specifically referenced the well-organized and easy-to-use curriculum map with associated examples and interactive notes, helpfulness of universal design, and utility of 'bells and whistles' for differentiated instruction. Teachers reported that the materials supported pacing adjustments to accommodate classroom and learner needs. One teacher described the course materials as *"priceless."* They also shared that using Replit made it easier for teachers and students alike to share and collaborate with one another; it is a valuable tool for both virtual and in-person classes.

School IT support is critical

The majority of focus group participants indicated that their IT colleagues were supportive and responsive to their technical needs. The most common issue they reported was software (e.g. NetsBlox, Replit) needing to be re-whitelisted in the school's filters. Two of the twelve participants recounted significant roadblocks due to IT concerns about privacy and contracts. They skipped parts of the curriculum as a result; one teacher explained *"I went two months … not having access to Replit and just having to work my way, as best we could, through parts of the curriculum that didn't require programming."*

Mixed student engagement in the courses

Focus group participants who teach DCS reported wide variation in students' class engagement. One teacher described two student groups: *"I have the group who, you know, wants to do coding and wants to do CS - you know, programming. And then I have the group that doesn't want to do anything."*

Those who teach CS110, on the other hand, reported students overall being happy in the class. A couple teachers reflected on the difference between students' engagement in required and elective courses. One said:

> *I've never taught an elective before so it's weird to have kids actually do work and, like, want to be there and, like, engaged. …It was totally weird the first homework assignment that everyone turned it in, complete, [I] didn't have to argue with anybody so that part was kind of nice.*

One focus group participant highlighted focus and diligence as characteristics of engagement, and emphasized that there is not one singular model of students who are engaged and successful in computer science:

> *there was a boy who was suspended for two days for trespassing and [he] comes in and he's so happy - he loves this class … I thought to myself here's a kid who's not a delinquent but a knucklehead … he's far from an academic star, but he can code. …in my opinion, anyone who can sit and look and type and read and do directions, is a win. So you know when I say this program is good, I think it's great because that's exactly the type of student when we say 'CS for All'.*

Teachers for both classes described having a mix of students who *"want to work through it … will just sit there and tinker, tinker, tinker"* and students who want explicit instructions or to be given the answer. They reflected on possible causes being general motivation issues or fallout from having had lower expectations during COVID.

Resistance to *CS in the News* and *Diversity in CS*

Focus group participants overwhelmingly reported that students dislike *CS in the News*. They cited the challenge of overcoming students' resistance, noting that they do the projects sparingly or use them to accommodate pacing adjustments. Only one teacher reflected on students' learning, saying *"in actuality, they are amazed at what they hear and learn… I walked around and… [there is] one shock over the other… you can't even believe how little they know [before the project]."* Focus group participants said they like *Diversity in CS*, though noted that students struggled to find adequate information about some of the people. They suggested that CSforAll refine the list of people and verify that links are valid and useful.

Teachers reported that, for both *CS in the News* and *Diversity in CS*, students were apprehensive about presenting in class and reluctant – or lacked the skills – to reflect or write.

Variety of efforts to enhance engagement

Several focus group participants discussed using partners and whole-class discussion to enhance engagement and comprehension. For example, a teacher who struggles with small classes, poor attendance, and low motivation works through labs as a class. Another teacher credited Siena faculty for introducing a "round-robin" approach to facilitate group problem-solving *"so that kids could play off of or tag on to whatever somebody else has said to understand"* the material. One of the teachers shared that

> *there's been a couple times in in both classes, where … they get to that frustration point where they can't - couldn't get through it. And through a discussion we're able to walk through what needs to happen and, and then it turns out to be a spacing error or a punctuation error. … and then they see it and then, what's fun for me is, like, that mistake is never made again.*

A couple teachers reported having students rotate partners. One explained the intention for doing so: *"I just kind of rotate them randomly so students of different backgrounds, skill levels, … they all get to work together."* Another observed that *"having students work on group assignments [or] partner assignments throughout the entire year really has an impact on their learning. [A] positive impact."*

Focus group participants also talked about encouraging their students to be creative, have fun, and show their personality in their work. One teacher explained how students' friendly competition fueled their learning:

> *Mine tend to get, like, competitive. … They tend to be like a little, like you know, 'well I'm gonna get all the extra points'… [and] 'if I hand this in right now will I get 35 out of 35?' … I'll be like, 'eeehhhh'. And then they'll go back and you know they're comparing to each other … In my mind it's like a positive thing, like we're pushing each other to, like,*

> *do better, and … I don't know if they realize, but every time they asked me I'm always like 'eeehhh'. Like, I never say yes. But they're always going back to try and do, like, one extra thing so that's just, like, how my class has been this year, …they're fun, [a] really good group.*

One of the teachers shared that he encourages students with presentation concerns by framing it as a learning opportunity - and using humor:

> *I just put it to them … 'when you go to college, when you get a job, and, you know, if you're going to be up for promotion, you're probably gonna have to sit down in front of somebody and sell yourself. And here's your chance to, you know, get a little bit more comfortable with the uncomfortable' … I also tell them 'if you just take a deep breath and you look out in the crowd, there's me and probably two other people looking at you. And the two other people looking at you probably aren't even paying attention, they just happen to be staring you in a direction.' And they laugh, and then they [are] kind of eased.*

Students' interest in computer science expands beyond CSforAll classes

Focus group participants reported that the classes reinforced and inspired new interest in computer science.

> *I had a combination of kids who thought they were, you know, computer nerds or geeks and this reinforces that idea … [of] what they want to do. And then I'm afraid that I've corrupted some of my liberal arts kids into thinking that science might be fun.*

Teachers report their students engaging in co-curricular opportunities, such as participating in the Siena College programming competition, and serving as a TA to mentor and help other CSforAll students.

Nearly all the focus group participants had examples of students interested in, or open to the possibility of, pursing computer science or a related field, like cybersecurity, in college. One of the teachers shared that, this year, five seniors with no prior plans to attend college or trade school now had plans to attend computer science programs.

No specific attention to female and underrepresented racial/ethnic minority engagement

One focus group participant commented that the girls seem to show more creativity in their work that the boys. Otherwise, the discussion did not touch on underrepresented students' experiences in the classroom, nor did the language used reflect an equity, inclusion, and justice orientation.

Students cultivate transferable skills

Teachers reported that the CSforAll curriculum and class experiences benefit students' use of directions, focus, attention to detail, problem solving, and collaborative group work. They credited the project-based learning design and rubrics for helping students gain independence in managing their learning. One of the teachers highlighted meaningful changes in students' confidence and social skills:

> *I can tell you that there's a kid on the first day of school that didn't even make eye contact with me and now we can have a conversation for 15-20 minutes. It just, it was a confidence booster. …whether it's them learning how to code and asked me questions, or … to understand something outside [of class], but using those problem solving skills - of context clues and whatnot - …taught them how to be a more social person and just get through the things that you might not always be comfortable getting through.*

F. Future Challenges & Opportunities.

Focus group discussions primarily explored teachers' experiences thus far in the program. As one would expect, teachers' reflections on the past invoked their thoughts about the future.

Increases in city school enrollment and course offerings

Focus group participants from city schools reported growth for next school year. Two of the four city schools plan to offer additional sections of existing CSforAll courses and/or offer additional computer science courses. Another city school expects more than double the number of students to be enrolled in DCS next year, which the teacher described as "*both exciting and terrifying.*"

Capacity gaps in schools

Focus group participants discussed capacity building at three levels – the individual teacher, the school, and the CSforAll program (inclusive of the CSforAll teacher network and Siena College partners). They indicated that capacity building for individual teachers and the CSforAll program is addressed through the CSforAll RPP. However, capacity building is needed at the school level to sustain and expand the program. For instance, one of the suburban school teachers reported that fewer computer science courses will be offered next year because he has to teach other courses and there is no one else to teach the subject.

As previously discussed, school-wide involvement is critical for enrollment and recruitment. One teacher described the effects of capacity gaps on school-wide involvement and support for computer science enrollment:

> *the math teachers were on board, but … as my computer science assignment grew the math position was not supplemented, so my peers were experiencing higher numbers in their classrooms. And this year I don't think they shared it as much with their students, because my numbers aren't as high this year.*

Another teacher described her struggles not having a departmental affiliation:

> *So, I'm just completely honest, …I am alone, I am the only one. I don't have a department. I'm not a part of the math department. I'm not a part of the English department. I am just me, so I kind of get lost in the shuffle too as well just being the lone person and having to advocate for myself and do all the meetings by myself and all that kind of thing. So, it's been a struggle.*

Additionally, teachers noted reduced buy-in, fewer course offerings, and dwindling recruitment efforts when computer science advocates (administrators and teachers) are promoted or leave the school.

G. Involvement in Research-Practice Partnership

The five dimensions of effective Research-Practice Partnerships (RPP) were naturally intertwined in the previously discussed findings, including trust (page 20), research informed actions (pages 22 and 23), impact on schools (pages 20 and 22), informing computer science educational improvement (pages 25 and 26), and building capacity (pages 19 and 27). Focus group discussion with executive board members further illuminated aspects the RPP's impact and effectiveness. Highlights from the discussion, supplemented with insights from participants in the other focus groups are provided below.

Teachers customize and share practices

In addition to the individual help and belonging afforded through the CSforAll teacher network (page 19), teachers commented on being engaged as contributors to many aspects of CSforAll project. For instance, teachers referenced their involvement in developing the *Diversity in CS* curriculum materials, creating interactive slides for virtual instruction, and switching course materials to Replit when this software was adopted. One of the teachers talked about having become involved in CSforAll as a student, using their training in education to apply universal design to the CSForAll materials. Furthermore, other teachers in the CSforAll network highlighted and expressed appreciation for the specific contributions of their peers.

Teachers share experiences with research and practice communities

Focus group participants reported presenting their experiences teaching computer science at conferences, individually and in collaboration with Siena College partners. One teacher described how, by co-presenting with Siena College partners, the teachers can address some of the specific concerns of conference attendees.

> *Because the questions are like 'what about scheduling? What about this?' – like, just something way more high school-y … but mostly to make sure they realize that it's so doable.*

RPP facilitates a pathway to certification

Teachers reported that, in addition to the practical utility for teaching computer science, taking Siena College courses as a part of the RPP is a helpful pathway to certification. One of the teachers commented that,

> *Because I started teaching this course and working with Siena, I decided to do the Computing Education Certificate at [a local university] as part of my master's degree, so I did get the certificate because of my experience with teaching these courses.*

Participation enhances teacher engagement and satisfaction

Focus group participants described the positive impact involvement in the CSforAll RPP has had on their teaching, professional opportunities, and satisfaction. One teacher said that teaching computer science "*made me more interested in the topic*" while another simply stated "*I love teaching it.*"

An early-career teacher noted the influence of CSforAll instruction practices on her other classes: "*I'm heavily inspired by the computer science teaching style … I converted [another subject] to completely project-based learning this year.*"

One teacher referenced her desire make a positive impact in the community through teaching. *"I was like 'awesome I want to actually learn like really how to program and stuff' and …teach the high school kids so we can have a greater impact on our area."*

Another teacher discussed the significance of involvement in the RPP on her teaching career:

> *I had a plan to, like, move out of New York … since pulling me up to the high school I definitely feel like I've become more of a leader in my district… Honestly, I was so sick of eighth grade math, and I couldn't picture myself teaching it forever. But since they pulled me up here and I've been teaching computer science it's just opened a whole new - just so many so many opportunities for me both like professionally but also personally and it's been great.*

Section 4: Impact of COVID-19 on CSforAll Courses.

This final section explores efforts to mitigate the impact in instructional modes between in-person and online instruction in 2020-21 school year due to the COVID-19 pandemic. This section starts with a review of adjustments by the research-practice partnership members to the computer science curriculum and related professional development. The subsequent sections highlight teachers' experience described in their focus groups and students' perceptions of their courses and teachers compared to the other two years gathered through the survey. Information concerning administration of student survey is available in Section 2 (page 6) and interview process for the teacher focus groups in Section 3 (page 18).

A. COVID-19 Adjustments to Activities.

With support of a supplemental grant, the CSforAll team spent the summer of 2020 and part of the school the 2020-21 school year working with high school teachers to adapt *Introduction to Computer Science* (CS110) and *Discovering Computer Science* (DCS) for remote instruction. This work was informed by experiences during Spring 2020 when New York State abruptly shifted to fully remote instruction in March 2020, at which point most of the computer science course material had been presented to students. This effort included revising the curriculum to include more scaffolding materials and in creating interactive materials to help students learn new concepts independently. In addition, new coding environments (Replit and Netxblox) were implemented to support remote collaborative programming and to run on Chromebooks that some schools had provided their students to use at home. These tools continued to be used in the 2021-22 school year, especially the coding environments that eliminated the need for a dedicated computer lab that was a barrier, especially in high-needs schools, to offering computer science courses.

B. Teachers' Reflections on Adjusting to COVID-19

During the focus groups, the interviewer regularly probed for differences across the three years in the CSforAll professional develop activities and implementation of the computer science curriculum. Not surprisingly, those teachers who were participating in the project before and during COVID often reflected on pandemic-related disruptions that not only included multiple shifts to remote instruction but also temporary layoffs and leadership changes. In this section, two common themes related to implementation of CS110 and DCS during or following COVID-19 are highlighted.

Transition to online course delivery was easy

Teachers commented that the transition to online delivery of the CSforAll courses was easy. As one teacher described the process, "*There really was very little bump in the road for the college course while we were hybrid*." They identified the Replit software as a key factor because, as noted on page 24, the coding platform allowed students and teachers to interact with and

share materials online. Hence, they reported, students continued interacting in ways that they had previously even though not in the same room or building with each other.

A second key factor was that the course materials, including rubrics, directions, and activities, supported students' independent learning. One teacher highlighted that the new curriculum materials helped address students' waning focus:

> *After two years of the COVID scheduling, their attention span went to mush. So, this was a chance to, like, say … 'whether it takes you 20 minutes or 30, this Is your goal today.'*

Adjustments offer enduring benefits

Focus group discussion illuminated that adjustments made in response to COVID-19 offer enduring benefits in three important ways. First, the adoption of one-to-one computers for kids and online learning platforms, like Replit, has reduced demand for computer lab space, thereby alleviating a source of scheduling problem that prevent students from enrolling in computer science courses. Second, online tools facilitate collaboration and make sharing easier for in-person classes, too. Teachers commented that they can project shared materials in the classroom to discuss and work through difficulties, as well as showcase accomplishments. They can also review and provide feedback outside of the established class space and time. Finally, teachers reported that course materials redesigned for independent learning foster transferable skills (see page 26), such as the use of directions and self-management.

C. Differences in Students' Perceptions of CSforAll Courses.

Each year, the post-course survey included items asking students for their perceptions of their CSforAll course and teacher. They were asked to indicate their level of agreement on a five-point scale (i.e., 1 = "strongly disagree" to 5 = "strongly agree") to questions such as "*I would recommend this class to fellow students*" and "*The teacher for this class presented material at a level that I could understand*." Table 8 shows students' average responses for each year both overall and for each course, with statistically significant differences from 2020-21 for either 2019-20 or 21-22 indicated. This analysis used the "merged sample" containing all valid responses for a given year regardless of whether they could be matched to a pre-course survey.

Like trends described in Section 2D (page 16), students' responses indicated generally positive feelings about their CSforAll courses in all years. As before, students tended to less strongly agree that "*I found this class to be challenging*" and "*This class increased my interest in computer science*" compared to the other statements but were well above "neither agree/disagree" (3). Differences in average responses between 2019-20 and 2020-21 were not statistically significant (i.e., could be due to random fluctuations in responses). Students' responses to three items – "*I found this class to be interesting*, *I would recommend this class to fellow students*," and "*Overall, I was satisfied with my experience in this class"* – indicated an average decline in the strength of agreement between 2020-21 and 2021-22. However, when examined separately, no statistically significant differences between years were found for either CS110 or DCS. These latter findings suggest that the overall differences may be due to

the disproportionate increase in respondents from DCS compared to CS110 (52 and 9 additional students respectively) in the last year rather than environmental factors such as COVID-19.

Table 8: Differences in Perception of Course and Teacher by CSforAll Course across Years (merged sample)

		All				CS110				DCS			
Please rate your level of agreement with the following statements (Q36 & Q30).		2019-20	2020-21	2021-22	Sig	2019-20	2020-21	2021-22	Sig	2019-20	2020-21	2021-22	Sig
I found this class to be interesting.	Mean	4.13	**4.21**	*4.03*	*	4.17	4.41	4.31		4.06	4.06	3.85	
	Std. Dev.	1.070	0.873	1.056		1.047	0.709	0.875		1.107	0.954	1.122	
I found this class to be challenging.	Mean	3.63	3.78	3.58		3.50	3.82	3.52		3.82	3.75	3.63	
	Std. Dev.	1.208	1.021	1.201		1.275	0.949	1.227		1.086	1.073	1.184	
I would recommend this class to fellow students.	Mean	4.02	**4.04**	*3.84*	*	4.07	4.23	4.06		3.94	3.90	3.70	
	Std. Dev.	1.008	0.895	1.045		0.968	0.758	0.970		1.068	0.966	1.069	
This class increased my interest in computer science.	Mean	3.85	3.85	3.76		3.89	4.01	3.99		3.79	3.73	3.61	
	Std. Dev.	1.175	1.106	1.180		1.182	1.000	1.078		1.170	1.169	1.220	
I felt my opinions were valued in this class.	Mean	4.04	4.04	3.88		4.14	4.19	4.11		3.89	3.92	3.73	
	Std. Dev.	0.961	0.791	0.953		0.970	0.700	0.912		0.934	0.836	0.952	
I felt comfortable asking questions in this class.	Mean	4.22	4.14	4.07		4.28	4.25	4.28		4.13	4.06	3.94	
	Std. Dev.	0.903	0.834	0.970		0.875	0.735	0.915		0.940	0.895	0.982	
Overall, I was satisfied with my experience in this class.	Mean	4.17	**4.30**	*4.12*	*	4.23	4.46	4.34		4.07	4.18	3.98	
	Std. Dev.	1.073	0.841	1.024		1.026	0.735	0.912		1.138	0.895	1.068	
The teacher for this class…													
displayed an interest in student learning.	Mean	4.58	**4.44**	*4.28*	*	4.62	4.66	4.54		*4.51*	**4.27**	4.11	*
	Std. Dev.	0.675	0.723	0.923		0.715	0.522	0.742		0.611	0.806	0.989	
encouraged my participation in the class.	Mean	*4.58*	**4.40**	4.32	*	4.59	4.59	4.52		*4.57*	**4.26**	4.18	**
	Std. Dev.	0.709	0.733	0.879		0.758	0.619	0.761		0.630	0.780	0.925	
made sure students understood the material	Mean	4.28	**4.33**	*4.13*	*	4.26	4.48	4.45		4.32	**4.22**	*3.92*	**
	Std. Dev.	0.976	0.785	1.009		1.061	0.636	0.840		0.837	0.866	1.055	
presented material at a level that I could understand.	Mean	4.34	4.33	4.22		4.40	4.57	4.52		4.24	4.14	4.03	
	Std. Dev.	0.944	0.824	0.955		0.961	0.656	0.780		0.916	0.891	1.009	
was knowledgeable about the subject matter of this class.	Mean	4.44	**4.47**	*4.32*	*	4.39	4.58	4.52		4.51	4.38	4.18	
	Std. Dev.	0.832	0.698	0.891		0.918	0.618	0.682		0.680	0.742	0.983	
was well organized.	Mean	4.40	**4.40**	*4.14*	**	4.50	4.48	4.38		4.26	**4.34**	*3.99*	**
	Std. Dev.	0.779	0.756	1.009		0.791	0.756	0.815		0.745	0.751	1.093	
was enthusiastic about the subject matter of this class.	Mean	4.58	4.48	4.38		4.67	4.68	4.65		4.43	4.33	4.19	
	Std. Dev.	0.701	0.707	0.896		0.730	0.499	0.697		0.630	0.801	0.964	
made me feel welcomed in this class.	Mean	4.64	**4.54**	*4.37*	*	4.66	4.67	4.63		4.60	**4.45**	*4.20*	*
	Std. Dev.	0.701	0.712	0.935		0.735	0.601	0.701		0.650	0.773	1.026	
* p < .05, ** p < .01, *** p < .001													
Italic -- comparison with 2020-21 was statistically significant.													

Students' responses also indicated strongly positive feelings about their teachers in all years and for both courses. Average responses to only one item – "*Encouraged my participation in the class"* – showed a statistically significant decrease from 2019-20 to 2020-21 overall and for DCS. Responses from CS110 students were not statistically significantly different between any of the three years, in which the means for all teacher-related items close to "strongly agree" (5). Responses for DCS students also indicated a slight decline in the strength of agreement

that their teacher "*displayed an interest in student learning*" between these two years but still clearly remained in the "agree" (4) range. More differences in average responses were found between 2020-21 and 2021-22, with overall differences again reflecting changes for DCS and not for CS110. Changes in responses to items such as "*Made sure students understood the material before proceeding to the next lesson*" and "*Was well organized*" may reflect the increase in new DCS teachers in the final year of the project. These trends also suggest that differences in students' perceptions of their teachers across years was probably not related to COVID-19. While not explored for this reports, the differences could be due to expansion of DCS with less experienced teachers offering the course in more challenging school environments.

Appendix A: CSforAll Pre-course Student Survey

HS Student Pre-Course Survey NSF:CSforAll - Y20-21

Start of Block: Block 3

Q20 Computer Science Student Start of School Year Questionnaire - Bethlehem Introduction to CS with Python and Multimedia

As you may be aware, your school is collaborating with Siena College and other upstate New York high schools on a two year project to increase the number and diversity of high school students taking computer science classes. This effort is supported through a grant provided by the National Science Foundation. As part of the project, the Siena project team has developed a survey to help us gauge student perceptions of computer science. This survey should take you about 10 minutes to complete. We greatly value your honesty in responding to our questions, which have no right or wrong answers. Your participation is voluntary and you have the right to not answer questions at any point during the survey. Please be assured that your responses are anonymous and will be kept completely confidential. No identifying information such as your name will be collected and only the Siena team led by Dr. Robin Flatland, Professor in Computer Science, will have access to your individual responses. When preparing reports on the project, the Siena team will combine your responses with those from others so that responses cannot be attributed to any particular person. The data we collect will help us improve computer science education in New York high schools. If you have any questions or concerns, please email Dr. Robin Flatland at flatland@siena.edu. The IRB approval for this project is #06-19-04 R2.

This section of the survey is being used to create an anonymous ID that will allow us to match pre- and post-course surveys.

Q1 What day of the month were you born? For example, if your birthday is December 18th, select 18.

day of the month you were born: (1)

▼ 1 (1) ... 31 (31)

Q2 What is the third letter of your middle name? For example, if it is Mary, select "r." If you have no middle name, do not answer this question.

third letter of middle name: (1)

▼ a (1) ... z (26)

Q19 How many siblings, living or deceased, did you have on September 1st of this academic year?

number of siblings: (1)

▼ 0 (1) ... 9 (10)

Q3 What is the last digit of your cell phone number? If you don't have a cell phone, enter the last digit of your home phone number.

last digit phone number: (1)

▼ 0 (1) ... 9 (10)

Q20 How many pets did you have on September 1st of this academic year? Only count dogs, cats, and birds.

dogs, cats, and birds: (1)

▼ 0 (1) ... 9 (10)

End of Block: Block 3

Start of Block: Default Question Block

Demographic Information

Q5 What is your gender?

- ○ Female (1)
- ○ Male (2)
- ○ Other (3)
- ○ Prefer not to state (4)

Q6 What is your race? Select all that apply.

- ☐ American Indian/Alaska Native (1)
- ☐ Asian (2)
- ☐ Black/African American (3)
- ☐ Hawaiian Native/Pacific Islander (4)
- ☐ White (5)
- ☐ Multiracial (6)
- ☐ Prefer not to state (7)

Q7 Are you Hispanic or Latino?

- ○ Yes (2)
- ○ No (1)
- ○ Prefer not to state (3)

Q8 In what grade are you currently enrolled?

- ○ 9th (1)
- ○ 10th (2)
- ○ 11th (3)
- ○ 12th (4)

Q9 In what range is your overall high school G.P.A.?

- ○ 90-100 (A) (1)
- ○ 80-89 (B) (2)
- ○ 70-79 (C) (3)
- ○ 60-69 (D) (4)
- ○ Less than 60 (F) (5)

Q20 Which of the following CS courses are you taking this year?

- ☐ Discovering Computer Science (1)
- ☐ Introduction to Computer Science with Python and Multimedia (2)
- ☐ Introduction to Software Development (with Java) (3)
- ☐ Other (4) _____

Q24 Which of the following classes have you taken prior to this academic year? Check all that you have taken.

- ☐ Algebra I (1)
- ☐ Geometry (2)
- ☐ Algebra II (3)
- ☐ Pre-calculus (4)
- ☐ Calculus (5)
- ☐ Statistics (12)
- ☐ Biology (6)
- ☐ Anatomy/Physiology (7)
- ☐ Chemistry (8)
- ☐ Computer Science (9)
- ☐ Earth Science (10)
- ☐ Physics (11)

Q11 How many hours do you spend on a computer in a typical week:

	0-4 (1)	5-9 (2)	10-14 (3)	15-19 (4)	20-24 (5)	25+ (6)
non-school related activities (1)	○	○	○	○	○	○
school-related activities (2)	○	○	○	○	○	○

Q12 Please rate your computer skills on the following scale:

	Very Poor (1)	Poor (2)	Fair (3)	Good (4)	Very Good (5)
Gaming skills (1)	○	○	○	○	○
Programming skills (2)	○	○	○	○	○
Using Office applications like Excel and PowerPoint (3)	○	○	○	○	○

End of Block: Default Question Block

Start of Block: first half of agree/disagree questions

Q13 Please rate your level of agreement with the following statements.

	Strongly Disagree (1)	Disagree (2)	Neither Agree nor Disagree (3)	Agree (4)	Strongly Agree (5)
I see examples of how computer science applies to my everyday life. (1)	○	○	○	○	○
I am a sophisticated computer user. (2)	○	○	○	○	○
I am able to solve basic problems through computer programming. (3)	○	○	○	○	○
I am aware of career opportunities in computer science. (4)	○	○	○	○	○
I am considering a career path in computer science. (5)	○	○	○	○	○
I am considering a college major related to computer science. (6)	○	○	○	○	○
I am considering taking additional courses in computer science (7)	○	○	○	○	○
I am good at math. (8)	○	○	○	○	○
I am good at science. (9)	○	○	○	○	○
I am good at using technology. (10)	○	○	○	○	○

Q21 Please rate your level of agreement with the following statements.

	Strongly Disagree (1)	Disagree (2)	Neither Agree nor Disagree (3)	Agree (4)	Strongly Agree (5)
I can explain what computer science is to my friends. (11)	○	○	○	○	○
I can learn new technology easily. (12)	○	○	○	○	○
I enjoy learning to use new technology. (14)	○	○	○	○	○
I enjoy solving problems. (15)	○	○	○	○	○
I have a basic understanding of the discipline of computer science. (16)	○	○	○	○	○
I have good problem solving skills. (17)	○	○	○	○	○
I like solving problems utilizing technology. (18)	○	○	○	○	○
I will need to utilize my computer programming skills for my future job. (20)	○	○	○	○	○
I will need to utilize technology for my future job. (21)	○	○	○	○	○

End of Block: first half of agree/disagree questions

Start of Block: second half of agree/disagree questions

Q27 Please rate your level of agreement with the following statements.

	Strongly Disagree (1)	Disagree (2)	Neither Agree nor Disagree (3)	Agree (4)	Strongly Agree (5)
My family encourages my interest in technology. (22)	○	○	○	○	○
My previous teachers encouraged my interest in technology. (25)	○	○	○	○	○
Computer science is interesting to me. (27)	○	○	○	○	○
Math is interesting to me. (28)	○	○	○	○	○
Science is interesting to me. (29)	○	○	○	○	○
Technology is interesting to me. (30)	○	○	○	○	○
Computer science can be used to solve problems facing society. (26)	○	○	○	○	○
I know a lot of students like me who are interested in computer science. (24)	○	○	○	○	○
I have role models in computer science who are women. (23)	○	○	○	○	○
I have role models in computer science who are people of color. (19)	○	○	○	○	○
I feel I am a part of a community of students who are interested in computer science. (32)	○	○	○	○	○
I feel comfortable leading, planning, and decision making when working with my peers. (13)	○	○	○	○	○
I believe my leadership skills are strong. (31)	○	○	○	○	○

Q28 What are your reasons for taking this course? Select all that apply and/or enter other reasons.

- ☐ I chose to take it (4)
- ☐ a teacher encouraged me to take it (1)
- ☐ a counselor encouraged me to take it (2)
- ☐ my parents encouraged me to take it (3)
- ☐ my friends encouraged me to take it (6)
- ☐ it is required (5)
- ☐ I did not choose to take it, but I was put into it anyway (7)
- ☐ Other: (8) _____

End of Block: second half of agree/disagree questions

Appendix B: CSforAll Post-course Student Survey

HS Student Post-Course Survey NSF:CSforAll - Y20-21

Start of Block: Block 4

Q20 Computer Science Student End of School Year Questionnaire - Bethlehem CSIS110
As you may be aware, your school is collaborating with Siena College and other upstate New York high schools on a two year project to increase the number and diversity of high school students taking computer science classes. This effort is supported through a grant provided by the National Science Foundation. As part of the project, the Siena project team has developed a survey to help us gauge student perceptions of computer science. This survey should take you about 10 minutes to complete. We greatly value your honesty in responding to our questions, which have no right or wrong answers. Your participation is voluntary and you have the right to not answer questions at any point during the survey. Please be assured that your responses are anonymous and will be kept completely confidential. No identifying information such as your name will be collected and only the Siena team led by Dr. Robin Flatland, Professor in Computer Science, will have access to your individual responses. When preparing reports on the project, the Siena team will combine your responses with those from others so that responses cannot be attributed to any particular person. The data we collect will help us improve computer science education in New York high schools. If you have any questions or concerns, please email Dr. Robin Flatland at flatland@siena.edu. The IRB approval for this project is #06-19-04 R2.
Click below to start the survey.

End of Block: Block 4

Start of Block: Block 3

This section of the survey is being used to establish an anonymous ID that will allow us to match pre- and post-course surveys.

Q1 What day of the month were you born? For example, if your birthday is December 18th, select 18.

day of the month you were born: (1)

▼ 1 (1) ... 31 (31)

Q2 What is the third letter of your middle name? For example, if it is Mary, select "r." If you have no middle name, do not answer this question.

third letter of middle name: (1)

▼ a (1) ... z (26)

Q19 How many siblings, living or deceased, did you have on September 1st of this academic year?

number of siblings: (1)

▼ 0 (1) ... 9 (10)

Q3 What is the last digit of your cell phone number? If you don't have a cell phone, enter the last digit of your home phone number.

last digit phone number: (1)

▼ 0 (1) ... 9 (10)

Q20 How many pets did you have on September 1st of this academic year? Only count dogs, cats, and birds.

dogs, cats, and birds: (1)

▼ 0 (1) ... 9 (10)

End of Block: Block 3

Start of Block: first half of agree/disagree questions

Q37 Which of the following computer science courses are you taking this year?

- ☐ Discovering Computer Science (1)
- ☐ Introduction to CS with Python and Multimedia (2)
- ☐ Introduction to Software Development (with Java) (3)
- ☐ Other (4) _____

Q13 Please rate your level of agreement with the following statements.

	Strongly Disagree (1)	Disagree (2)	Neither Agree nor Disagree (3)	Agree (4)	Strongly Agree (5)
I see examples of how computer science applies to my everyday life. (1)	○	○	○	○	○
I am a sophisticated computer user. (2)	○	○	○	○	○
I am able to solve basic problems through computer programming. (3)	○	○	○	○	○
I am aware of career opportunities in computer science. (4)	○	○	○	○	○
I am considering a career path in computer science. (5)	○	○	○	○	○
I am considering a college major related to computer science. (6)	○	○	○	○	○
I am considering taking additional courses in computer science (7)	○	○	○	○	○
I am good at using technology. (10)	○	○	○	○	○

Q35 Please rate your level of agreement with the following statements.

	Strongly Disagree (1)	Disagree (2)	Neither Agree nor Disagree (3)	Agree (4)	Strongly Agree (5)
I can explain what computer science is to my friends. (11)	○	○	○	○	○
I can learn new technology easily. (12)	○	○	○	○	○
I enjoy learning to use new technology. (14)	○	○	○	○	○
I enjoy solving problems. (15)	○	○	○	○	○
I have a basic understanding of the discipline of computer science. (16)	○	○	○	○	○
I have good problem solving skills. (17)	○	○	○	○	○
I like solving problems utilizing technology. (18)	○	○	○	○	○
I will need to utilize my computer programming skills for my future job. (20)	○	○	○	○	○
I will need to utilize technology for my future job. (21)	○	○	○	○	○
I believe my leadership skills are strong. (34)	○	○	○	○	○

End of Block: first half of agree/disagree questions

Start of Block: second half of agree/disagree questions

Q27 Please rate your level of agreement with the following statements.

	Strongly Disagree (1)	Disagree (2)	Neither Agree nor Disagree (3)	Agree (4)	Strongly Agree (5)
Computer science is interesting to me. (27)	○	○	○	○	○
Technology is interesting to me. (30)	○	○	○	○	○
Computer science can be used to solve problems facing society. (26)	○	○	○	○	○
I know a lot of students like me who are interested in computer science. (24)	○	○	○	○	○
I have role models in computer science who are women. (23)	○	○	○	○	○
I have role models in computer science who are people of color. (19)	○	○	○	○	○
I feel I am a part of a community of students who are interested in computer science. (32)	○	○	○	○	○
When working with my lab partner(s), I feel comfortable taking the lead on how we are going to solve a problem. (13)	○	○	○	○	○

Q36 Please rate your level of agreement with the following statements.

	Strongly Disagree (1)	Disagree (2)	Neither Agree nor Disagree (3)	Agree (4)	Strongly Agree (5)
I found this class to be interesting. (29)	○	○	○	○	○
I found this class to be challenging. (28)	○	○	○	○	○
I would recommend this class to fellow students. (25)	○	○	○	○	○
This class increased my interest in computer science. (34)	○	○	○	○	○
I felt my opinions were valued in this class. (36)	○	○	○	○	○
I felt comfortable asking questions in this class. (38)	○	○	○	○	○
Overall, I was satisfied with my experience in this class. (22)	○	○	○	○	○

End of Block: second half of agree/disagree questions

Start of Block: course instructor

Q30 The teacher for this class...

	Strongly Disagree (1)	Disagree (2)	Neither Agree nor Disagree (3)	Agree (4)	Strongly Agree (5)
displayed an interest in student learning. (27)	○	○	○	○	○
encouraged my participation in the class. (24)	○	○	○	○	○
made sure students understood the material before proceeding to the next lesson. (23)	○	○	○	○	○
presented material at a level that I could understand. (19)	○	○	○	○	○
was knowledgeable about the subject matter of this class. (32)	○	○	○	○	○
was well organized. (30)	○	○	○	○	○
was enthusiastic about the subject matter of this class. (13)	○	○	○	○	○
made me feel welcomed in this class. (31)	○	○	○	○	○

Q38 On average, how many hours per week did you spend doing work for this course outside of class?

- 0-2 hours (1)
- 3-5 hours (2)
- 6-8 hours (3)
- 9-11 hours (4)
- 12+ hours (5)

Q30 What grade do you expect to get in this course?

- 90-100 (A) (1)
- 80-89 (B) (2)
- 70-79 (C) (3)
- 60-69 (D) (4)
- Less than 60 (F) (5)

Q29 What is your gender?

- Female (1)
- Male (2)
- Other (3)
- Prefer not to state (4)

Q39 In what grade are you currently enrolled?

- 9th (1)
- 10th (2)
- 11th (3)
- 12th (4)

Q31 What were the best aspects of this class?

_____

_____

_____

_____

_____

Q33 What about this class could be improved?

_____

_____

_____

_____

_____

Q34 Do you have any additional comments that you would like to make?

_____

_____

_____

_____

_____

End of Block: course instructor

Appendix C: Teacher Focus Group Protocols.

Teacher Focus Group Protocol Structure & Questions

Two interview protocols: 1) CSforAll Research Practice Partnership (RPP) participants, and 2) Teachers of Discovering Computer Science (DCS) & Dual-enrollment CS (CSIS110)

1) CSforAll Research-Practice Partnership Participants:

- Review of informed consent document and procedures.
    - The interview questions are structured to explore three stages of the project: 1) How the RPP was formed, 2) How the RPP operated and your role in it, and 3) What were the results of the partnership.
- Part 1: Becoming involved in CSforAll RPP.
    - How did you become involved in CSforAll? Probes: Why did your school become involved? What were the reasons for offering CS course? How did you start teaching CS courses?
    - What did you expect involvement in CSforAll RPP to be like? Probes: What prior relationships with Siena partners did you have? Have you been involved in other RPPs?
- Part 2: Implementing CSforAll in your school.
    - How do you describe your role in implementing CSforAll at your school? Probes: In what ways were you involved in the following: planning course offerings and scheduling, obtaining technological resources, recruiting and supporting teachers, and developing strategies for recruiting diverse students?
    - What interactions have you had with the CSforAll developers around implementing CS in your school? Probes: In what ways were you involved in the following: developing the CS materials, designing student recruitment strategies, planning professional development activities, and obtaining assistance for teachers?
    - What interactions did you have with other CSforAll teachers during the school year? Probes: Were they able to share experiences using CSforAll materials? In what ways were they able to learn from each other?
    - What impact has participating in CSforAll had on your school? Probes: To what extent have approaches to teaching CS or other subjects changed? What changes in students' interest in CS, particularly among under-represented groups?

- Part 3: Impact of participating in the CSforAll Research-Practice Partnership.
    - What impact has participation in CSforAll RPP had on you? Probes: How have your skills or comfort as a leader changed? What sort of analytical skills have you gained and how might you use them in the future? What plans do you have for continued professional growth (e.g., seeking additional certifications or degrees)?
    - In what ways did you participate in CSforAll research? Probes: What did you learn from activities such as the following: Collecting data (e.g., enrollment trends and student interviews), analyzing data, preparing reports or publications, and presenting or co-presenting at conferences.
    - Based on your experience with CSforAll, what recommendations do you have concerning research-practice partnerships? Probes: What are the challenges? What works? What doesn't work? What are the benefits? What types of RPPs might the school participate in the future?
- Part 4: Conclusion
    - Do you have any other comments about your experience with CSforAll?

2) Teachers of Discovering Computer Science (DCS) or Dual-enrollment CS (CSIS110).

- Review of informed consent document and procedures.
    - The interview questions are structured to explore three stages of your involvement in CSforAll: 1) How you became involved in teaching CS; 2) Your experiences teaching CS; and 3) The impact of CS on your students, yourself, and your school.
- Part 1: Becoming involved in CSforAll.
    - How did you come to teach DCS/CSIS110 – volunteered or assigned?
    - What did you expect teaching the course would be like? Probes: How prepared did you feel to teach DCS/CSIS110? What instructional supports did you expect from CSforAll developers?
    - What students did you expect to have in your DCS/CSIS110 classes? Probes: What was the process for them to be enrolled – assigned vs recruited? What efforts were made to increase participation from under-represented groups?
- Part 2: Implementing CSforAll.
    - What supports or resources did you receive from your school to prepare for offering DCS/CSIS110? Probes: What technological resources were needed and

how were they obtained? What curriculum and instructional resources – including planning time – were needed and how were they obtained?

- What supports did you receive from CSforAll developers to teach CS courses? Probes: What did you expect to experience at the workshops? What did you value? What did you need? What materials (e.g., diversity unit) or strategies did you use in your DCS/CSIS110 lessons?
- How did your students engage in learning during your lessons? Probes: Did students appear to differ in what they found interesting or engaging? Which students struggled to relate to the materials or lessons? Did you notice differences in engagement or connecting to the material by gender, race, or any other background characteristics? If so, describe.
- In what ways did you try to use or adapt the materials to engage all students? Probes: DCS ask about "CS in the news" and/or "diversity in CS"; CSIS110 ask about open-ended programming projects encouraging student creativity. What did you learn from how students responded to these efforts?
- What interactions did you have with other CSforAll teachers and developers during the school year? Probes: How were those interactions initiated? What kinds of topics came up in those interactions? Did you share your experiences teaching DCS/CSIS110? Did other teachers share their experiences?

- Part 3: Results of CSforAll:
  - What did your students learn from your DCS/CSIS110 course? Probes: How well did they master the skills and topics? How did their interest in CS change? What differences between students did you observe? How many do you expect will take additional CS courses and/or consider it as a career?
  - In what ways has your teaching of other courses and subjects changed? Probes: Have you tried similar pedagogical approaches in other courses? In what ways have your interactions with students, especially those from under-represented groups, in other courses changed?
  - What are your expectations about teaching CS courses in the future? Probes: What changes would you make to the DCS/CSIS110 course? Do you plan to pursue CS certification? What would you tell other teachers about teaching CS?
  - In what ways will you continue interacting with CSforAll teachers and developers? Probes: What would you hope to get out of those interactions? Will you participate in future research-practice partnerships?
- Part 4: Conclusion
  - Do you have any other comments about your experience with CSforAll?