Creating Apps for Community and Social Good: Preliminary Learning Outcomes from a Middle School Computer Science Curriculum

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This study examined student learning outcomes from a middle school computer science (CS) curriculum developed through a researcher and practitioner partnership (RPP) project. The curriculum is based on students creating mobile apps that serve community and social good. We collected two sets of data from 294 students in three urban districts: (1) pre- and post-survey responses on their learning experiences and attitudes toward learning CS and creating community-serving apps; (2) the apps created by those students. The analysis of student apps indicated that students were able to create basic apps that connected with their personal interests, life experiences, school community, and the larger society. Students were significantly more confident in coding and creating community-focused apps after completing the course, regardless of gender, race/ethnicity, and grade. However, their interest in solving coding problems and continuing to learn CS decreased afterward. Analyses of students' attitudes by gender, grade, and race/ethnicity showed significant differences among students in some groups. Seventh-grade students rated more positive on their attitudes than eighth graders. Students identifying with different race/ethnicity groups indicated significantly different attitudes, especially students identifying as Southeast Asian, Black/African American, and Hispanic/Latino. Self-identified male students also reported stronger interest and more positive attitudes overall than self-identified female students. Students also reported positive experiences in learning how to create real apps serving their community, while there were disparities in their experiences with coding in general and some of the instructional tools used in the class.

CCS Concepts: • **Social and professional topics** → **Professional topics**; **Computing education**; **K-12 education**;

Additional Key Words and Phrases: Middle school students, Apps, Community, Culturally responsive pedagogy, Attitudes

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1 INTRODUCTION

Computer science (CS) education is becoming increasingly important as technology continues to shape the way we live and work. However, there is still a significant gap in access to CS education by gender, race, ethnicity, socioeconomic status, and geography [19]. For example, students from historically underrepresented race and ethnicity groups (Black/African American, Hispanic/Latina/Latino/Latinx, and Native American/Alaskan students) continue to be less likely to attend a school that offers CS. Hispanic/Latina/Latino/Latinx high school students are 1.5 times less likely than their white and Asian peers to enroll in foundational CS, even when they attend a school that offers it [5]. In addition to the disparities in student experience by race and/or ethnicity, female students' participation in CS remains significantly lower than male students in both school as well as in the workforce [38]. Girls' participation in an **Advanced Placement (AP)** CS exam only accounted for 30.6% of total AP CS exam-takers in 2021. Girls of Grade 7–12 are less likely to be encouraged to pursue CS-related careers, and they are also less willing to work in a CS career [14]. Closing these gaps is critical to ensure that all students have access to the skills and knowledge they need to succeed in today's increasingly digital world.

The CS Pathways project is a **researcher and practitioner partnership (RPP)** [34] collaboration among the University of Massachusetts Lowell, the University at Albany, and three urban school districts in MA (Lowell and Methuen) and NY (Schenectady). All three districts have substantial populations of students who are underrepresented in **science, technology, engineering, and mathematics (STEM)** fields, including CS [36]. The project is aimed to establish inclusive and sustainable middle school **CS and digital literacy (CSDL)** programs that serve all students. To achieve this project goal, we need a curriculum that can engage all middle school students in our partner districts. **Culturally responsive pedagogy (CRP)** advocates use cultural awareness, prior knowledge and experience, and cultural expressions to make learning more relevant and equitable to culturally diverse students [13, 25]. In 2021, the project re-designed its curriculum through a collaborative team of teacher leaders, district leads, and researchers attempting to integrate culturally relevant pedagogical practices [31] into its curriculum units [37]. It is an approximately 18-hour curriculum focused on students developing mobile apps that are culturally responsive or can serve their communities, using App Lab from Code.org. More information about the project curriculum will be introduced in Section 2. By establishing the CS curriculum in required courses, the project aims to engage all of the districts' middle school students in learning CSDL.

This study explores the preliminary learning outcomes of students who learned the project curriculum in the past school year. We examined four research questions:

- RQ1: How did students' attitudes toward learning CS and creating apps for community and social good change before and after they learned the CS Pathways curriculum?
- RQ2: Did students' attitudes differ by grade, gender, and race/ethnicity before and after learning the curriculum?
- RQ3: What were the learning experiences reported by the students?
- RQ4: To what extent did students demonstrate their capability to create community-serving apps?

This article presents preliminary results on student learning experiences and outcomes regarding their attitudes and ability of creating apps that are connected to their life experience, culture, community, and the broader society.

2 BACKGROUND

2.1 Attitudes toward Learning CS

Prior research has investigated students' attitudes and learning experience in computing education across different gender and racial groups. First, in addition to the low participation of female students, research has revealed differences among female students' attitudes and CS learning experiences in comparison with their male peers. Starting as early as from elementary schools, female students showed lower levels of perceived competence, interest, and sense of belongings in CS than male students [19, 22, 49]. For example, through a survey with 559 students, Duncan and Bell found that girls tended to underestimate their achievement in computing [6]. Girls were observed taking longer time to comprehend a concept and struggled with certain activities when learning computational thinking. Those girls seemingly "lagged behind"; however, it was not because they did not understand but they needed more encouragement and being perfectionist on the activities. Another study examined elementary students' computational thinking skills and their self-efficacy development through partial pair-programming activities [51]. The result indicated that girls had no increase in their programming self-efficacy in either girl–boy or girl–girl paired group. Further qualitative analysis reviewed that girls were more likely to give up without assistance. Yadav et al. [52] also found gender differences in middle school students' perceptions and attitude toward programming. Male students presented significantly higher interest and were more excited in programming than female students. Given the influence of interest in computing on students' career choices [48], the authors recommended addressing gender differences in computing early on.

Second, prior work has also investigated students' attitudes and computing learning experience by race and/or ethnicity. Garcia et al. [12] investigated Latinx elementary students' coding attitudes and their critical thinking skills developed through a year-long computing curriculum. This study analyzed 24 demographic variables and 5 coding-related attitudes (confidence, interest, utility, perception, and social influence) to understand what predicted students' performance. The results showed that students' coding confidence was the only statistically significant predictor of their performance. In another study, Robinson et al. [42] studied the interest and participation of African American middle school girls in CS after they completed a 5 day CS workshop. This study found that African American female students' attitudes toward CS were negative when entering the program. However, many students who voiced a negative perception earlier became either interested in learning more or developed a positive perception after the workshop. In addition, participants showed better ability to connect CS to real-world situations, consider CS career options, and complete CS work on their own. Importantly, students from less-privileged backgrounds actually showed the most improvement in their interest and attitudes toward CS. At the high school level, Escobar et al. [9] developed a peer-learning community program to prepare African American female students for the AP CS Principles exam. The community used culturally responsive and project-based learning pedagogy to connect students' personal lives and career goals with computing concepts. The results showed a positive impact on the students' AP exam performance and self-efficacy in learning CS. In particular, the authors found that the program increased students' willingness and awareness of pursuing a career in CS career as African American females.

A growing body of research advocates for teaching CS to students at an early age, before they reach the "middle school cliff" [23, 43]. Middle school age is a crucial stage where teachers observe a dramatic drop in students' interest in CS [4]. In this study, we investigated the learning experiences and attitudes of participating middle school students, including their confidence and interest in (learning) coding and app creations, pursuing computing related jobs, as well as making apps that connect with their interest, life experiences, culture, and serve their community. We analyzed differences and similarities based on gender, race/ethnicity, and grade, using a pre/post design (before and after they completed the project's CS curriculum).

2.2 Integrating Culturally Relevant Pedagogical Practices

The education research community has dedicated many efforts to increasing access and providing meaningful participation of students of all socio-cultural backgrounds, including races, ethnicities, and genders, in STEM education [28], with frameworks from culturally relevant pedagogy [25] to CRP [13] and culturally sustaining pedagogy [39]. Culturally relevant pedagogy or CRP aims to facilitate and support all students' learning through learner-centered contexts and utilizing students' cultural backgrounds and experiences as cultural assets [41]. **Culturally responsive computing (CRC)** education applies the long-standing CRP framework directly to CS education. CRC programs recognize the mission of CRP by engaging students in and empowering them through computing education [7, 18, 27]. Students' lived experiences, connections to real-world contexts, students' self-identity and their community are all important assets that can enhance students' interest and engagement in computing [33]. For example, Khan and Luxton-Reilly [21] reviewed research on the impact of socially relevant examples and topics in changing female students' stereotypical views of CS and increasing their participation in computing. Inclusion of social issues and professional practices in a social context can increase students' career awareness, challenge stereotypical thinking, and promote meaningful learning of computing by highlighting the real-world relevance [40]. Built upon CRP, CRC, and other related work, the Kapor Center recently developed a culturally responsive sustaining framework for K-12 CS education, which serves as a guide for CS educators to adopt CRP into their CS classrooms [20]. This framework aims to ensure access to CS education for students of all cultural and social backgrounds through raising teachers' awareness of cultural responsiveness, developing a rigorous culturally responsive and sustaining CS curriculum and embracing students' culture and prior life experiences.

To understand how cultural relevance, social justice, and equity were integrated in K–12 computing curricula, Leonard and Sentance [28] analyzed the design principles of 12 computing curricula, including Scratch and the Exploring CS courses. The authors identified several key focuses used to design culturally relevant or CRC curricula: (1) highlighting the relevance of computing by connecting learners to different careers and roles of computing in real life, encouraging them to become agents of change; (2) establishing learners' identities through intersectional lens, which allows learners to identify themselves through multiple identities; and (3) building on learners' culture and community knowledge. These principles are well-aligned with the three recommended culturally relevant pedagogical practices for teaching CS [31], which include (1) connecting with students' culture and life experience; (2) fostering relationships with students, families, and communities; and (3) empowering students to become change agents.

Our CS Pathways project does not specifically address social justice issues emphasized in the larger culturally responsive-sustaining CS education framework [20]. The project aims to provide an engaging and inclusive middle school CS curriculum for students in the three partner districts. The design of the project curriculum was informed by the three specific types of culturally relevant pedagogical practices [31]. Through the project's CSDL curriculum, students learn CS by creating "culturally responsive" or community-focused mobile apps, broadly speaking, that matter to themselves, their communities, and the larger society. Rooting the CSDL curriculum and pedagogy in the cultural experiences and the social identities of students allows them to engage and learn about CS in meaningful ways [37].

In this study, we explored students' attitudes toward learning and creating community-focused computing artifacts (mobile apps), and how they were able to connect their learning of coding and app creations with themselves, their families, and communities, and became empowered to be the change agency of their community.

2.3 Overview of the CS Pathways Curriculum and Implementation

The project curriculum is a product of collaborative design by the project researchers, teacher leaders, and administrators from the partner districts [37]. It is an approximately 18-hour CSDL curriculum consisting of five units. Each unit includes two to six modules. Unit 1 introduces the impact of computing and apps for social good. Unit 2 aims to help students make a first app in App Lab and research on their communities to introduce CS in a way that motivates students with various levels of CS experience and interest. In Unit 3, students explore careers in CS and further develop their problem solving and programming skills to be able to create an app independently. Unit 4 introduces more advanced CS concepts such as conditionals and functions as students work on more complex apps with multiple functions. In Unit 5, teachers organize an app showcase for students to present the apps they developed for community and social good.

The curriculum co-design process began with a team of six teachers collaborating with the research team in the summer of 2020 and formally continued through the school year 2020–2021. As participants in an iterative process, five of the six teachers also enacted the curriculum while co-designing to provide formative feedback to make adjustments. To organize and study the co-design process, all the project team members engaged in 12 bi-weekly group meetings, and selected researchers and co-designing teachers met bi-weekly to weekly for collaborative one-on-one meetings. These meetings facilitated consensus-building and mutual learning among teachers, administrators, and researchers within the RPP [10, 37]. The most recent iteration of the curriculum can be found at https://cspathways.org.

Teachers' collaborative work with the project researchers also afforded classroom visits by graduate and undergraduate researchers to support students and teachers in the classroom, as well as to share their experience with computing. These visits, along with the process of planning and debriefing visits, also supported the curriculum co-design process by providing informed feedback on the kinds of apps and CS concepts for which teachers and students required assistance. The teacher–researcher collaboration led to professional learning and classroom presentations of how to use App Lab's data collection features, as well as offering examples for the curriculum repository.

By the beginning of the project's third year—the year reported upon in this article—the project curriculum provided guidance and materials for teachers to support students' creation of community-serving/related apps. Specifically, the curriculum suggested and provided (1) framing activities for connecting app development to students' experience of community, (2) links to specific Code.org App Lab instructions and instructional sequences to support teaching and learning concepts useful for making community-related apps, and (3) avenues for connecting students to people who used CS in the real-world outside of the classroom [16]. Framing activities, such as developing a Vision Board, centered on student interests, life experiences, and consequently community connections as subjects for app development. Framing activities also included more subject area-oriented activities such as reporting on a specific topic (e.g., inventors) or wider community issues to fit with curriculum goals. CS concept-oriented units guided teachers to teach CS concepts that students could use to enhance their apps' appeal and functionality, which also included "unplugged units" and encouraged pair programming. Finally, the curriculum suggested and provided resources for teachers to solicit stories from computing professionals from outside of the classroom and with

Table 1. Project Curriculum Implementation Overview

School	# of Classes	# of Students	Grade	Subject
I-A	2	46	5	Computer
I-B	10	293	7 and 8	Computer
I-C	2	45	8	Civics
I-D	7	177	8	STEM
II-A	7	177	7 and 8	Civics, Science
II-B	4	83	8	Civics
III-A	6	127	7	Technology
Total	38	948		

diverse backgrounds. Resources included links to Code.org volunteers and the Amazon Future Engineers to engage in real time virtual visits, as well as videos of speakers representing diverse life experiences and backgrounds.

In total, nine teachers from seven middle schools piloted this curriculum after completing initial professional learning. Teachers continued their professional learning with ongoing support during the school year through monthly meetings, coaching from teacher leaders, and class visits from researchers and CS undergraduate students. Table 1 shows an overview of the curriculum implementation during the 2021–2022 school year.

While the curriculum is designed to align with state standards and organized units to introduce concepts in a progressive order, teachers had the autonomy to choose modules as suited in their classroom contexts. The rationale for this approach was to allow students and teachers to begin quickly *doing* CS, while also providing opportunities to leave the "shallow end" [17] of the CS education pool in future classes or future iterations of curriculum enactment. In teaching this course, teachers' instruction time varied ranging from 10 to 23 hours with different class schedules. All nine teachers began with Unit 1 introducing the impact of computing and apps for social good, followed with Unit 2 on introduction to App Lab. In Unit 3 and Unit 4, there was variation among teachers in their coverage of CS concepts: seven teachers introduced variables, five taught conditionals, and only two taught functions. Digital literacy skills, such as downloading and storing images and sound, were introduced in all classes. At the conclusion of the course, all teachers assigned students a final project to make an app for community and social good. Several teachers were able to provide additional opportunities for their students to make more than one app during the course. In total, the curriculum was implemented in 38 classes, reaching 948 students. The curriculum was offered to all students in these classes, regardless of parental consent status or students survey responses.

3 METHODS

3.1 Participants

Of the 948 participants, with parental consent, 449 students replied to the pre-survey (47%); 312 students replied to the post-survey (33%), resulting in 294 students completing both surveys (31%). Table 2 presents the demographics of the students who participated in the project and completed both surveys. Due to only having one student from Grade 6, this study focused on students from Grade 7 and Grade 8. Student race/ethnicity information was collected through the question of "What is your race/ethnicity?" on the pre-survey. Students were presented with 10 racial/ethnic categories including a write-in choice of "Other," from which they could choose all that applied. Responses marked as "Other" were carefully reviewed, re-coded, and categorized accordingly. These categories were developed to align with derivations and applications of race and ethnicity used by

Table 2. Surveyed Student Demographic Information

	Students (**N = 294**)	***n* (%)**
Gender	Male	143 (48.6%)
	Female	115 (39.1%)
	Non-binary	11 (3.7%)
	Do not wish to say	25 (8.5%)
Race/ethnicity	African	2 (0.7%)
	African American/Black	18 (6.1%)
	East Asian	7 (2.4%)
	Native Hawaiian or Pacific Islander	1 (0.3%)
	South Asian	6 (2.0%)
	Southeast Asian	71(24.1%)
	Alaska Native or Native American	3 (1.0%)
	Hispanic/Latino	50 (17%)
	White/Caucasian	69 (23.5%)
	Multiracial (two or more choices)	55 (18.7%)
	Not specified	12 (4.08%)
Grade	Grade 6	1 (0.3%)
	Grade 7	114 (38.8%)
	Grade 8	163 (55.4%)
	Not specified	16 (5.4%)

prior researchers studying the representation of United States population groups in computing fields [1–3, 46, 50]. Regional examples were also provided to clarify the categories. By combining the categories of race and ethnicity into race/ethnicity, we sought to allow students to determine how they identified their heritage as informed by their lived experiences.

3.2 Data Collection

This study collected two datasets to understand students' attitudes and learning experiences: (1) pre- and post-student survey responses; (2) the apps created by students who were enrolled in the project curriculum.

The pre- and post-student surveys collected data on three dimensions of student attitudes: confidence and interest in coding and in tasks to be facilitated by the program (e.g., creating apps), and perceptions on CRC focused on serving community and social good. These items were measured on a five-point Likert scale (1 = low or negative, 5 = high or positive). The majority of the survey items were adapted from previously validated instruments. The items assessing confidence and interest in coding were adapted from the confidence and interest constructs of the Elementary Student Coding Attitudes Survey [32]. Three new items were included to specifically refer to app design. Another additional item was adapted from the STEM Career Interest Survey [22] to measure interest in a job related to coding. The CRC items assessed the extent to which students feel (1) they understand and are interested in learning about their own culture and community; (2) they are interested in other students' cultures and can collaborate with others from different cultures; and (3) they can make apps connecting with their interests, life experiences, cultures and serving their community. These items were inspired by the **culturally responsive teaching (CRT)** Survey [29], which was designed to measure teachers' CRT self-efficacy and associated students' outcomes. Example items include "I feel comfortable describing my cultural background in this classroom," "I can make apps to share my culture with others," and "I can use my interests to make apps to help others."

The survey items underwent content validation through review by the project's external evaluator, teacher participants, and the whole research team. Before this study, the survey was piloted during the 2020–2021 school year, involving 51 students who completed both pre- and post-surveys. Teacher participants provided further feedback to the research team based on their students' comments during survey administration. Although multiple qualitative validations were conducted, we recognize the need for more rigorous quantitative validations, particularly in the form of construct validation, to strengthen the overall validity of the student attitude survey. The reliability of the survey items was checked using Cronbach's alpha. The results showed strong internal consistency of the three subscales: confidence (9 items, pre: $\alpha = 0.87$; post: $\alpha = 0.91$), interest (8 items, pre: $\alpha = 0.94$; post: $\alpha = 0.95$), and CRC perceptions (11 items, pre: $\alpha = 0.87$; post: $\alpha = 0.88$).

The post-survey also contained three open-ended questions to capture students' learning experiences. These open-ended questions included "What was your favorite part of this class?" "What was your least favorite part of this class?" "In this class, what did you learn about CS and making apps?" The open-ended questions provided students with the opportunity to express their thoughts about the course and elaborate on their responses and provide more detailed feedback.

Both pre- and post-student surveys were distributed through Qualtrics by the participating teachers during the first and last classes they taught the curriculum, respectively. Student apps were collected through their teachers. The apps were created either as final projects or as assignments while learning the course. In total, 92 apps were collected, including 24 apps from seventh grade and 68 from eighth grade.

3.3 Data Analysis

Student Attitude Analyses. To answer the first two research questions, we conducted three sets of analyses using the responses from the 294 students who answered both pre- and post-surveys. After removing responses with missing values, the sample sizes per construct were 245 (confidence), 247 (interest), and 250 (CRC), respectively.

First, descriptive statistics and paired sample t-tests were conducted to understand students' attitudes before and after they learned the curriculum (RQ1). These tests compared the mean differences in students' attitudes (confidence, interest, and CRC). The results provided us with an initial understanding of students' attitude changes. Second, we compared the attitudes among students of different gender, race/ethnicity, and grade level to answer the second research question (RQ2). One-way ANOVA tests were used to examine whether students' confidence, interest, and CRC perspectives differed significantly by gender and race/ethnicity. For grade comparison, unpaired sample t-tests were applied to examine the differences by grade (Grade 7 and Grade 8), excluding the Grade 6 data ($n = 1$). For those significant ANOVA test results, *post hoc* analyses with a Bonferroni adjustment were conducted for multivariate pairwise comparisons to identify the source of differences. Third, based on ANOVA and *post hoc* analysis results at the construct level, responses to specific items in selected construct(s) were analyzed to gain a further understanding of the differences. All the quantitative analyses were conducted using RStudio.

When analyzing race/ethnicity differences, we reduced the race/ethnicity categories from 10 (Table 2) to 6 because of the low number of responses in our sample. Thus, the categories we used in analysis were Asian all ($n = 99$), Southeast Asian ($n = 82$), Black/African American ($n = 20$), Hispanic/Latino ($n = 50$), White/Caucasian ($n = 69$), and Multiracial ($n = 41$). The American Indian and Alaska Native category was removed because of the low number of responses ($n = 3$). The Native Hawaiian/Pacific Islander category ($n = 1$) was combined into the Asian category to include the response, which is aligned with the student demographics categories in New York State [35].

Table 3. Codebook and Emerging Themes for Students' Favorite Part of the Course

Theme	Initial Code	Definition	Interview Extract Example
Coding Experience	Coding	Mentioned coding without explanation.	"Coding."
	Learning to code	Mentioned learning to code.	"My favorite part was learning how to code."
App Creation	Making apps	Mentioned making apps.	"Making the app."
	Making real apps	Turning their ideas into real apps.	"When you make an app, you have this idea in your head and it just comes to life."
	Connected with personal interest	Students could pick app topics connected with their interest.	"My favorite part was creating an app based on what I am interested in."
	Making apps to help others	Making apps to help others or solve a community problem.	"I liked the freedom to make an app that helps solve a problem in our community."
	Making apps: fun	Making apps is fun and can be creative.	"Making apps. It made it seem very fun and had a creative tint to it."
	App design	Students liked designing the app.	"Designing the screens of my app."
Classroom Instruction	CS topics	Students liked CS topics they learned.	"Learning about cybersecurity, computer history."
	Other computing tools	Computing tools introduced in the class (e.g., 3D printers, Spheros).	"My favorite part of the class was getting to create things with the 3D printer."
	CS professionals' visit	Students liked CS professionals' visit.	"I liked when we met the Amazon engineers."
	Unplugged activities	Students mentioned unplugged activities.	"When we had to take a step-by-step peanut butter jelly sandwich."
Classroom Community	Peer collaboration	Students liked collaborating with classmates.	"Being collaborative with peers and problem-solving together was my favorite."
	Sharing apps	Students enjoyed seeing others' or sharing their own apps.	"Going through other people's apps because it was fun and I could improve myself."
	Supportive teacher	Students referred to their teacher.	"The teacher is always willing to help you, even if we do not speak the same language."
Learning Opportunity	Learning new things	Students loved learning new things.	"Learning new things always made me interested."
	Early CS exposure	Students liked they could learn CS early.	"That I get to start this [learning CS] early is good."

Similarly, East Asian, South Asian, Southeast Asian, and Native Hawaiian/Pacific Islander were combined as one group (Asian all). Meanwhile, Southeast Asians were analyzed as an individual group as they represent a significant population in one school district serving Southeast Asian refugees [46]. To maintain consistency, we re-categorized students in the multiracial group to align them with other five categories. For instance, students who chose only East Asian and South Asian were reclassified as "Asian all" instead of "Multiracial." It is important to note that the necessity to remove and combine responses due to low sample size represents a limitation of this study.

Analysis of Open-Ended Question Responses. To answer the third research question (RQ3), we conducted thematic analysis on students' responses to the three open-ended questions. The inquiry of the qualitative data involved two steps. First, we performed thematic coding on the responses from the 294 students. Two researchers coded the responses separately and developed initial codes. Then these two researchers worked together to refine the codes including merging similar codes and identifying new codes. For the questions of students' favorite or least favorite aspects of the class, 17 independent codes were generated for their favorite part of the class, with another 16 codes for the least favorite part of the class. These codes were further discussed with a third researcher to generate emerging themes inductively [11]. Eventually, we identified five major themes regarding both students' favorite and least favorite aspects of the class. Tables 3 and 4 present the hierarchy of the codes and emerging themes.

The theme "Coding Experience" encompasses student responses related to their general coding experience, while "App Creation" is more specific to students' experience in app development. "Classroom Instruction" summarizes responses pertaining to learning activities, topic introduced, and tools used in the class. "Classroom Community" focused on the interactions and collaboration among students and the teacher within the class. "Learning Opportunity" highlights students'

Table 4. Codebook and Emerging Themes for Students' Least Part of the Course

Theme	Initial Code	Definition	Interview Extract Example
Coding Experience	Coding: debugging	Students did not like debugging.	"Trying to find the mistakes in my code."
	Coding: confusing/hard	Coding was confusing or hard.	"Sometimes it [coding] is very hard to do and confusing."
	Coding: heavy workload	Coding took much effort.	"It was hard and took a lot of thinking and effort."
	Coding: boring	Coding was boring.	"Sometimes coding can be boring since there a lot of numbers and letters and difficult password."
	Coding: time-consuming	Coding took (too) much time.	"Some of it [coding] was hard and it took a while."
	Coding: lack of time	Students did not get enough class time for coding.	"Having so little time to work on my app project. I had to rush a lot so it's not as nice as I would like it to be."
App Creation	Creating apps overall	Students disliked creating apps.	"My least favorite part was creating an app."
	App components	Learning different components.	"Learning all the different controls and buttons."
	App design	Students disliked designing apps.	"Designing the screens."
	App creation software	Struggled with the App Lab site.	"Making apps. It was more so due to the code.org site than the class, but I hate how there are different labs."
Classroom Instruction	Content: repetitive or non-CS topics	Students disliked repetitive content or some non-CS topics.	"We didn't learn anything new from last year. It was kind of like a refresh."
	Learning activities and tools for app ideas	Struggled with finding ideas, or activities for identifying app ideas.	"Trying to find ideas when you are out of ideas."
	Instruction resources	Disliked resources used, e.g., Edpuzzle videos and quiz.	"Watching a lot of Edpuzzle [videos]."
Classroom Community	Ineffective collaboration	Group work was disruptive or not productive.	"Possibly when I have to work with other kids, I found rather disruptive."
Lack of Confidence	New to coding	Students new to coding found it confusing or hard to start.	"If you're a beginner… it can be challenging because you don't know how to do certain things."
	Fear of making mistakes	Students were afraid of messing up things.	"Sometimes I would get stressed because I would miss click stuff and would maybe have to restart the page."

comments regarding the type of learning opportunities provided in the class. Additionally, "Lack of Confidence" addresses students' comments regarding their lack of confidence in coding or creating apps.

Second, we sorted the codes and themes based on gender, grade, and race/ethnicity for cross-group comparisons. While the Alaska Native of Native American group ($n = 3$) was excluded from the quantitative analyses, we acknowledge that data from groups with small sample sizes are important and valuable [47]. Therefore, open-ended question responses from this group were examined and will be discussed.

Analysis of Student Apps. To answer our research question regarding students' capacity of making community-serving apps (RQ4), student apps were analyzed based on the topics addressed, app type, and complexity. The topics of student apps were categorized based on the purpose of the apps, using creators' descriptions of the app purposes and their functionality. Apps were also examined in terms of whether they addressed issues or topics connected with students, their families, communities, and students being change agents for their communities or society.

Student apps were classified into four types: informational, utility (e.g., survey apps), game, or multiple. An informational app provides the user with information. A utility app was designed as a tool, such as a quiz to test the user's knowledge with a defined answer, a survey to gather information, or a service app providing service for those in need. Game apps provided recreation. Apps presenting multiple types were coded as the multiple type.

To measure the complexity of student apps, we developed a rubric adapted from Sherman et al.'s work [45], aligned with the project curriculum's learning objectives. The rubric focused on basic App Lab functionality and CS concepts introduced in the curriculum. It examined to what extent the apps addressed the five CS concepts (events, variables, conditionals, iteration, and data storage as an optional component) and **user interface (UI)** design (e.g., using images, buttons, and

Table 5. Survey Items with Significant t-Test Results ($p < 0.01$)

Confidence (Conf), Interest (Inst), and CRC	Pre		Post		t
	M	SD	M	SD	
Conf: I am good at coding.	2.58	0.99	3.04	0.97	6.89
Conf: I am good at creating my own apps.	2.42	0.97	3.09	0.98	−9.71
Conf: I can write code to make an app work.	2.80	1.10	3.38	1.00	−7.70
Conf: I am good at creating apps to help others	2.78	1.07	3.14	0.95	−5.23
Conf: I have been told that I would be good at coding.	2.38	1.13	2.62	1.15	−3.20
Inst: I like coding.	3.30	1.19	3.13	1.18	2.74
Inst: I like creating apps.	3.27	1.17	3.10	1.16	2.77
Inst: I like creating apps to help others.	3.30	1.10	3.10	1.05	3.00
Inst: Solving coding problems seems fun.	3.14	1.12	2.9	1.09	3.79
Inst: Coding is interesting.	3.63	1.10	3.46	1.12	3.07
Inst: I would like to learn more about coding.	3.47	1.09	3.06	1.10	6.83
CRC: I feel welcomed in this classroom.	4.01	0.83	3.88	0.83	2.76
CRC: I am interested in learning about my community.	3.86	0.86	3.71	0.86	2.64

user inputs). The apps were scored using a 1–3 scale (1-beginner, 2-proficient, and 3-advanced) per element. Apps were then classified as beginner apps with a total score of 1–5 points, proficient apps with 6–10 points, and advanced apps scoring between 11 and 15 points. Apps with data storage features gained an extra 3 points in the complexity score.

4 RESULTS

This section presents the results of student learning outcomes answering our four research questions regarding (1) student attitudes before and after they learned the curriculum, (2) their attitudes by gender, race/ethnicity, and grade level, (3) reported learning experiences, and (4) their capability of making community-serving apps.

4.1 Pre- and Post-Course Student Attitudes

Paired sample t-test results showed that there were significant differences between the pre-survey and post-survey in students' confidence (pre: $M = 3.12$, SD = 1.16; post: $M = 3.37$, SD = 1.04; $t(293) = -11.63$, $p = <0.001$), interest (pre: $M = 3.19$, SD = 1.18; post: $M = 2.95$, SD = 1.16; $t(293) = 9.75$, $p < 0.001$), and CRC attitudes (pre: $M = 3.73$, SD = 0.99; post: $M = 3.67$, SD = 0.96; $t(293) = 2.18$, $p = 0.03$). The results indicated that students' overall confidence in coding and creating apps significantly increased, but their overall interest in learning coding and creating apps decreased significantly afterward. Their CRC-related attitudes showed a marginal decline.

To further understand the changes in student attitudes, we compared the mean scores of each survey item. Items with significant t-test results are presented in Table 5. The results showed that students' confidence in coding, creating their own apps, writing code to make an app work, and creating apps to help others increased significantly. However, their confidence in debugging and problem-solving remained about the same. Among all confidence items, students rated consistently highest on "I can learn to code" in both pre- ($M = 4.01$) and post-surveys ($M = 4.06$).

On the other hand, students' interest in coding, creating apps, creating apps to help others, debugging, and learning more about coding all significantly decreased after learning the curriculum. Their interest in coding-related jobs (pre: $M = 2.74$; post: $M = 2.62$) and studying coding in the future (pre: $M = 2.47$; post: $M = 2.41$) remained the lowest among all the interest items. The mean scores on the CRC items in both pre-survey ($M = 3.73$) and post-survey ($M = 3.67$) were relatively

Table 6. Comparing Students' Attitudes by Gender

		Male (143)		Female (115)		Other[a] (36)	
		Pre	Post	Pre	Post	Pre	Post
Confidence	*M*	3.14	3.36	3.1	3.36	3.16	3.40
	SD	1.16	1.00	1.14	1.03	1.25	1.17
Interest	*M*	3.35	3.21	2.96	2.66	3.28	2.86
	SD	1.11	1.10	1.19	1.11	1.32	1.29
CRC	*M*	3.72	3.66	3.74	3.71	3.68	3.60
	SD	0.98	0.93	0.98	0.95	1.06	1.09
Overall	*M*	3.43	3.44	3.31	3.30	3.40	3.32
	SD	1.11	1.02	1.15	1.11	1.22	1.21

[a]"Other" incudes "non-binary," "do not wish to say," and missing responses.

higher than the confidence and interest items. Students reported they felt slightly less welcome in the class and their interest in learning about their community decreased. This might indicate they had known a lot about their community.

4.2 Comparing Students' Attitudes by Gender, Race/Ethnicity, and Grade

This section presents results of the differences in students' attitudes by gender, race/ethnicity, and grade respectively. The results are provided for each construct (interest, confidence, and CRC), followed by further analyses of specific survey items based on ANOVA results.

4.2.1 Comparing Students' Attitudes by Gender. Table 6 presents the attitudes of students from different gender groups. Among the three aspects of attitudes, CRC had the highest scores across all gender groups. Students showed relatively strong confidence and perceived themselves being able to connect their culture, life experiences, and community with their learning. Female students' interest was remarkably lower than other groups.

One-way ANOVA results on each construct indicated that students of different gender had no significant differences in their *confidence* both before (pre) and after (post) learning the course. However, their *interest* was significantly different in both pre-survey [$F(2,244) = 20.05$, $p < 0.001$] and post-survey [$F(2,244) = 54.20$, $p < 0.001$]. *Post hoc* analyses with a Bonferroni adjustment revealed that male students' interest was significantly higher than female students in both pre-survey [male: $M = 3.35$, SD = 1.11; female: $M = 2.96$, SD = 1.19; $p < 0.001$]) and post-survey [male: $M = 3.21$, SD = 1.1; female: $M = 2.66$, SD = 1.11; $p < 0.001$]. Male students reported significantly higher interest than the "other" gender group ($M = 2.86$, SD = 1.29) only after the course ($p < 0.001$). Regarding *CRC*, students of different gender had significantly different attitude only after the course [$F(2,247) = 4.98$, $p < 0.01$]. *Post hoc* analysis revealed that the "other" gender group rated significantly lower attitude than both male [$M = 3.66$, SD = 0.93, $p < 0.05$] and female students [M = 3.71, SD = 0.95, $p < 0.005$] only after the course. However, the "other" group had a significantly smaller sample size than the male and female groups, which might introduce a potential source of bias.

Interest Items. To understand the sources of differences in interest between female and male students, we examined each item, which assessed various aspects of student interest. First, dependent (paired) t-tests were applied to compare the pre- and post-survey scores of the same gender group. Male students' mean scores remained high (greater or equal to 3) on both pre- and post-surveys, with no significant changes in all interest items except in their interest in learning more about

Table 7. Female Students' Interest (Pre- and Post-Surveys)

Interest Item	Pre		Post		$t(98)$	p
	M	SD	M	SD		
l like coding.	3.03	1.17	2.8	1.12	2.36	0.02*
I like creating apps.	3.11	1.2	2.88	1.09	2.44	0.02*
I like creating apps to help others.	3.32	1.16	3.02	1.05	2.97	0.004**
Solving coding problem seems fun.	3.08	1.15	2.75	1.06	3.38	0.001***
Coding is interesting.	3.43	1.11	3.19	1.11	2.7	0.008**
I would like to learn more about coding.	3.29	1.1	2.78	0.99	5.41	<0.001***
I would like to study coding in the future.	2.36	1.09	2.25	1.01	1.16	0.25
I would like a job that is related to coding.	2.14	0.97	2.08	0.97	0.65	0.52

*$p < 0.05$; **$p < 0.01$; ***$p < 0.001$.

coding. For this particular item, male students' interest decreased significantly [pre: $M = 3.61$, SD = 0.98, post: $M = 3.30$, SD = 1.04, $t(118) = 3.59$, $p < 0.001$]. In contract, as shown in Table 7, female students reported significant decreases in many interest items, including creating apps to help others, solving coding problems, coding as interesting, and learning more about coding. Their ratings on "I like coding" and "I like creating apps" were marginally decreased. It is worth noting that girls still had notable strong interest in creating apps to help others ($M = 3.02$) and found coding to some extent interesting ($M = 3.19$), despite the marginal declines after learning the curriculum. On the contrary, female students rated very low on their interest in learning more about coding and pursuing a job related to coding with no significant differences before and after taking the course, which potentially presented a floor effect. Despite an increase in their confidence with coding and creating apps, female students showed little interest in continuing learning coding and doing coding-related work in the future.

Second, independent t-tests were also conducted to compare male and female students' interest per item in pre- and post-surveys, respectively. The results confirmed that female students had significant lower interest in coding, creating apps, studying coding in the future, and pursuing a job related to coding both before and after learning the course, compared to their male peers (Table 8). The interest gap between the two gender groups became wider after taking the course. It is worth noting that male and female students had similar interest in creating apps to help others, which suggests that this particular aspect of coding may be appealing to both genders.

4.2.2 Comparing Students' Attitudes by Race/Ethnicity. Students' attitudes were compared across the six race/ethnicity groups: Asian (all), Southeast Asian, Black/African American, Hispanic/Latino, White/Caucasian, and Multiracial. As presented in Table 9, *Black/African American and White/Caucasian* students had the highest overall attitude mean scores in both pre- and post-surveys. Students from all race/ethnicity groups perceived that their confidence increased after learning the curriculum. However, their interest decreased across all groups. Black/African American and White/Caucasian students' interest remained higher than other groups. As to CRC attitude, Asian (all) and Southeast Asian students showed a slight increase in their CRC attitudes, while all other groups' attitudes decreased marginally.

ANOVA tests revealed significantly differences among students of different race/ethnicity in their overall *confidence*, both in pre-survey [$F(5,231) = 2.36$, $p < 0.05$] and post-survey [$F(5,231) = 3.38$, $p < 0.01$]. However, *post hoc* analysis with Bonferroni correction on pre-survey responses

Table 8. Comparing Male and Female Students' Interest per Survey Item

Interest Item	Pre				Post			
	Male *M* (SD)	Female *M* (SD)	*t*	*p*	Male *M* (SD)	Female *M* (SD)	*t*	*p*
I like coding.	3.54 (1.10)	3.03 (1.17)	3.30	0.001***	3.43 (1.12)	2.80 (1.12)	4.14	<0.0001***
I like creating apps.	3.43 (1.09)	3.11 (1.20)	2.07	0.04*	3.33 (1.11)	2.88 (1.09)	3.00	0.003**
I like creating apps to help others.	3.30 (1.01)	3.32 (1.16)	−0.14	0.89	3.22 (0.99)	3.02 (1.05)	1.44	0.15
Solving coding problem seems fun.	3.18 (1.06)	3.08 (1.15)	0.65	0.51	3.03 (1.09)	2.75 (1.06)	1.93	0.06
Coding is interesting.	3.76 (1.01)	3.43 (1.11)	2.26	0.02*	3.66 (1.04)	3.19 (1.11)	3.27	0.001**
I'd like to learn more about coding.	3.61 (0.98)	3.29 (1.10)	2.25	0.03*	3.30 (1.04)	2.78 (0.99)	3.79	0.0002***
I'd like to study coding in the future.	3.08 (1.14)	2.36 (1.09)	4.74	<0.0001***	2.97 (1.11)	2.25 (1.01)	5.05	<0.0001***
I'd like a job that is related to coding.	2.71 (1.19)	2.14 (0.97)	3.98	<0.0001***	2.74 (1.13)	2.08 (0.97)	4.67	<0.0001***

*$p < 0.05$; **$p < 0.01$; ***$p < 0.001$.

Table 9. Student Attitudes by Race/Ethnicity

		Confidence		Interest		CRC		Overall	
		Pre	Post	Pre	Post	Pre	Post	Pre	Post
Black/African American	*M*	3.09	3.51	3.30	3.11	3.79	3.78	3.42	3.50
	SD	1.27	0.96	1.12	0.98	0.92	0.83	1.14	0.96
Asian (all)	*M*	3.18	3.40	3.11	2.93	3.64	3.71	3.36	3.39
	SD	1.03	0.95	1.14	1.10	0.90	0.82	1.05	1.00
Southeast Asian	*M*	3.09	3.35	3.01	2.87	3.64	3.69	3.28	3.35
	SD	0.99	0.93	1.12	1.08	0.89	0.79	1.04	0.98
Hispanic//Latino	*M*	3.08	3.20	3.14	2.83	3.75	3.59	3.37	3.25
	SD	1.18	1.16	1.24	1.26	1.03	1.10	1.18	1.20
White/Caucasian	*M*	3.21	3.42	3.35	3.06	3.73	3.68	3.45	3.44
	SD	1.20	1.02	1.17	1.20	1.03	0.98	1.15	1.09
Multiracial	*M*	3.03	3.38	3.04	2.91	3.79	3.64	3.33	3.35
	SD	1.24	1.06	1.25	1.13	1.08	1.03	1.24	1.11

indicated no significant differences in pairwise comparisons, primarily due to the weak significance in the global effect ($p = 0.04$). The same test applied to post-survey responses identified significant differences solely between Hispanic/Latino and White/Caucasian students ($p < 0.01$), as well as Hispanic/Latino and Black/African American students ($p < 0.05$). These differences were attributed to the relatively lower confidence level of *Hispanic/Latino* students compared with the other two groups, who exhibited the highest confidence levels.

Concerning *interest*, ANOVA tests indicated significant differences among the six racial/ethnic groups in both pre-survey [$F(5,233) = 5.47$, $p < 0.001$] and post-survey [$F(5,233) = 4.5$, $p < 0.001$]. *Post hoc* analyses revealed significant differences only in specific pairings. First, before the course, *White/Caucasian* students exhibited the highest interest. Their interest was significantly higher compared to Asian all ($p < 0.01$), Southeast Asian ($p < 0.001$), and Multiracial students

($p < 0.001$). After taking the course, differences between White/Caucasian and Asian, as well as White/Caucasian and Multiracial groups, became nonsignificant. However, White/Caucasian students' interest remained significantly higher than *Hispanic/Latino* and *Southeast Asian students*, with Hispanic/Latino students presenting the lowest interest among all groups.

For *CRC* attitude, ANOVA tests yielded marginally significant results only in the pre-survey [$F(5,234) = 2.73$, $p < 0.05$] among the six groups. Bonferroni *post hoc* analysis on the pre-survey revealed only weak difference between Southeast Asian and Multiracial students ($p = 0.04$).

Interest Items. As shown in Table 9, respondents of all race/ethnicity groups exhibited decreased interest. Therefore, further analysis was conducted using dependent t-tests on each individual interest item to explore the sources of differences before and after learning the course. All six racial/ethnic groups showed marginally significant decline in their interest in learning more about coding ($p < 0.05$). In addition, although not showing significant declines, all groups rated lowest ($M < 3$) on their interest in studying coding in the future and doing jobs relating to coding. White/Caucasian students' interest in creating apps to help others was significantly decreased while it remained above the mean [pre: $M = 3.47$, SD = 1.04, post: $M = 3.13$, SD = 1.03, $t(61) = 3.14$, $p < 0.01$]. Of notable concern is that *Hispanic/Latino* students showed marginally decreased interest in coding [pre: $M = 3.27$, SD = 1.28, post: M = 2.89, SD = 1.22, $t(36) = 2.34$, $p = 0.03$] and creating apps [pre: $M = 3.30$, SD = 1.29, post: $M = 2.97$, SD = 1.24, $t(36) = 2.03$, $p = 0.05$], as they already had the lowest interest scores coming into the class (slightly above the Southeast Asian students). Their interest in pursuing coding in the future was still the lowest among all groups [pre: $M = 2.35$, SD = 1.21, post: $M = 2.08$, SD = 0.98]. These findings suggest more work is needed to engage Hispanic/Latino students and help close their interest gap.

ANOVA tests indicated there were significant differences among the different racial/ethnic groups in their interest in learning more about coding before the class, with the lowest interest from *Southeast Asian* students. In particular, *post hoc* analyses showed that Southeast Asian and White/Caucasian students had the largest difference in their interest in learning more about coding in the pre-survey ($diff = 0.57$, $p < 0.01$). The differences in this item were eased after taking the course with no significant difference among all racial groups. However, students from different racial/ethnic groups still showed significant differences in their interest in coding and creating apps and studying coding in the future after learning the course. *Southeast Asian students* had significantly lower interest in creating apps than *Black/African American students* who showed the highest interest in creating apps after taking the course ($diff = 0.93$, $p = 0.02$). On their interest in studying coding in the future, *Hispanic/Latino students* had the lowest score ($M = 2.19$, SD = 1.10), which were marginally lower than *White/Caucasian students* ($diff = 0.65$, $p = 0.05$), who had the highest score ($M = 2.84$, SD = 1.20).

4.2.3 Comparing Students' Attitudes by Grade. Descriptive statistics indicated that 8th grade students had lower scores across all three attitude constructs than seventh graders. Among the three constructs, eighth-grade students' interest was the lowest from both pre- and post-surveys (Table 10). Seventh grade students reported significantly higher confidence, interest, and CRC attitude than 8th graders ($p < 0.001$) in both pre- and post-surveys. Therefore, further analyses on specific items were conducted.

Confidence Items. Further analyses using dependent t-tests on each item confirmed that students from both grades perceived that their confidence increased in coding, creating apps, and coding to make an app work and creating apps that can help people in their community. Their confidence in debugging and problem-solving did not significantly increase. The independent t-tests compared the differences in each confidence item between seventh- and eighth-grade students. The results indicated that seventh-grade students came into the class with significantly or marginally stronger

Table 10. Student Attitudes by Grade

		Grade 7 (n = 114)		Grade 8 (n = 163)	
		Pre	**Post**	**Pre**	**Post**
Confidence	M	3.38	3.61	2.96	3.22
	SD	1.12	1.05	1.15	1.01
Interest	M	3.51	3.23	2.95	2.76
	SD	1.16	1.19	1.16	1.11
CRC	M	3.85	3.76	3.64	3.61
	SD	1.01	1.00	0.97	0.93
Overall	M	3.60	3.57	3.23	3.25
	SD	1.11	1.09	1.14	1.07

confidence on all items. After learning the curriculum, their confidence in two items ("I am good at problem-solving" and "I have been told I would be good at coding") were not significantly different from eighth graders.

Interest Items. Dependent t-test results showed marginal to significant declines in seventh-grade students' interest on all items except for the two items with the lowest interest in both pre and post ("studying coding in the future" and "pursuing a job related to coding"). The eighth-grade students' interest only significantly decreased in the item of "learning more about coding" [pre: M = 3.19, SD = 1.1, post: M = 2.83, SD = 1.1, $t(134) = 4.33$, $p < 0.01$]. In spite of these differences, independent t-tests showed that seventh-grade students rated significantly higher on all interest items than eighth-graders both before and after taking the class. In terms of *CRC items*, both dependent and independent results met some ceiling effects with few significant changes.

4.3 Student Learning Experiences

The first open-ended question asked students what you learned about CS and making apps in this course. First of all, most students reported they learned how to code and/or create apps, mentioning some specific aspects of app creations (e.g., how to use variables and conditionals, and how to design the screens). Second, many students remarked they learned that app creation was a process requiring time and effort. For example, one student said: "*I learned that computer science and making apps takes a lot of coding, which is very time consuming*." Students further commented on the process of debugging took time: "*Bugs always happen, apps are never fully completed, and adjustments are always made. Creating an app can take some time*." Third, many students also highlighted in a more positive way that they learned how to fix their code or debug their projects. One student commented, "*When you make your code, there may be bugs in them, but you can always go back in to fix it*." Another student said: "*I learned that you can make mistakes, but you can learn from your mistakes and test every coding*." Last, students also acknowledged the value of learning CS and coding, as one student commented, "*I learned about how computer science and coding can help you with many things with future jobs or devices*."

Favorite Part of the Course. When asked about their favorite aspects of the course, 259 students provided valid responses to this question. These responses were categorized into five main themes (as shown in Table 11), with some answers overlapping across multiple themes. First, most students highlighted making real apps as their favorite part of the course. They enjoyed learning the process of brainstorming app ideas with peers and bringing ideas into life. Students also appreciated the

Table 11. Students' Favorite Part and Least Favorite Part of the Course

Favorite Part	# of Responses	Least Favorite Part	# of Responses
App Creation: making real apps, being creative, fun, and helping others	161	Coding Experience: boring, confusing, hard, and time-consuming	78
Classroom Instruction: topics, tools, activities, and CS professionals' visit	76	Classroom Instruction: Edpuzzle (videos, quiz), tools for generating app ideas	76
Classroom Community: collaboration, peers, and instructor	57	App Creation: interface and function, design in App Lab	21
Coding Experience: learning to code	40	Classroom Community: collaboration	18
Learning Opportunity: learning something new or unusual	14	Lack of Confidence: afraid of making mistakes, not knowing where to start	8

creative aspects of app creation. Students commented that learning coding and making apps gave them a chance to "*be creative and expressing [their] ideas*." Moreover, making apps to help others was also appreciated by many students as a highlight of the course. For example, one student commented: "*I loved being able to look at real-world problems and find the research so I can help prevent this issue in my community*." Second, many students commented positively on the way their teachers taught the course, especially on the diverse topics introduced, unplugged activities, the variety of instructional resources used in the class (e.g., Spheros, robots, and 3D printers), as well as the virtual visit from computing professionals. Third, many students highlighted the classroom community as their favorite part of the course. Students loved collaborating with their peers in creating apps, supporting each other, and getting help from the teacher. For example, one student commented, "Being collaborative with peers and problem-solving together was my favorite." Fourth, in addition to sharing about their positive experience of creating apps specifically, students also commented their experiences of enjoying coding and learning to code in general. Another important finding is that several students specifically mentioned that the course provided a refreshing learning experience, which allowed them to learn something new or they never thought the school would teach (i.e., coding and creating apps).

Least Favorite Part of the Course. There were 252 valid responses to this question. Among these responses, 60 said "nothing." We identified five themes indicating students' least favorite aspects of their learning experience, as presented in Table 11. First, many students expressed minimal interest in coding in general and found it to be "time-consuming," "sometimes boring," "confusing," or "difficult" with debugging. Second, a group of students commented negatively about the instructional tools that teachers used, in particular, Edpuzzle, an online video learning platform. Students shared that they were given too many self-learning tasks through Edpuzzle and felt overwhelmed by the information provided. Furthermore, the quiz from Edpuzzle also made some students stressed about their grades. While this tool was not part of the project's CS curriculum, it was used by all the participating teachers as a recommended instructional tool in one of the partner districts. In addition, students also complained about the activities (e.g., discussion board, research project) and tools (e.g., BrainPOP) used to help them identify app ideas. This finding aligns with the results from a previous study on teachers' curriculum implementation experiences, where teachers reported facing challenges when helping students generate ideas for the apps they wanted to create [37].

Third, while most students liked their experience in creating apps serving their communities, a small group of students also commented that learning the functions of App Lab components (e.g., buttons, labels) and designing the app screens in App Lab was their least favorite part of the course. Several students commented the need to debug their projects disinterested them more, as one student commented, "My least favorite part is running into a coding problem that I cannot fix myself." Fourth, while many students enjoyed collaborating with their peers as the highlight of the class, a small group of students (n = 18) reported the collaborative process of app creation could occasionally become "distracting" and "wasting time" for them. Last, several students were not confident in coding and creating apps. They were afraid of "messing up and restart" and "not knowing what to do" in the process.

Gender, Grade, and Race/Ethnicity. We further analyzed both negative and positive responses by gender (male and female), grade (Grade 7 and Grade 8), and race/ethnicity (Asian all, Hispanic/Latino, White/Caucasian, Black/African American, Multiracial). First, both female and male students highlighted app creation as a positive experience overall. However, more female students (49) than male students (29) reported their least favorite part related to coding in general. Most female students did not specify the reasons why they did not like coding but mentioned "*nointerest*" in their answers. Looking at the responses by grade, we found that the seventh graders and eighth graders provided nearly identical negative comments on coding and classroom instruction. However, seventh graders reported more positive experience than eighth graders.

The responses by race/ethnicity showed that app creation was the most favorite part for each race/ethnicity group. The responses of low confidence in coding and creating apps were mainly from *Black/African American and Hispanic/Latino students*, even if they also found creating app was fun and rewarding. Black/African American students thought coding was "*hard" and* "*confusing.*" Similarly, *Hispanic/Latino students* mentioned their fear of "*messingup"* or *"debugging"* as their least favorite part of the course. Despite the struggle, Hispanic/Latino students also provided many positive responses on app creation and classroom community. *Asian and White/Caucasian* students had the most negative responses related to the use of Edpuzzle.

Three students who self-identified as Alaska Native or Native American also answered these open-ended questions. One student was struggling with finding app ideas but then was successful ultimately, writing that he enjoyed "making my ideas into reality with code." Another student enjoyed exploring other apps. These responses were similarly mentioned by the students of the other racial/ethnicity groups. The third Alaska Native or Native American student made an off-topic response to both questions.

4.4 Student Apps

This section presents the results on student apps, including the identified themes, types, and levels of complexity.

4.4.1 App Topics. Seven app themes emerged from the analysis of student apps (Table 12). First, the most popular apps were about students' personal interest, such as sports and music. In these apps, students tended to use trivia questions to check users' knowledge of the topics. In addition, some apps were designed to help students understand each other (e.g., personal life choices) or introduce family and culture (e.g., autobiography apps introducing one's home country).

Second, a group of student apps spanned multiple topics on issues concerning their lives and their community. Those apps provided information about an issue impacting them, e.g., Vaping Awareness. This civic app aimed to distribute information about research findings, laws and regulations, and local contacts to change the vaping situation. Students also took a step forward to create apps addressing broader social issues. For these apps, the students usually included multiple components such as games or surveys beyond the presentation of information. Figure 1 illustrates an app designed to enhance users' awareness of light pollution. In addition, there were also apps addressing local community issues in students' neighborhoods or schools. Examples included an informational app about snow removal services, apps introducing teachers to new students, and

Table 12. Themes of Student App Topics

Emerging Theme	No.	Example
1. Personal interest	31	Disney Movie Quiz
2. Understanding themselves and others	7	Your Hogwarts House
3. Introducing family/culture	5	Asian Countries
4. Issues concerning their lives	7	Anxiety Relief
5. Addressing issues in the neighborhood or school community	7	Teachers in Your School
6. Addressing social issues	8	Our Environment
7. Learning tool	14	My Calculator
8. Multiple themes	13	Pollution Information

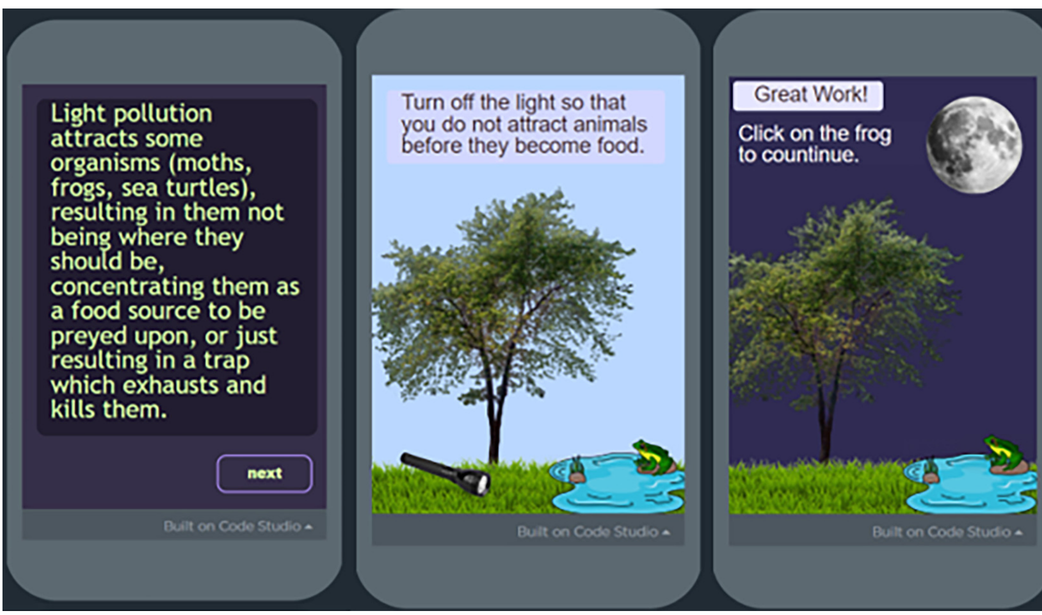

Fig. 1. An example of student app on light pollution.

an afterschool bus scheduling app. Related to apps helping their school community, students also created study or homework aids apps as learning tools (e.g., calculator). Figure 2 presents a word cloud illustrating the specific topics of all student-created apps.

The diversity of themes emerged from students' choices of app topics demonstrates that students could connect their personal interests, cultures, and life experiences to coding and creating apps for their community and social good. These artifacts presented their engagement and ability to learn coding in a meaningful way. Their enthusiasm for addressing social and community issues underscores their motivation to become change agents for their community and society.

4.4.2 App Types. Most student apps were classified as utility apps (n = 53), including 35 quiz apps, 7 service apps, and 11 survey apps. Quiz apps were designed to test users' knowledge on a topic that the student designers were interested in, such as recycling, music, or science. Service apps contained information about a service provided in the community (e.g., snow removal). Survey

Fig. 2. A word cloud of student app topics.

apps showed a similar design as Quiz apps but were designed to capture opinions on a topic that matters to the students. For example, one survey app collected votes on users' daily energy-saving behaviors. Four of the survey apps also stored data and shared the information with users.

Informational apps were the second most popular ($n = 21$). Students created these apps to share information about issues concerning their lives and/or to introduce their families and culture. For example, one app provided information on techniques for relieving anxiety and stress. There were also two mini-game apps, in which students simply used button click and changing screens to complete the game. In addition to informational, utility, and game apps, 16 apps presented multiple types. Typically, some informational apps also include a game, quiz, or survey to introduce a community issue and enhance users' knowledge or awareness of the topic.

4.4.3 App Complexity. The apps were graded using a 1–3 scale on six elements (events, variables, conditionals, iteration, data storage as optional, and UI design). The average score on app complexity was 6.53, which met the curriculum's learning objective of using a combination of these elements to create a functioning app. The average scores for CS concepts and UI scores were 3.90 (out of 12) and 2.64 (out of 3). Table 13 presents the average scores of apps in the beginner (1–5 points), proficient (6–10 points), and advanced (11+ points) categories.

The majority of student apps were classified as proficient ($n = 54$), which indicated that most students were meeting the curricular learning goals. This result is also consistent with the survey finding of students' increased confidence in coding and making community-serving apps. Those proficient apps included three to six screen changes and successful execution of a variable, conditional,

Table 13. App Complexity Scores

		Beginner	Proficient	Advanced
	N	29	54	9
CS Concepts	Min	1	3	8
	Max	4	8	15
	M (SD)	2.59 (0.78)	3.47 (1.10)	10.78 (1.48)
UI Design	Min	1	2	1
	Max	3	3	3
	M (SD)	1.97 (0.50)	2.95 (0.23)	2.78 (0.67)
Total	Min	2	6	11
	Max	5	10	16
	M (SD)	4.52 (0.99)	6.42 (0.99)	13.56 (1.59)

or iteration. The advanced apps ($n = 9$) had six or more state (screen) changes and incorporated multiple variables, conditionals, iterations, and/or the use of data collection. On the other hand, we observed little use of control structures, specifically iterations. More information is needed to be able to interpret this result. For example, this result might indicate a lack of student knowledge of complex iterative statements, or insufficient instructional time for this concept. Consistent with our results, Grover et al. also pointed to the challenges with advanced programming concepts such as Boolean logic and loops and the need for teachers to provide opportunities for students to develop more advanced computational artifacts [15].

5 SUMMARY AND DISCUSSION

This study explored preliminary results of students' learning outcomes from a middle school CSDL curriculum, which focused on creating mobile apps serving students, their local communities, and the larger society. Using pre- and post-survey responses from 294 students and 92 student-created apps, this study examined four research questions around (RQ1) student attitudes before and after they learned the CS Pathways curriculum, (RQ2) their attitudes by gender, race/ethnicity, and grade level, (RQ3) student reported learning experiences, and (RQ4) their capability of making community-serving apps.

Concerning student learning experiences, our findings indicated that students were able to engage in meaningful CS learning in creating apps relevant to their communities and/or themselves. The process of creating real apps and engaging in collaborative, creative work with their peers was highly enjoyable for students.

Regarding student attitudes, results of the student surveys indicated that students built their confidence in coding and creating apps through this process, regardless of their grade level, gender, and race/ethnicity. However, the results also revealed a significant decrease in their interest across all interest items after learning the curriculum. The decreased interest may be attributed to negative learning experiences reported by the students. Specifically, many students disliked certain learning tools used in the class, such as Edpuzzle, which was not part of the CS curriculum. Additionally, some students found debugging to be challenging and felt coding was a very time-consuming task that required lots of effort. Black/African American and Hispanic/Latino students also reported low levels of confidence in coding and debugging, which they identified as their least favorite aspect of the course.

There were also gender, grade, and racial/ethnic differences in students' interest. In summary, female students had significantly lower interest than male students, and eighth graders' interest was lower than that of seventh graders. Despite their increased confidence with coding and creating apps, female students reported very low interest in learning more about coding and pursuing a job related to coding both before and after taking the course, which potentially presented a floor effect. These findings are consistent with prior findings from other studies. For example, Kong et al. also found girls' interest in CS being consistently lower than that of boys; students' interest in coding declined in higher grade levels [24]. Our finding indicated that a brief exposure to a CS curriculum focused creating apps for community and social good was useful but insufficient to address the gender and grade gaps, especially in attracting student to continue learning or pursue careers in CS. Future studies are needed to further understand and effectively address these gaps.

With respect to race/ethnicity differences, this study found that Black/African American students reported more positive attitudes toward learning CS and creating apps for their communities. Southeast Asian students brought the lowest interest, but they were able to catch up with other groups of students after learning the project's CS curriculum. This result might indicate some promise of a community-focused or culturally relevant CS curriculum in serving these historically under-represented groups [30].

Regarding students' ability to create apps for community and social good, the results of student-developed apps demonstrated their capacity to create basic apps that connected with their personal interests, cultures, life experiences, and communities, thereby meeting the curriculum goal. The project's curriculum provided students with opportunities to learn CS in relevant and meaningful ways. However, we acknowledge that it may fall short of fully embodying culturally responsive and sustaining CS practices [20]. Research continues to develop our understanding and enactment of student-centered, culturally responsive and/or sustaining computing practices [8, 20, 26, 44]. Acknowledging that understandings of cultural responsiveness unavoidably differ and are mediated by research, community, school, and classroom contexts, the project researchers deferred to individual classroom teachers' developing interpretations and enactments of cultural responsiveness. We believed that teachers had the best understanding of their students and were most qualified to negotiate and prioritize learning goals for their students.

In our project contexts, teachers facilitated students in expressing their interests as part of a school assignment, addressing two of the five tenets of CRC: tenet one, "All students are capable of digital innovation," and tenet two, "The learning context supports transformational use of technology" or students' use of technology to pursue their interests [44]. Even if those interests were mediated by a hegemonic commercial culture and content agnosticism (e.g., Harry Potter and Disney Princesses) [26], these iterations of student apps and teacher assignments represent initial steps toward continually developing culturally responsive enactments.

6 LIMITATIONS AND FUTURE WORK

We acknowledge that this study has limitations. First, as reported in Section 3, we encountered a major challenge with low response rates of student responses and especially parental consent. While all students in the 38 classes were exposed to the curriculum as part of their regular class learning activities, this study was only able to use survey results from less than one-third of these participating students.

Second, students in this study had a short exposure to the project's CS curriculum, and they learned the curriculum from different teachers with varied schedules, teaching styles, resources, and tools. Teachers participated in this project had great autonomy in implementing the curriculum. The total number of students from each participating teacher ranged from 46 to 293 students. The data were not disaggregated by each teacher and by other related factors (e.g., prior coding experience). Therefore, factors specific to their teachers and the learning activities students experienced should also be considered when interpreting the student learning outcomes.

Third, we attempted to provide students with flexible race/ethnicity survey choices. We encountered difficulty categorizing those choices aligned with normative categories of extant research. This indicates the need for further work to develop nuanced and relevant socio-cultural categories for broadening participation in CS.

Finally, we also recognize the limitation of using quantitative research methods when studying groups with small representation. In the case of this study, we were unable to incorporate the experiences of our Native American and Alaskan Native students for the quantitative analyses owing to the small numbers of students in our study. Relatedly, we brought results from our Hawaiian Native and Pacific Islander students into our larger group of Asian students (following New York State's statistics of student demographics) and thereby failed to learn from the particular experiences of these students.

Moving forward, we plan to follow up with those students and teachers and collect additional qualitative data (e.g., class observations and student interviews) to gain a deeper understanding of students' learning experiences and how the curriculum can be effectively infused into various classrooms to engage students from diverse backgrounds. The project continues its RPP efforts with the partner districts, providing professional learning and support for our teachers to develop more engaging and inclusive CS teaching practices for their students. As recommended by the Culturally Responsive-Sustaining CS Framework [20], in addition to the efforts centered around increasing access to computing courses, we need to invest deeply in the development of curriculum, teachers, and their pedagogical practices to ensure meaningful participation and success in CS education for students from all backgrounds to close racial/ethnic, gender, and socioeconomic equity gaps in CS.

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REFERENCES

[1] Sophie Andrews and Lucia Morris. 2020. Diversity in CS: Race and Gender among CS Majors in 2015 vs 2020. Retrieved from https://stanforddaily.com/2020/08/08/how-has-diversity-within-stanfords-cs-department-changed-over-the-past-5-years

[2] Abby Budiman and Neil G. Ruiz. 2021. Key Facts about Asian Americans, a Diverse and Growing Population. Pew Research Center. Retrieved from https://www.pewresearch.org/short-reads/2021/04/29/key-facts-about-asian-americans

[3] Tamer Burçin. 2016. A Comparison of East Asian, South Asian, Southeast Asian, and White Undergraduate Student Familial Support. Retrieved from https://cra.org/crn/2016/06/comparison-east-asian-south-asian-southeast-asian-white-undergraduate-student-familial-support

[4] Jones Carolyn. 2017. Girls Draw Even with Boys in High School STEM Classes, but Still Lag in College and Careers. Retrieved from https://edsource.org/2017/girls-now-outnumber-boys-in-high-school-stem-but-still-lag-in-collegeandcareer/578444#::text=Boys%20consistently%20outnumbered%20girls%20in,engineering%20and%20computer%20science%20classes

[5] Code.org. 2022. State of Computer Science Education: Understanding our National Imperative. Retrieved from https://advocacy.code.org/2022_state_of_cs.pdf

[6] Caitlin Duncan and Tim Bell. 2015. A pilot computer science and programming course for primary school students. In *Proceedings of the Workshop in Primary and Secondary Computing Education (WiPSCE '15)*. 39–48. DOI: https://doi.org/10.1145/2818314.2818328

[7] Ron Eglash, Juan E. Gilbert, and Ellen Foster. 2013. Toward culturally responsive computing education. *Communications of the ACM* 56, 7 (2013), 33–36. DOI: https://doi.org/10.1145/2483852.2483864

[8] Ron Eglash, Audrey Bennett, Laquana Cooke, William Babbitt, and Michael Lachney. 2021. Counter-hegemonic Computing: Toward computer science education for value generation and emancipation. *ACM Transactions on Computing Education (TOCE)* 21, 4 (October 2021), 29:1–29:30. DOI: https://doi.org/10.1145/3449024

[9] Martha Escobar, Jeff Gray, Kathy Haynie, Mohammed Qazi, Yasmeen Rawajfih, Pamela McClendon, Donnita Tucker, and Wendy Johnson. 2021. Engaging Black female students in a year-long preparatory experience for AP CS Principles.

In *Proceedings of the 52nd ACM Technical Symposium on Computer Science Education (SIGCSE '21)*. ACM, New York, NY, USA, 7 pages. DOI: https://doi.org/10.1145/3408877.3432560

[10] Bernardo Feliciano, Gillian Bausch, Lijun Ni, Pauline White, Fred Martin, and Hsien-Yuan Hsu. 2021. One-on-one meetings as boundary practices: Managing RPP computer science curriculum co-design. In *The Intersection of RPPs and BPC in CS Education: A Culmination of Papers from the RPPforCS Community* [White paper], CSforALL and SageFox Consulting Group (Eds.), CSEdResearch.org. DOI: 10.13140/RG.2.2.13590.47683

[11] Jennifer Fereday and Eimear Muir-Cochrane. 2006. Demonstrating rigor using thematic analysis: A hybrid approach of inductive and deductive coding and theme development. *International Journal of Qualitative Methods* 5,1 (2006), 80–92. DOI: https://doi.org/10.1177/160940690600500107

[12] Leiny Y. Garcia, Miranda C. Parker, Santiago Ojeda-Ramirez, and Mark Warschauer. 2023. Confidence is the key: Unlocking predictive factors of Latinx elementary students on a computational thinking measure. In *Proceedings of the 54th ACM Technical Symposium on Computer Science Education V. 1 (SIGCSE '23)*, ACM, New York, NY, USA, 7 pages. DOI: https://doi.org/10.1145/3545945.3569811

[13] Geneva Gay. 2018. *Culturally Responsive Teaching: Theory, Research, and Practice*. Teachers College Press, New York, NY.

[14] Google Gallup. 2020. Moving Forward: Closing the Computer Science Learning Gap Girl. Retrieved from https://services.google.com/fh/files/misc/closing-computer-science-learning-gaps-girls.pdf

[15] Shuchi Grover, Satabdi Basu, and Patricia Schank. 2018. What we can learn about student learning from open-ended programming projects in middle school computer science. In *Proceedings of the 49th ACM Technical Symposium on Computer Science Education (SIGCSE '18)*. ACM, NY, USA, 6 pages. DOI: https://doi.org/10.1145/3159450.3159522

[16] Garima Jain, Fred Martin, Bernardo Feliciano, Hsien-Yuan Hsu, Barbara Fauvel-Campbell, Gillian Bausch, Lijun Ni, and Elizabeth Thomas-Cappello. 2022. CS Pathways: A culturally responsive computer science curriculum for middle school. In *Proceedings of the IEEE Frontiers in Education Conference (FIE '22)*. 1–9. DOI: 10.1109/FIE56618.2022.9962664

[17] Jane Margolis. 2017. *Stuck in the Shallow End, Updated Edition: Education, Race, and Computing*. MIT Press.

[18] Yasmin B. Kafai, Eunkyoung Lee, Kristin Searle, Deborah Fields, Eliot Kaplan, and Debora Lui. 2014. A crafts-oriented approach to computing in high school: Introducing computational concepts, practices, and perspectives with electronic textiles. *ACM Transactions on Computing Education (TOCE)* 14, 1 (2014), 1–20. DOI: https://doi.org/10.1145/2576874

[19] Hosun Kang, Angela Calabrese Barton, Edna Tan, Sandra D. Simpkins, Hyang-Yon Rhee, and Chandler Turner. 2019. How do middle school girls of color develop STEM identities? Middle school girls' participation in science activities and identification with STEM careers. *Science Education* 103, 2 (2019), 418–39.

[20] Kapor Center (2021). Culturally Responsive-Sustaining Computer Science Education: A Framework. Retrieved from https://www.kaporcenter.org/equitablecs

[21] Nazish Zaman Khan and Andrew Luxton-Reilly. 2016. Is computing for social good the solution to closing the gender gap in computer science?. In *Proceedings of the Australasian Computer Science Week Multiconference (ACSW '16)*. 1–5. DOI: http://dx.doi.org/10.1145/2843043.2843069

[22] Meredith W. Kier, Margaret R. Blanchard, Jason W. Osborne, and Jennifer L. Albert. 2014. The Development of the STEM Career Interest Survey (STEM-CIS). *Research in Science Education* 44, 3 (June 2014), 461–481. DOI: https://doi.org/10.1007/s11165-013-9389-3

[23] John King, Trevor Bond, and Sonya Blandford. 2002. An investigation of computer anxiety by gender and grade. *Computers in Human Behavior* 18, 1 (2002), 69–84. DOI: https://doi.org/10.1016/S0747-5632(01)00030-9

[24] Siu-Cheung Kong, Ming Ming Chiu, and Ming Lai. 2018. A study of primary school students' interest, collaboration attitude, and programming empowerment in computational thinking education. *Computers & Education* 127 (2018), 178–189. DOI: https://doi.org/10.1016/j.compedu.2018.08.026

[25] Gloria Ladson-Billings. 1994. *The Dream Keepers*. Jossey-BASS, San Francisco, CA.

[26] Michael Lachney, William Babbitt, and Ron Eglash. 2016. Software design in the "construction genre" of learning technology: Content aware versus content agnostic. *Computational Culture* 5. Retrieved from http://computationalculture.net/software-design-in-the-construction-genre-of-learning-technology-content-aware-versus-content-agnostic

[27] Jieun Lee, Jenefer Husman, Kimberly A. Scott, and Natalie D. Eggum-Wilkens. 2015. COMPUGIRLS: Stepping stone to future computer-based technology pathways. *Journal of Educational Computing Research* 52, 2 (2015), 199–223.

[28] Hayley C. Leonard and Sue Sentance. 2021. Culturally-relevant and responsive pedagogy in computing: A quick scoping review. *International Journal of Computer Science Education in Schools* 5, 2 (2021), 3–13. DOI: https://doi.org/10.21585/ijcses.v5i2.130

[29] Jacqueline Leonard, Monica Mitchell, Joy Barnes-Johnson, Adrienne Unertl, Jill Outka-Hill, Roland Robinson, and Carla Hester-Croff. 2018. Preparing teachers to engage rural students in computational thinking through robotics, game design, and culturally responsive teaching. *Journal of Teacher Education* 69, 4 (2018), 386–407. DOI: https://doi.org/10.1177/0022487117732317

[30] Colleen M. Lewis, Niral Shah, and Katrina Falkner. 2019. Equity and diversity. In *The Cambridge Handbook of Computing Education Research*. Sally A. Fincher and Anthony V. Robins (Eds.), Cambridge University Press, 481–510.

[31] Tia C. Madkins, Jakita O. Thomas, Jessica Solyom, Joanna Goode, and Frieda McAlear. 2020. Learner-centered and culturally relevant pedagogy. In *Computer Science in K-12: An A-to-Z Handbook on Teaching Programming*. S. Grover (Ed.), Edfinity, 125–129.

[32] Stacie L. Mason and Peter J. Rich. 2020. Development and analysis of the elementary student coding attitudes survey. *Computers & Education* 153 (August 2020), 103898. DOI: https://doi.org/10.1016/j.compedu.2020.103898

[33] Jessica Morales-Chicas, Mauricio Castillo, Ireri Bernal, Paloma Ramos, and Bianca L. Guzman. 2019. Computing with relevance and purpose: A review of culturally relevant education in computing. *International Journal of Multicultural Education* 21, 1 (2019), 125–155.

[34] National Science Foundation. 2020. Computer Science for All (CS for All: Research and RPPs). Retrieved from https://www.nsf.gov/publications/pub_summ.jsp?ods_key=nsf20539

[35] New York State Education Department (NYSED). 2023. NY State Data. Retrieved from https://data.nysed.gov

[36] Lijun Ni, Fred Martin. Gillian Bausch, Rebecca Benjamin, Hsien-Yuan Hsu, and Bernardo Feliciano. 2021. Project, district, and teacher levels: Insights from professional learning in a CS RPP collaboration. In *Proceedings of the 52nd ACM Technical Symposium on Computer Science Education (SIGCSE '21)*. 764–752.

[37] Lijun Ni, Gillian Bausch, Bernardo Feliciano, Hsien-Yuan Hsu, and Fred Martin. 2022. Teachers as curriculum co-designers: Supporting professional learning and curriculum implementation in a CSforAll RPP project. In *Proceedings of the Conference on Research in Equitable and Sustained Participation in Engineering, Computing, and Technology (RESPECT '22)*. 1–8.

[38] Zachary Opps and Aman Yadav. 2022. Who belongs in computer science?. In *Proceedings of the 53rd ACM Technical Symposium on Computer Science Education V. 1 (SIGCSE '22)*. ACM, New York, NY, USA, 7 pages. DOI: https://doi.org/10.1145/3478431.3499401

[39] Django Paris. 2012. Culturally sustaining pedagogy: A needed change in stance, terminology, and practice. *Educational Researcher* 41, 3 (April 2012), 93–97. https://doi.org/10.3102/0013189X12441244

[40] Joan Peckham, Peter D. Stephenson, Lisa L. Harlow, David A. Stuart, Barbara Silver, and Helen Mederer. 2007. Broadening participation in computing: Issues and challenges. In *Proceedings of the 12th Annual SIGCSE Conference on Innovation and Technology in Computer Science Education (ITiCSE '07)*. ACM, New York, NY, USA, 9–13. DOI: https://doi.org/10.1145/1269900.1268790

[41] Heraldo V. Richards, Ayanna F. Brown, and Timothy B. Forde. 2007. Addressing diversity in schools: Culturally responsive pedagogy. *Teaching Exceptional Children* 39, 3 (2007), 64–68. DOI: https://doi.org/10.1177/004005990703900310

[42] Ashley Robinson, Manuel A. Pérez-Quinones, and Glenda Scales. 2015. Understanding the attitudes of African American middle school girls toward computer science. In *Proceedings of the Research in Equity and Sustained Participation in Engineering, Computing, and Technology (RESPECT '15)*. IEEE, 1–8. DOI: http://doi.org/10.1109/RESPECT.2015.7296507

[43] Darcy Ronan, Dennis Brylow, Maverick Berner, Sydney Crespo, Heidi Williams, Christine Thorp, and D. Cenk Erdil. 2023. Complexities in computer science teaching attitudes and beliefs: Findings of a baseline study of elementary school educators. In *Proceedings of the 54th ACM Technical Symposium on Computer Science Education V. 1 (SIGCSE '23)*. ACM, New York, NY, USA, 7 pages. DOI: https://doi.org/10.1145/3545945.3569746

[44] Kimberly A. Scott, Kimberly M. Sheridan, and Kevin Clark. 2015. Culturally responsive computing: A theory revisited. *Learning, Media and Technology* 40, 4 (January 2015), 412–436.

[45] Mark Sherman, Fred Martin, Larry Baldwin, and James DeFilippo. 2014. App Inventor Project Rubric–Computational Thinking through Mobile Computing. Retrieved from https://nsfmobilect.files.wordpress.com/2014/09/mobile-ct-rubricfor-app-inventor-2014-09-01.pdf

[46] Deepa Shivaram. 2021. Southeast Asians are Underrepresented in STEM. The Label "Asian" Boxes them out more. Retrieved from https://www.npr.org/2021/12/12/1054933519/southeast-asian-representation-science

[47] Amy E. Slaton and Alice L. Pawley. 2018. The power and politics of engineering education research design: Saving the 'Small N'. *Engineering Studies* 10, 2–3 (2018), 133–157.

[48] Robert H. Tai, Christine Qi Liu, Adam V. Maltese, and Xitao Fan. 2006. Planning early for careers in science. *Science* 312, 5777 (2006), 1143–1144.

[49] Jennifer Tsan, Fernando J. Rodríguez, Kristy Elizabeth Boyer, and Collin Lynch. 2018. "I Think We Should. . ." : Analyzing elementary students' collaborative processes for giving and taking suggestions. In *Proceedings of the 49th ACM Technical Symposium on Computing Science Education (SIGCSE '18)*. 6 pages. DOI: https://doi.org/10.1145/3159450.3159507

[50] United States Census Bureau. 2016. American Community Survey (ACS)—Why We Ask: Hispanic Origin. Retrieved from https://www2.census.gov/programs-surveys/acs/about/qbyqfact/2016/Hispanic.pdf

[51] Xuefeng Wei, Lin Lin, Meng Nanxi, Tan Wei, Kong Siu-Cheung, and Kinshuk. 2021. The effectiveness of partial pair programming on elementary school students' computational thinking skills and self-efficacy. *Computers & Education* 160 (January 2021), 104023. DOI: https://doi.org/10.1016/j.compedu.2020.104023

[52] Aman Yadav, Sarah Gretter, and Jon Good. 2017. Computer science for all: Role of gender in middle school students' perceptions about programming. In *Proceeding of the Annual Meeting of American Educational Research Association (AERA '17)*.

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