Creating Apps for Community and Social Good: Learning Outcomes of a Culturally Responsive Middle School Computer Science Curriculum

Lijun Ni
Gillian Bausch
Elizabeth Thomas-Cappello
University at Albany, State University of New York
Albany, NY, USA
lni@albany.edu, gyu@albany.edu,
ethomas-cappello@albany.edu

Fred Martin
Bernardo Feliciano
University of Massachusetts Lowell
Lowell, MA, USA
Fred_Martin@uml.edu
Bernardo_Feliciano@uml.edu

ABSTRACT

This study examined student learning outcomes from a culturally responsive middle school computer science (CS) curriculum. The curriculum is based on students creating mobile apps serving community and social good. Two sets of data were collected from 294 students in three urban districts: (1) pre- and post- survey responses on their attitudes toward learning CS and creating culturally responsive apps; (2) the apps created by those students. The analyses of student apps indicated that students were able to create basic apps that connected with their personal interests, life experiences, class community, and the larger society. Paired sample t-tests of pre- and post- survey results indicated that students were significantly more confident in coding and creating community-focused apps after completing the course, regardless of gender and race. However, their interest in solving coding problems and continuing to learn CS decreased afterward. Analyses of students' attitudes by gender, grade, and race showed significant differences among some of those groups. Seventh grade students rated more positively on their attitudes than eighth graders. Students of different racial groups indicated significantly different attitudes, especially the Southeast Asian and African American groups. Male students also reported stronger confidence and interest and more positive attitudes overall than female students.

CCS CONCEPTS

• Social and professional topics • Professional topics
• Computing Education • K-12 Education

KEYWORDS

Middle School Students, Apps, Culturally Responsive Pedagogy, Attitudes, App Complexity

SIGCSE 2023, March 15–18, 2023, Toronto, ON, Canada

ACM ISBN 978-1-4503-9431-4/23/03…$15.00 https://doi.org/10.1145/3545945.3569781

ACM Reference format:

Lijun Ni, Gillian Bausch, Elizabeth Thomas-Cappello, Fred Martin, and Bernardo Feliciano. 2023. Creating Apps for Community and Social Good: Learning Outcomes of a Culturally Responsive Middle School Computer Science Curriculum. In *Proceedings of the 54th ACM Technical Symposium on Computer Science Education V. 1 (SIGCSE 2023), March 15--18, 2023, Toronto, ON, Canada. ACM, New York, NY, USA,* 7 pages. https://doi.org/10.1145/3545945.3569781.

1 INTRODUCTION

Culturally responsive pedagogy (CRP) advocates using cultural awareness, prior knowledge and experience, and cultural expressions to make learning more relevant and equitable to culturally diverse students [2, 9]. The CS Pathways project is a researcher and practitioner partnership (RPP) [16] 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 STEM fields, including computer science [13]. The project is aimed to establish inclusive and sustainable middle school computer science and digital literacy (CSDL) programs that serve all students. To achieve this project goal, we need a culturally responsive curriculum that can engage all middle school students in our partner districts. In 2021, the project re-designed its curriculum through a collaborative team of teacher leaders, district leads and researchers to explicitly integrate CRP into its curriculum units [14]. It is an approximately 18-hour curriculum focused on students developing mobile apps that are culturally responsive or serve their communities using Code.org's App Lab. More information about the project curriculum will be introduced in Section 2. By establishing the CRP-embedded curriculum in required courses, the project aims to engage all of the districts' middle school students in learning CSDL.

This study explores the learning outcomes of students who learned the project curriculum in the past school year. We examined two research questions: (1) What were the students' attitudes to learning computer science (CS) and creating apps for community and social good before and after they learned the CS Pathways curriculum? (2) To what extent did students demonstrate their capability of making culturally responsive apps? This paper presents our preliminary results on student learning experiences and outcomes regarding their attitudes and ability of creating apps that connected to their life experience, culture, community, and the broader society.

2 BACKGROUND

2.1 Literature Review

Culturally responsive pedagogy (CRP) has become an important and effective means for improving student equity and inclusion in education [2, 4, 9]. CRP aims to facilitate and support all students' learning through learner-centered contexts and utilizing students' cultural backgrounds and experiences as cultural assets [17]. Culturally responsive computing (CRC) education applies the long-standing CRP framework directly to CS education. CRC programs recognize the mission of CRP and engage students and empower them by learning computing [1, 5]. Built upon CRP, CRC, and other related work, the Kapor Center recently developed a culturally responsive-sustaining framework for K-12 CS education, which provides a guide for CS educators to adopt CRP into their CS classrooms [6]. This framework strives to ensure access to CS education for students of all races through raising teachers' awareness of cultural responsiveness, preparing a rigorous culturally responsive and sustaining CS curriculum, and embracing students' culture and prior life experience [6].

Many studies have been dedicated to promoting CS education equity with CRP. For example, the COMPUGIRLS program [10] was developed to better reach urban special needs students through a relevant and engaging afterschool program. This program directly empowered girls to become change agents and bridged the gap in their technology access [19]. As another example, the pH Empowered program [8] demonstrated that including local community cultural experts (African American cosmetologists) led to better engagement of minority students with little or no programming experience by designing apps that predicted hair color and style.

The CS Pathways project is informed by the three types of CRP practices: connecting with students' culture and life experience; fostering relationships with students, families, and communities; and empowering students to become change agents [15]. Through the project's CSDL curriculum, students learn computer science principles by creating "culturally responsive" 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 computer science in meaningful ways [14]. In this study, we explored student's attitudes toward learning and creating culturally responsive 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 and the society.

2.2 Study Context

The project curriculum is a product of collaborative design by the project researchers, teacher leaders, and administrators from the partner districts [14]. It is an approximately 18-hour CRP-embedded 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 different 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.

Table 1. Project Curriculum Implementation Overview

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

In total, nine teachers from seven middle schools piloted this curriculum after completing initial professional learning with the project. Teachers continued their professional learning with ongoing support during the school year through monthly meetings, coaching from teacher leaders, and class visits from researchers. Table 1 shows an overview of the curriculum implementation. The teachers had autonomy in ways of integrating the curriculum into their home content areas. Their instruction time varied between 10 to 23 hours with different class schedules. In total, the curriculum was implemented in 38 classes, reaching 948 students.

3 METHODS

3.1 Participants

Of the 948 participants, 449 students replied to the pre-survey (47%); 312 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. Southeast Asians are listed as an individual group as they represent a significant population in one school district serving Southeast Asian refugees.

3.2 Data Collection

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

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	Asian, Southeast Asian only	98 (33.3%), 82 (27.9%)
	Black/African American	20 (6.8%)
	Hispanic/Latino/Latina	50 (17%)
	White/Caucasian Native	69 (23.5%)
	Hawaiian/Pacific Islander	1 (.3%)
	Native American/Alaskan	3 (1%)
	2 or More Races	41 (13.9%)
	Not specified	12 (4.1%)
Grade	Grade 6	1 (.3%)
	Grade 7	114 (38.8%)
	Grade 8	163 (55.4%)
	Not specified	16 (5.4%)

The student surveys collected data on three dimensions of student attitudes on a 5-point scale (1 = low or negative, 5 = high or positive): **confidence** (9 items) and **interest** (8 items) towards CS and in tasks to be facilitated by the program (e.g., creating apps, debugging), and perceptions on **culturally responsive computing** (CRC, 11 items). The CRC items were designed to understand to what extent 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 culture; 3) they can make apps connecting with their interests, life experiences, culture and serving their community. These items were inspired by the Culturally Responsive Teaching (CRT) Survey [11], 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 values of Cronbach's Alpha ranged from .87 to .94 for the pre-survey and .88 to .95 for the post-survey, indicating the internal consistency reliability was good for both surveys. The surveys were distributed through Qualtrics by 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 from 7th Grade and 68 from 8th Grade.

3.3 Data Analyses

Student survey analyses. We conducted two sets of analyses using the responses from the 294 students who answered both pre- and post-surveys. First, descriptive statistics and paired sample t-tests were conducted to understand students' attitudes based on the pre- and post-survey responses. These tests compared the mean differences in students' attitudes (overall, confidence, interest, and CRC). The results provided us with an initial understanding of students' attitude changes. Second, one-way ANOVA tests were used to examine whether students' attitudes differed significantly by gender and race. Paired sample t-test was used 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 were conducted using Tukey's HSD to further compare the overall attitudes of different student groups, and Bonferroni tests were conducted for multivariate pairwise comparisons.

Analyses of student apps. 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. Aligned with CRP teaching practices their teachers might implement, apps were 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., *quiz, survey,* and *service apps*), *game, or multiple.* An informational app provides the user with information. A utility app was designed as a tool for the user, 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 aforementioned 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 [18], aligned with the project curriculum's learning objectives. The rubric focused on basic App Lab functionality and the CS concepts introduced by the project 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 hyperlinks, images, sounds, buttons, and user inputs). The apps were scored using a 1-3 scale (1-beginner, 2-proficient, 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 11-15 points. Apps with data storage features gained extra 3 points.

4 RESULTS

4.1 Student Attitudes and Learning Experiences

4.1.1 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: $M = 3.13$, $SD = 1.16$; post: $M = 3.37$, $SD = 1.03$; $t(244) = -10.89$, $p < .001$], interest [pre: $M = 3.16$, $SD = 1.19$; post: $M = 2.97$, $SD = 1.16$; $t(246) = 8.74$, $p < .001$], and CRC attitudes [pre: $M = 3.71$, $SD = 0.99$; post: $M = 3.65$, $SD = 0.95$; $t(249) = 3.37$, $p < .001$]. 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 margin decline (*diff.* = -0.06).

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 3. 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 the confidence items, students rated consistently highest on "I can learn to code" in both pre-survey (M = 4.01) and post-survey (M = 4.06).

Table 3. Items with Significant t-test Results ($P < .01$)

Confidence (Conf), Interest (Inst), CRC	Pre		Post		*t*
	M	*SD*	*M*	*SD*	
Conf: Good at coding	2.58	0.99	3.04	0.97	6.89
Conf: Create my own apps	2.42	0.97	3.09	0.98	-9.71
Conf: Code to make an app work	2.80	1.10	3.38	1.00	-7.70
Conf: Create apps to help others	2.78	1.07	3.14	0.95	-5.23
Conf: Good at coding (by others)	2.38	1.13	2.62	1.15	-3.20
Inst: Like coding	3.30	1.19	3.13	1.18	2.74
Inst: Like creating apps	3.27	1.17	3.10	1.16	2.77
Inst: Creating apps to help others	3.30	1.10	3.10	1.05	3.00
Inst: Debugging 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: Learn more about coding	3.47	1.09	3.06	1.10	6.83
CRC: Feel welcomed in classroom	4.01	0.83	3.88	0.83	2.76
CRC: Learning about my community	3.86	0.86	3.71	0.86	2.64

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

4.1.2 Comparing Students' Attitudes by Gender

Table 4 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 awareness of cultural responsiveness, 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 result showed that students of different gender had significantly different attitudes overall. Both pre-survey [$F(2, 291) = 9.24$, $p < .001$] and post-survey [$F(2, 291) = 15.97$, $p < .001$] comparisons across the three gender groups were significantly different. Tukey's HSD post-hoc analysis of the gender groups indicated that male students rated significantly higher on the overall attitude than female students in both pre-survey (*diff.* = 0.12, $p < .001$) and post-survey (*diff.* = 0.14, $p < .001$). No significant difference was found between the male group and the *other* group, nor female and *other* groups. Multivariate pairwise comparisons using Bonferroni test indicated that the difference between male and female students' overall attitude was contributed by the difference in their interest. Male students reported significantly stronger interest than female students in both pre-survey [$F(3, 291) = 7.49$, $p < .001$] and post-survey [$F(3, 291) = 4.80$, $p < .001$].

Table 4. Comparing Students' Attitudes by Gender

		Male (143)		Female (115)		Other* (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

*Other incudes "non-binary", "do not wish to say", and blank responses.

4.1.3 Comparing Students' Attitudes by Race

When analyzing the ethnic differences, data from Native Hawaiian/Pacific Islander (n=1) and Native American/Alaskan (n=3) students were removed due to the small sample sizes. As presented in Table 5, African American and White students had the highest overall attitude scores in both pre- and post-surveys. Students from all race groups perceived that their confidence increased after learning the project curriculum. However, their interest decreased across all race groups. African American and White students' interest remained higher than other groups. Asian (all) and Southeast Asian (only) students showed a slight increase in their CRC attitudes, while all other groups' attitudes decreased marginally. Based on a Welch's ANOVA test, students of different ethnic groups did have significant different attitudes both before [$F(5, 273) = 15.45$, $p < .001$] and after [$F(5, 273) = 10.92$, $p < .001$] learning the project curriculum.

Table 5. Student Attitudes by Race/Ethnicity

		Confidence		Interest		CRC		Overall	
		Pre	Post	Pre	Post	Pre	Post	Pre	Post
African America	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	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	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
Multi-Race	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

Post-hoc analyses using Tukey's HSD indicated that in the **pre-survey**, Southeast Asian students rated significantly lower on overall attitude compared to White students (*diff.* = -0.17, $p < .001$).

White students had the highest score on their overall attitude among all the ethnic groups, but that was only significantly higher than the Southeast Asian group. In the **post-survey**, Hispanic students scored the lowest on overall attitude ($M = 3.25$, $SD = 1.20$), which were significantly lower than White (*diff.* = -0.19, $p < .001$), African American (*diff.* = -0.25, $p < .001$), and Asian students (*diff.* = -0.14, $p < .001$). The Southeast Asian group only presented a significantly lower attitude score than the African American (*diff.* = -0.15, $p = .03$). African American students had the highest overall score in the post-survey. Moreover, the difference between white and southeast Asian groups was no longer significant (*diff.* = -0.09, $p = .05$). Bonferroni test showed that the differences among Asian students and other groups in the pre-survey were because of their low interest compared with African American students [$F(5,273) = 3.44$, $p < .01$].

4.1.3 Comparing Students' Attitudes by Grade

Descriptive statistics indicated that Grade-8 students had lower scores across all three attitude constructs than 7th-graders. Among the three attitude constructs, 8th-grade students' interest was the lowest from both pre- and post-surveys. Paired t-tests on pre-survey and post-survey showed 7th-grade students reported significantly higher confidence, interest, and CRC attitudes than 8th-grade students ($p < .001$).

Table 6. Students' Attitudes by Grade

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

4.2 Culturally Responsive Apps

In this section, we report the results on student apps, in terms of the topics students chose, app type, and app complexity.

4.2.1 App Topics

Seven culturally responsive app topics emerged from the analysis (Table 7). The seven themes reflected cultural responsiveness [9]. First, the most popular apps were about students' personal interests, such as sports and music. In these apps, students tended to use trivia questions to check users' knowledge of the topics of interest. In addition, some apps were design 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 to their lives and their community. Those apps provided information about an issue impacting them, for example, *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 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).

Table 7. Themes of Culturally Responsive App Topics

Emerging Theme	No.	Example
1. Personal interest	31	Disney Movie Quiz
2. Understanding themselves & 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

The variety of themes emerged from students' choices of app topics demonstrates that students were able to connect their personal interests, culture, and life experience to coding and creating apps for community and social good. These artifacts presented their engagement and ability to learn coding in a meaningful way. Their interest in tackling social and community issues shows how students were motivated to become change agents for their community and society.

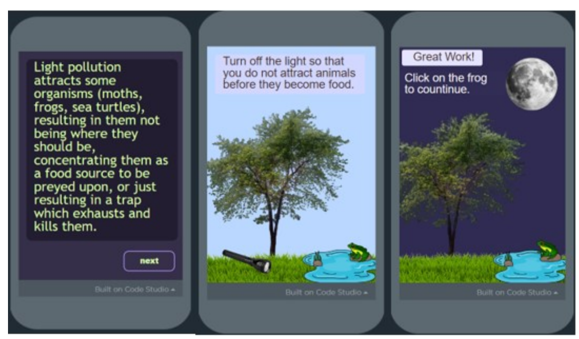

Figure 1. An Example of Student App on Light Pollution

4.2.2 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 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 the techniques for relieving anxiety and stress. There were also 2 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 included a game, quiz, or survey to introduce a community issue and enhance users' knowledge or awareness of the topic.

4.2.3 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 8 presents the average scores of apps in the beginner (1-5 points), proficient (6-10 points), and advanced (11+ points) categories.

Table 8. 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
	Mac	5	10	16
	M (SD)	4.52 (0.99)	6.42 (0.99)	13.56 (1.59)

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 socially/culturally responsive apps. Those proficient apps included three to six screen changes and successful execution of a variable, conditional, 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 [3].

5 SUMMARY & DISCUSSION

This study explored preliminary results of students' learning experiences and outcomes from a culturally responsive middle school CSDL curriculum, which focused on creating culturally responsive apps serving students, their local communities, and the larger society. Our findings indicated that students were able to engage in meaningful CS learning in creating culturally responsive apps. They also built confidence in coding and creating apps through this process. Results from student apps further demonstrated their ability to create basic culturally responsive apps, meeting the curriculum goal.

On the other hand, the student survey results indicated that their interest in learning coding and creating apps significantly decreased after learning the curriculum. There were gender, grade, and racial differences in students' interest. First, female students had significantly lower interest than male students, and 8th graders' interest was lower than that of 7th graders. 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 [7]. Our finding indicated that brief exposure to a culturally responsive CS curriculum was useful but insufficient to address the gender and grade gaps. Further study is needed to effectively address these gaps. This study also found that African American students reported more positive attitudes toward learning CS and creating culturally responsive apps. Southeast Asian students were able to catch up with other groups of students. This result might indicate some promise of a CRP-embedded CS curriculum in serving these historically under-represented groups [12].

We acknowledge that this study has limitations. First, we encountered a major challenge with low response rates of parental consent and student responses. This study was able to use survey results from only less than one-third of the participating students. Second, students in this study had a short exposure to the project CS curriculum, and only self-reported survey data and app products were collected to understand their learning outcomes. Moving forward, we plan to follow up with those students with surveys and collect additional qualitative data (e.g., interviews and class observations) to further understand their learning experiences and how CRP can be effectively enacted to engage students of diverse backgrounds.

ACKNOWLEDGMENTS

We thank the participating students, teachers, district partners, and project staff (Foozieh Mirderikvand, Hsien-Yuan Hsu, Diane Schilder, and Pauline White) for their support. This work is supported by the National Science Foundation under Grants No. 1923452, and No. 1923461. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the National Science Foundation.

REFERENCES

[1] Eglash, R., Gilbert, J. E., & Foster, E. (2013). Toward culturally responsive computing education. *Communications of the ACM*, *56*(7), 33-36.

[2] Gay, G. (2018). *Culturally responsive teaching: Theory, research, and practice*. New York, NY: Teachers college press.

[3] Grover, S., Basu, S., & Schank, P. (2018, February). 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* (pp. 999-1004).

[4] Hammond, Z. (2015). *Culturally responsive teaching and the brain: Promoting authentic engagement and rigor among culturally and linguistically diverse students*. Corwin Press.

[5] Kafai, Y. B., Lee, E., Searle, K., Fields, D., Kaplan, E., & Lui, D. (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), 1-20.

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

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

[8] Lachney, M., Eglash, R., Bennett, A., Babbitt, W., Foy, L., Drazin, M., & Rich, K. M. (2021a). pH empowered: community participation in culturally responsive computing education. *Learning, Media and Technology*, *46*(3), 333-354.

[9] Ladson-Billings, G. (1994) *The dreamkeepers*. San Francisco, CA: Jossey-BASS.

[10] Lee, J., Husman, J., Scott, K. A., & Eggum-Wilkens, N. D. (2015). COMPUGIRLS: Stepping stone to future computer-based technology pathways. *Journal of Educational Computing Research*, *52*(2), 199-223.

[11] Leonard, J., Mitchell, M., Barnes-Johnson, J., Unertl, A., Outka-Hill, J., Robinson, R., & Hester-Croff, C. (2018). Preparing Teachers to Engage Rural Students in Computational Thinking Through Robotics, Game Design, and Culturally Responsive Teaching. *Journal of Teacher Education*, *69*(4), 386–407.

[12] Lewis, C. M., Shah, N., & Falkner, K. (2019). 16 Equity and Diversity. In S. A. Fincher, & A.V. Robins (Eds.), *The Cambridge handbook of computing education research* (pp. 481 – 510). Cambridge University Press.

[13] Ni, L., Martin, F., Bausch, G., Benjamin, R., Hsu, H., & Feliciano, B. (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.

[14] Ni, L., Bausch, G., Feliciano, B., Hsu, H., & Martin, F. (2022). Teachers as curriculum co-designers: Supporting professional learning and curriculum implementation in a CSforAll RPP project. In *Proceedings of 2022 Conference on Research in Equitable and Sustained Participation in Engineering, Computing, and Technology (RESPECT)*. 1-8. IEEE.

[15] Madkins, T., Thomas, J. O., Solyom, J., Goode, J., & McAlear, F. (2020). Learner-centered and culturally relevant pedagogy. In S. Grover (Ed.), *Computer science in K-12: An A-to-Z handbook on teaching programming* (pp.125-129). Edfinity.

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

[17] Richards, H. V., Brown, A. F., & Forde, T. B. (2007). Addressing diversity in schools: Culturally responsive pedagogy. *Teaching Exceptional Children*, *39*(3), 64-68.

[18] Sherman, M., Martin, F., Baldwin, L., & DeFilippo, J. (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.

[19] Scott, K. A., Sheridan, K. M., & Clark, K. (2015). Culturally responsive computing: A theory revisited. *Learning, Media and Technology*, *40*(4), 412-4.