A High School Camp on Algorithms and Coding in Jamaica

Daniel T. Fokum*
daniel.fokum@uwimona.edu.jm

Zaria Chen Shui*
zaria.chenshui@mymona.uwi.edu

Kerene Wright*
kerene.wright@mymona.uwi.edu

Orr Paradise†
orrp@eecs.berkeley.edu

Gunjan Mansingh*
gunjan.mansingh@uwimona.edu.jm

Daniel Coore*
daniel.coore@uwimona.edu.jm

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Abstract

This is a report on JamCoders, a four-week long computer-science camp for high school students in Jamaica. The camp teaches college-level coding and algorithms, and targets academically excellent students in grades 9–11 (ages 14–17).

Qualitative assessment shows that the camp was, in general terms, a success. We reflect on the background and academic structure of the camp and share key takeaways on designing and operating a successful camp. We analyze data collected before, during and after the camp and map the effects of demographic differences on student performance in camp. We conclude with a discussion on possible improvements on our approach.

1 Introduction

We report on *JamCoders*, a four-week coding camp for high school students in Jamaica. The camp targets a pool of academically excellent, yet demographically diverse, students from urban and rural areas across all parishes of Jamaica. There were no mathematical or programming prerequisites; the only requirement on applicants was that they are in grade 9–11, i.e., ages 14–17.

The majority of the population of Jamaica in which the camp was held are members of ethnic groups underrepresented in Computing [17]. In fact, over 90% of the population identifies as black. To increase Computing education opportunities in Jamaica, it is important to understand the barriers affecting student interest and retention.

Previous work shows that one potential factor contributing to the under-representation of these groups may be limited early exposure to Computing [1, 16, 21, 7]. Indeed, within Jamaica, most students are given the option to graduate from high school with no Computing exposure. Another known inhibiting factor is a high student-teacher ratio [11, 14]. The camp attempted to directly address these two factors by offering a summer camp for high schoolers with a relatively low teacher-student ratio of 1:4. The camp experience, provided at no cost to the students, included meals, lodging and a Computing lab hosted on a local university campus.

The camp succeeded in securing applications from all parishes of Jamaica, with 51% of these applicants being female students. The admission process ensured that there was gender balance and equitable representation of students from across the country.

The camp required a significant investment of financial and human resources. Our goal in this report is to communicate the structure and implementation of this ambitious project, and analyse data collected from the camp so as to understand how these resources could be better invested in the future. We hope that

*The University of the West Indies, Mona.
†University of California, Berkeley.

this report informs other educators who are considering organizing a similar camp in the future, as well as scholars researching Computing education in similar settings to ours.

Outline Section 2 reviews related work on middle school and high school coding camps. Section 3 provides details about this camp, our research questions, and the collected data. Section 4 offers statistical analysis of this data, and Section 5 discusses our findings. In Section 6, we share limitations of our work. We provide concluding remarks in Section 7.

2 Related Work

The use of summer camps to introduce coding and technology to high school students has been explored by many Computer Science education researchers [5, 9]. Several coding camps were developed with the intention of supporting minorities within Computing and were found to be successful in targeting these groups through their recruitment process or camp design [3, 13, 2, 10]. Similarly, the organizing team of this camp incorporated a deliberate recruitment process towards including students from each parish of Jamaica. Bryant *et al.* [3] describes a camp that emphasizes data science for social good in order to attract minority groups that are likely to prioritize careers that improve their communities. Grant [10] investigates a coding camp designed exclusively for girls. Krug *et al.* [13] discusses a camp based upon using code to make hip hop beats and appeal to urban youth of color who are likely to enjoy this genre of music. Begel *et al.* [2] aimed to increase Computing exposure for students with autism by designing and implementing an entirely remote summer camp, intending to prioritize comfort and accessibility.

Coding camps have been found to improve systematic problem-solving skills, interest in coding, and coding-related confidence [15, 10, 19]. In particular, Bryant *et al.* [3] found that self-efficacy increased more for girls than boys. However, the aforementioned coding camps lasted for only one week and were not generally designed to introduce algorithms and algorithmic thinking within their respective curricula [15, 6, 12]. Bryant *et al.* [3] did expose students to algorithms within the context of using data science for social good, and Chen *et al.* [4] present a camp that exposed students to the application of algorithms within the digital humanities. The current paper similarly diverges from this non-algorithmic trend and discusses a camp that explicitly sets out to teach high school students college-level programming and algorithms. This camp is different as it lasts 4 weeks instead of the literature's established standard of 5 days.

Robotics summer camps have been found to boost middle school student interest in engineering careers [19], possibly because these camps expose youth to material and skills to which they have not been previously introduced [15]. By similarly introducing students to concepts to which they have not yet been exposed, the camp described in the current paper sought to increase student interest in related Computing careers. Research into the previously mentioned robotics program went on to show that participation in robotics camps, clubs, and competitions improved robotics related self confidence and promoted STEM learning, including knowledge of programming. In Section 4.3, we explore this further by discussing the impact of prior participation in STEM clubs on programming and algorithms performance while at camp.

3 Study Design

This section documents our study design. We present an overview of the camp, the camp syllabus, our research questions and the data collection approach.

3.1 Camp Overview

This 4-week summer residential camp focused on teaching high school students college-level programming and algorithms. The intent was to expose students to programming and develop their problem-solving skills. The academic schedule of camp consisted of lectures followed by lab sections in which students solved programming exercises related to the concepts introduced in the lecture. Additional details about camp are provided next.

Camp Staff Academic staff consisted of 4 lecturers and 11 teaching assistants (TAs). Lecturers were senior Computer Science researchers (tenured faculty or equivalent), with each lecturer present for exactly one week of camp for a total of 12 on-site academic staff. Among the TAs, there were seven graduate-level and four undergraduate-level Computer Science students. Three academic staff members were local (one lecturer, two TAs), and the rest traveled from abroad.

Non-academic staff consisted of 8 "chaperones" responsible for the students' safety and well-being. In addition, the camp was supported by university facilities (administration, cooking, cleaning, and healthcare) and an organizing committee.

Student Recruitment and Admission Students were recruited indirectly by organizers contacting high schools in all parishes of Jamaica, with the goal of including students from every parish. School administrators, teachers, and parents then encouraged students to apply. Applications were collected in an online portal. Student applicants submitted transcripts from the last two academic years, a short essay on why they would like to attend, and demographic details: name, age, gender, grade, and high school. In all, there were 432 applicants and 1 additional student who was referred to the organizers by a government agency outside of the application process. Amongst the 432 applicants there were 222 female applicants and 210 male applicants.

Applications were reviewed by TAs and a member of the organizing team over three rounds. First, applications were split amongst the TAs and reviewed using a provided rubric evaluating the applicant's transcript and essay. Based on these, each reviewer composed a *long list* of potential applicants (the remainder were rejected). The second round involved each reviewer evaluating a different long list based on the same rubric, so that each long-listed application received two reviews.

Reviewers then met to narrow down the cumulative long list, taking into account each applicant's parish and high school. By the end of this process, 50 high school students from across Jamaica were offered admission to the camp (acceptance rate 11.5%). While all 50 students accepted their offer to join the camp, only 48 students actually attended.[1] Given the racial and ethnic makeup of Jamaica's population, race was not considered during the selection process. However, all but one of the students were of black origin.

Syllabus The camp syllabus was modeled after an affiliated camp, *AddisCoder*, that targets a similar audience in Ethiopia. A few changes had to be made to accommodate the different mathematical background of students in the two countries.

1. Python programming constructs (types, operators, conditional statements, loops, functions, lists and dictionaries).
2. Recursion.
3. Big O notation and asymptotic running time analysis.
4. Searching and sorting algorithms (linear search, binary search, selection sort, and merge sort).
5. Graphs (breadth-first search and depth-first search).

See `https://jamcoders.org.jm/syllabus/2023/` for a full syllabus, lecture notes, exercises and exams.

[1]It is unknown why the two students did not attend.

Lectures and Labs The academic portion of camp took 8 hours/day, including breaks and transitions, and consisted of two sessions (morning and afternoon), with an hour-long lecture and two hours of lab in each. Each week, lectures were given by a different lecturer.

Lab sessions were led by the TA team. Each lab would start with a recap session reiterating concepts needed for the lab, and an open discussion about any concepts the students struggled with in the preceding lecture. Following this, students would complete exercises on individual computers, during which they could ask for help from the 11 TAs by raising their hand. If multiple students seemed to be interested in hearing clarifications about certain topics while attempting the lab exercises, the TAs would offer impromptu sessions in a separate classroom. This meant that students could elect to be exposed to the material multiple times, in a variety of settings, in order to cement their understanding.

Quizzes and Study Halls Students received three quizzes during the camp. The first quiz, which we called quiz 0, was an ungraded mock exam held in Week 2. The purpose of this quiz was to prepare students for quizzes 1 and 2, which were graded. These quizzes were administered in weeks 3 and 4. In the evening before each quiz, optional "Study Hall" sessions were held outside of the student dorms. In these open-ended revision sessions, students could ask the TAs present questions about any portion of the material (as opposed to labs, which were focused on the preceding lecture). The five commuting students were accommodated via a virtual option facilitated by one TA.

Big Siblings At the end of Week 1, each student was assigned a TA as their "Big Sibling." TAs would then meet their "Little Siblings" (in groups or individually) in informal sessions meant to complement the technical guidance given in lab. The goal was to make sure that each student has at least one TA they are comfortable talking to about *any* emotional and academic challenges that arise in this academically-intensive camp. On the other hand, the small number of Little Siblings allocated to each TA (4–5 per TA) ensured that the academic team was generally aware of the state of each student and could provide personalized support.

Academic Staff Meetings At the end of each academic day, TAs and the on-site lecturer met for a *debrief* to reflect on the day's events and make adjustments for future days. Additionally, each week was preceded by an academic all-hands meeting of TAs with the incoming lecturer to report on the camp status and finalize content for the upcoming week.

3.2 Research Questions

The following research questions guided our study of this 4-week algorithms and coding camp for high school students:

RQ1. Are there gender differences in performance between male and female students?

RQ2. Does school location or school ranking have an impact on student performance?

RQ3. How does participation in a STEM club at a school affect student performance?

RQ4. What are the changes in students' attitudes toward studying Computing after taking part in the camp?

3.3 Data collection

During the camp the students received two graded quizzes (at the end of Weeks 3 and 4). The quizzes were taken by all attending students: 48 for the first quiz and 47 for the second.[2] Each quiz covered the entire material taught until its date, and was scored out of 100 points.

[2]One student could not attend the second quiz due to a severe illness.

Our dataset consists of quiz scores aligned with student demographic information. Quiz scores are our only "traditional" metric for performance in the camp.

Following the camp, a survey was sent to students collecting feedback about camp and additional demographic information. Of the 48 students, 24 filled out the survey and consented to analysis of their responses.[3]

4 Results

In this section we present the results showing student performance on the quizzes administered during the camp. These results are presented to highlight the answers to the research questions posed in Section 3.2. We rely on nonparametric statistical tests for our analysis given that the quiz scores are not normally distributed.

4.1 Gender Differences

Of the 48 students who took part in the camp, 28 were female, and 20 were male. To answer RQ1, we examined two boxplots of Quiz 1 scores grouped by gender, as shown in Figure 2. The numbers within each boxplot represent the mean for each group.

From Figure 2, it is clear that the median score on Quiz 1 for male students was greater than that for female students. The same was true for the variations in scores (larger variation among male students). However, a Wilcoxon signed rank test showed that the difference in median scores between the genders was not statistically significant ($W = 351.5; Z = 1.5; p = 0.1375$). A similar analysis for Quiz 2 yielded the same comparisons.

Figure 3 shows per-student performance improvement. While the performance improvement for female scores *increased* by about 10.7 points, male student scores *decreased* by about 1.5 points. We provide one possible explanation for this noticeable difference in Section 5.

A Wilcoxon signed rank test showed that there was a statistically significant difference ($W = 167; Z = -2.36; p = 0.0176$) between the median improvement in scores between Quiz 1 and Quiz 2 for female and male students.

4.2 Impact of School Location and Rank

School Location The Jamaican Ministry of Education classifies high schools as being in either rural or urban locales. Of the 48 students selected, 40 attended an urban high school, 7 a rural school, and 1 attended a foreign school in another small island developing state. This foreign student was excluded from the analysis in this section. The median Quiz 1 grade for urban students was 74.7 whereas the corresponding statistic for rural students was 37.8. A Wilcoxon signed rank test showed that there was a statistically significant difference ($W = 219; Z = 2.36; p = 0.0190$) between the median score for urban and rural students. In Quiz 2, urban students outperformed rural students with a statistically significant difference ($W = 211; Z = 2.12; p = 0.0351$). Figure 4 shows the performance improvement in scores from Quiz 1 to Quiz 2. Figure 4 shows that the average performance improvement in scores from Quiz 1 to Quiz 2 was about +14.5 points for rural students, whereas on average the urban students scored about +6.3 points more on Quiz 2 compared to Quiz 1. Furthermore, this performance improvement was statistically significant ($W = 70; Z = -2.38; p = 0.0160$). As a result, we conclude that the rural students improved more between the quizzes. In Section 5, we will provide one argument for this observation. We also examined the differences between students who participated in STEM clubs in schools versus those who did not. Due to constraints of a small data set, we did not find statistically significant differences.

A Wilcoxon signed rank test showed that there was a statistically significant difference ($W = 69; Z = -2.12; p = 0.0330$) between the median performance improvement from Quiz 1 to Quiz 2 for urban and rural students.

[3] One respondent completed the survey but did not consent to having their data analysed; it is excluded from our dataset.

School Rank Within Jamaica, a nongovernmental organization has ranked high schools at periodic intervals based on student performance in regional examinations. Some schools are excluded from the rankings if the school does not meet the NGO's minimum requirement for ranking.[4] For the camp, 22 students came from schools ranked between 1 and 10, 8 from schools ranked between 11 and 20, 5 from schools ranked between 21 and 30, and 12 from unranked schools. Figure 5 shows boxplots with Quiz 1 grades and the school rank.

From Figure 5, it is seen that the median score for students declines as the school rank decreases. The exception is schools that are ranked between 11 and 20. Repeated pairwise Wilcoxon signed rank tests show that a statistically significant difference in the median Quiz 1 scores only existed between those students from the top-ranked and unranked schools ($W = 219.5; Z = 3.15; p = 0.0017$).

4.3 Impact of a STEM Club

High schools in Jamaica have different STEM-related clubs for students, e.g., math, Computing/software engineering, robotics, engineering, environmental, chemistry, and medical study based clubs. To answer RQ3, we examined student report cards and application essays for evidence of participation in these clubs. The review of student records showed that 18 students participate in STEM clubs, while 30 did not.

From Figure 6 it is clear that students who participated in a STEM club at school generally performed better on Quiz 1 than non-participants. The median Quiz 1 grade for students participating in STEM clubs was 80.4% whereas the corresponding statistic for non-participants was 57.4%. A Wilcoxon signed rank test showed that there was not a statistically significant difference ($W = 353; Z = 1.77; p = 0.0789$) between the median score for participants and non-participants in STEM clubs. Similar analysis for Quiz 2 also reflected no statistically significant difference ($W = 361; Z = 1.94; p = 0.0539$).

The average performance improvement from Quiz 1 to Quiz 2 was about +5.6 (median 11.4) points for students who were non-participants in STEM clubs, whereas on average the STEM club participants scored about +5.9 points (median 4.6) more on Quiz 2 compared to Quiz 1. A Wilcoxon signed rank test showed that there was not a statistically significant difference ($W = 213; Z = -1.21; p = 0.2314$) between the median performance improvement from Quiz 1 to Quiz 2 for STEM club participants and non-participants.

4.4 Changes in Attitude toward Studying Computing

To answer RQ4, we conducted a post-camp survey (24 responses) which included these two questions: (a) state your preferred majors in college/university before the camp, and (b) state your desired major in college/university after the camp. Nine students responded that they wanted to major in Computer Science or a Computing-related discipline prior to the camp. Following the camp, 14 students said that they wanted to major in Computer Science or a Computing-related discipline. Looking at the results in greater detail, it was seen that six students who did not want to major in Computing prior to the camp thought that they would like to major in Computing after the camp. However, there was one student who wanted to major in Computing prior to the camp, who then indicated that he/she wanted to study a non-Computing discipline after the camp. These two numbers amount to a net increase of five students who wanted to major in Computing disciplines in university/college following the camp. We conclude that the camp had a positive impact on student interest in pursuing higher education in Computing.

5 Discussion

Next, we expand on the quantitative analysis of Section 4 with additional perspectives from the camp staff.

[4]The nongovernmental organization ranks high schools on the basis of the institution's cohort leaving grade 11 with passing scores in five (or more) subjects, including mathematics and English, at one sitting. Schools that have less than 50% of the cohort leaving grade 11 with five or more subjects, including mathematics and English, are excluded from the ranking.

Big Siblings as urban-rural equalizers The Big Sibling program was determined to be a success, especially for students from schools ranked 21–30 or unranked. A significant amount of time and effort, during and outside the classroom, was invested in students who were slower to understand early topics. Indeed, TAs assigned as Big Siblings to these students directed more of their efforts towards tutoring these students on early topics, averting an unbridgeable gap later on.

This qualitative testimony is supported by our analysis in Section 4.2: students from rural areas were slower to understand early topics (lower Quiz 1 score) and, therefore, received increased tutoring from their Big Siblings. The result: students from rural areas improved 14.1 points between quizzes, compared to just a 3.9-point improvement for students in urban areas.

Why did female students improve more than male students? Female students improved significantly more than their male counterparts between quizzes (+10.7 versus -1.5 points, respectively). Camp TAs could not provide a qualitative explanation,[5] and so we turn to the literature: Female student population in other Caribbean islands are underrepresented in higher education Computing programs [8], yet are known to academically outperform their male counterparts at a general high-school level [20]. Could it be that the same societal factors that inhibit female student success in Computing positioned them at a disadvantage at the start of our camp, yet their academic ability helped them bridge the gap by the end of it? At the very least, we conclude that camp was a comfortable environment for female students to learn and improve.[6]

Changes in attitudes towards studying Computing It is worth noting that the camp resulted in a net gain of five students who wanted to major in Computer Science in university/college. Two of the five students come from schools where they are not required to take "Information Technology" for the grade 11 regional examinations. In addition, their schools do not offer Computer Science at the grade 13 regional examinations. Thus, the coding camp provides students to high quality Computer Science instruction, and it also attracts more students to the discipline.

Heterogeneity affords gaps The camp organizers explicitly sought to recruit a diverse pool of students in terms of gender, age, parish, school locale (urban/rural) and rank. As seen in Section 4, these demographics were sometimes noticeably correlated with quiz score in camp. Throughout camp, the academic staff emphasized repeatedly to the students that quiz scores should not be viewed as the main outcome of camp, but rather as a form of feedback (indeed, these scores are not reported back to the high schools or parents). We ask our reader to do the same: scores are convenient for statistical analysis, but students that scored below average did not, by any means, "fail" at camp.[7]

6 Limitations

Data collection The *STEM club participation* demographic may be underreported in our dataset, as we manually collected it from essays and transcripts but not all transcripts explicitly report this. Our reliance on two quiz grades as a sole metric is fundamentally limited by the imperfection of examination as a measurement of understanding (see, e.g., an early concern in [18]).

[5]In particular, TAs reported that female students did *not* receive noticeably more tutoring than male students, unlike the urban-rural case above.

[6]To quote a female student: "This camp not only teach me about coding and algorithm, but is a *safe space* for children my age that have a common interest in technology."

[7]Consider a student that initially refused to take the first quiz for fear of earning a low score; a lengthy conversation with her Big Sibling conveyed that attempting a significant challenge and failing is, sometimes, more rewarding than not facing it at all. The student took the first quiz and indeed earned the lowest score in class. But in the second quiz, the student improved threefold! On graduation day, neither staff nor the student viewed the student's performance in camp as a failure.

Author positionality This paper was authored by some members of the academic staff or organizing team of the camp. All but one author are Jamaican locals and affiliated with the university in which the camp was located. This deep and personal understanding of the camp and its context may be viewed as either an advantage or a disadvantage (or both).

7 Conclusions

Our work examines a summer camp that teaches college-level algorithms and programming to high school students in grades 9–11. The camp successfully included demographically diverse students, with 15%/83% students from rural/urban schools,[8] and 58%/42% female/male students, respectively. We found that female students improved significantly more over the duration of the camp than their male counterparts, and likewise for rural versus urban students. This demonstrates that camp can be an effective and empowering exposure to Computing, even in a heterogenous environment.

A low student-teacher ratio can help maximize student success [11, 14]. We found this to be particularly true when examining the impact of the Big Sibling program on the rural-urban divide in student performance. A low student-teacher ratio allowed each Big Sibling to give personalized tutoring to all of their assigned students, with no student left behind.

We conclude that introducing advanced Computer Science concepts at a young age is possible, even in a student population of mixed background and life opportunities. A low student-teacher ratio was instrumental in identifying and supporting at-risk and underrepresented students. We recommend the inclusion of a similar Big Sibling program in any coding camp with sufficient academic staff, especially when the camp population is demographically heterogeneous.

A main goal of this camp was to introduce Computing as a viable career option (or at the very least, area of interest) to students in an island whose population is almost-entirely underrepresented in the field of Computer Science. Our post-camp survey found that 58% of respondents would like to major in Computing at a tertiary level. This includes 25% of respondents who previously did not want to major in Computing.[9]

This profound change imparts the impact of such a camp, which offers students from all backgrounds the opportunity to gain Computing exposure for free and with the academic support required to bridge existing knowledge gaps. If well-delivered, these camps can result in even more people from diverse backgrounds being drawn into the discipline.

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[8] There was a single student from a foreign school.

[9] Rest assured, only one respondent who previously wanted to major in Computer Science changed their mind after camp.

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A Figures

Variable	Data type	Data values	Mean	Median
Quiz 1 score	Float	8.3–99.1	62.5	70.7
Quiz 2 score	Float	15.8–98.3	69.7	73.3
Performance improvement	Float	-21.1–41.8	7.9	8.4
			Mode (count)	
Gender	Categorical	Male, Female	Female (28)	
Grade	Categorical	9, 10, 11	11 (26)	
Residence type	Categorical	Commuting, Dorm	Dorm (30)	
School locale	Categorical	Rural, Urban	Urban (40)	
School rank	Categorical	1–10, 11–20, 21–30, Unranked	1–10 (22)	
STEM club participant	Categorical	Participant, Non-participant	Non-participant (30)	

Figure 1: List of variables and summary statistics. Mean and median is reported for float type variables, and mode reported for categorical variables. Performance improvement is defined as the score on Quiz 2 minus the score on Quiz 1.

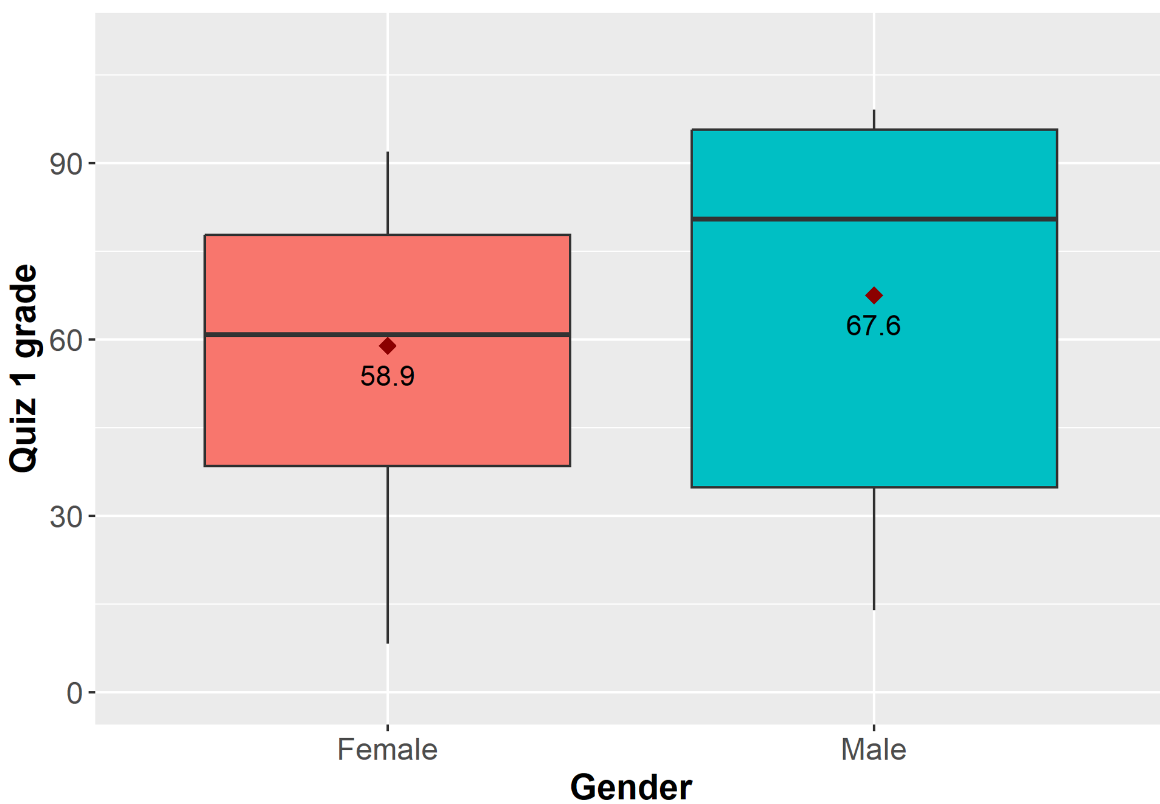

Figure 2: Boxplot showing quiz 1 scores by gender

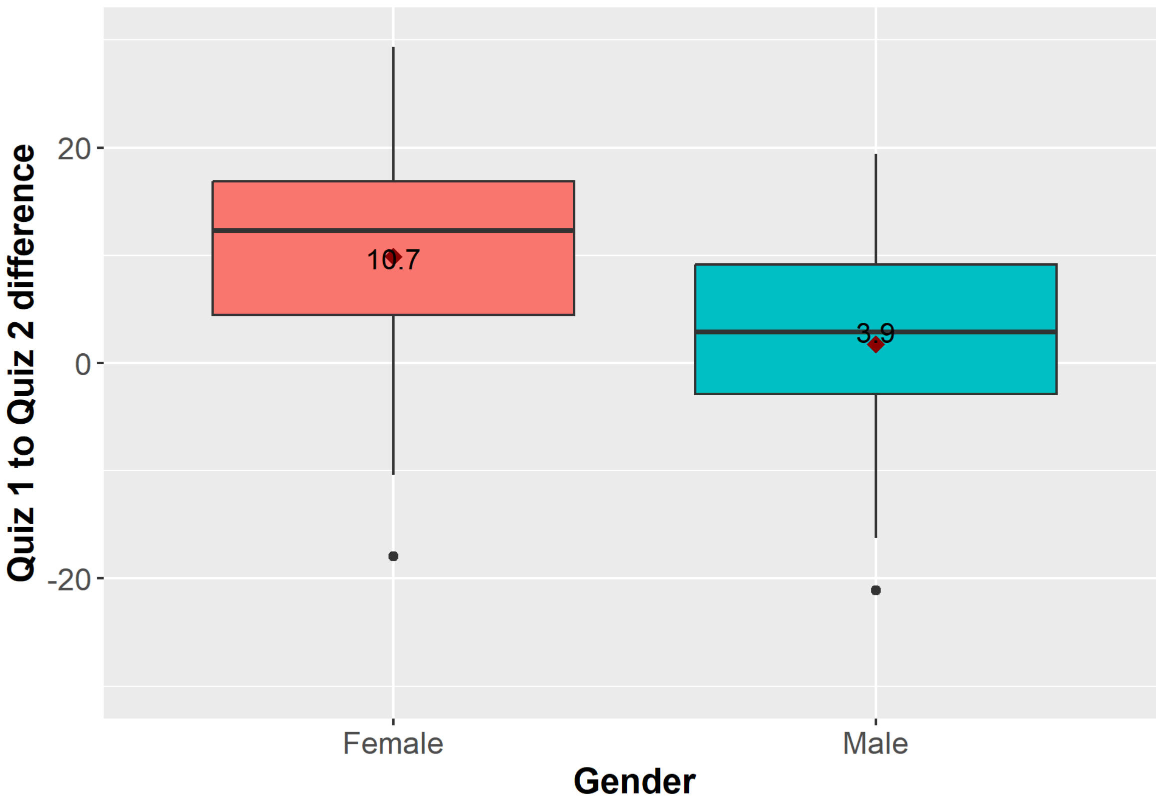

Figure 3: Boxplot showing improvement in scores from Quiz 1 to Quiz 2 by gender

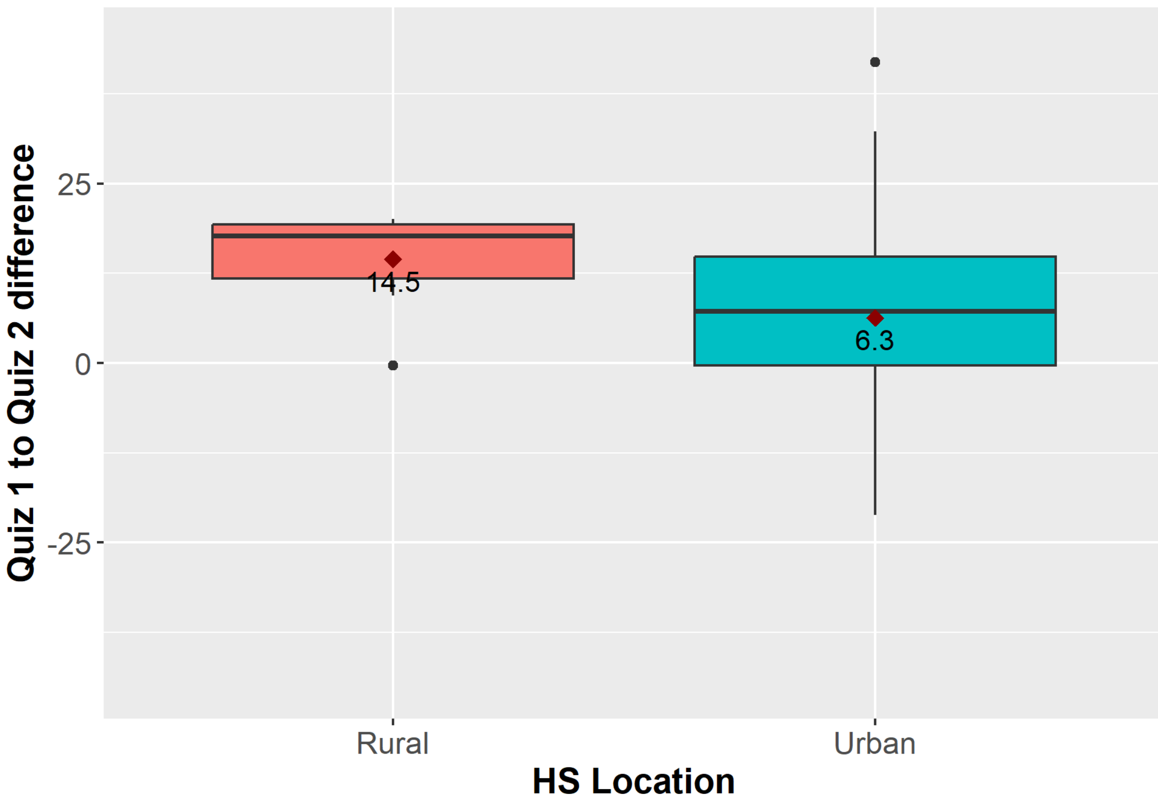

Figure 4: Boxplot showing performance improvement from Quiz 1 to Quiz 2 by high school location

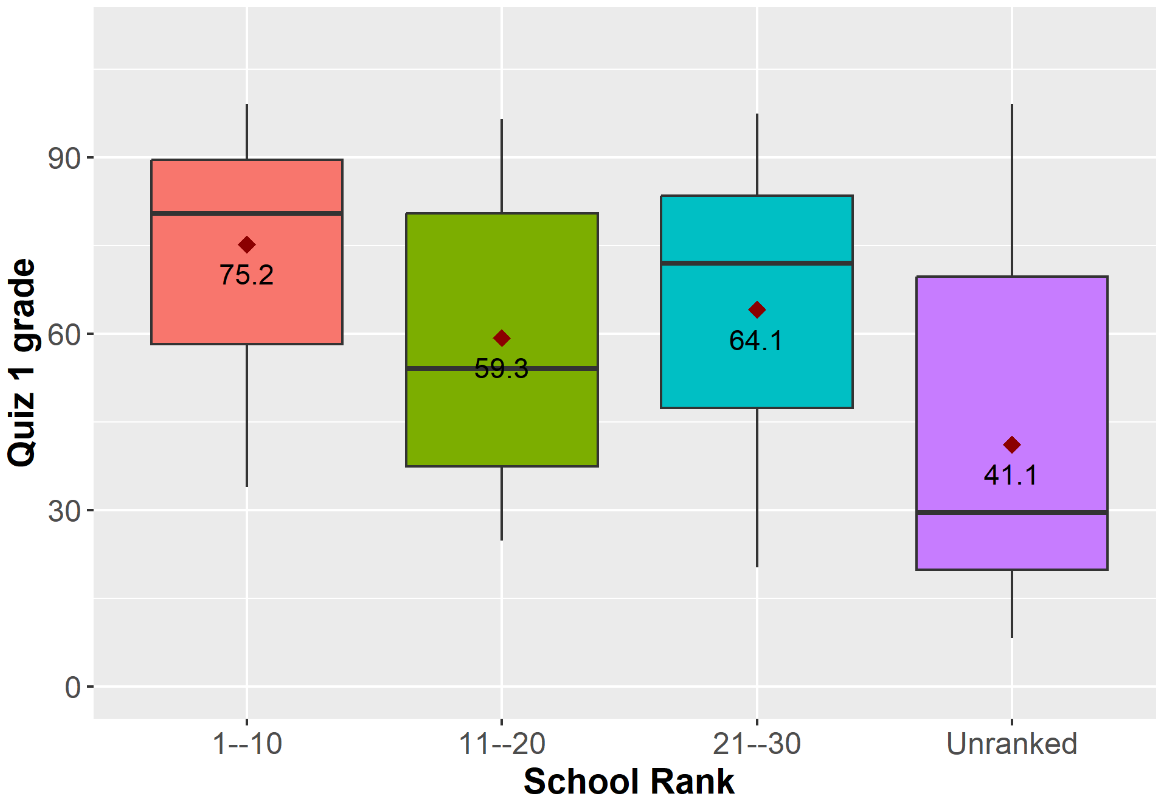

Figure 5: Boxplot showing Quiz 1 scores by school rank

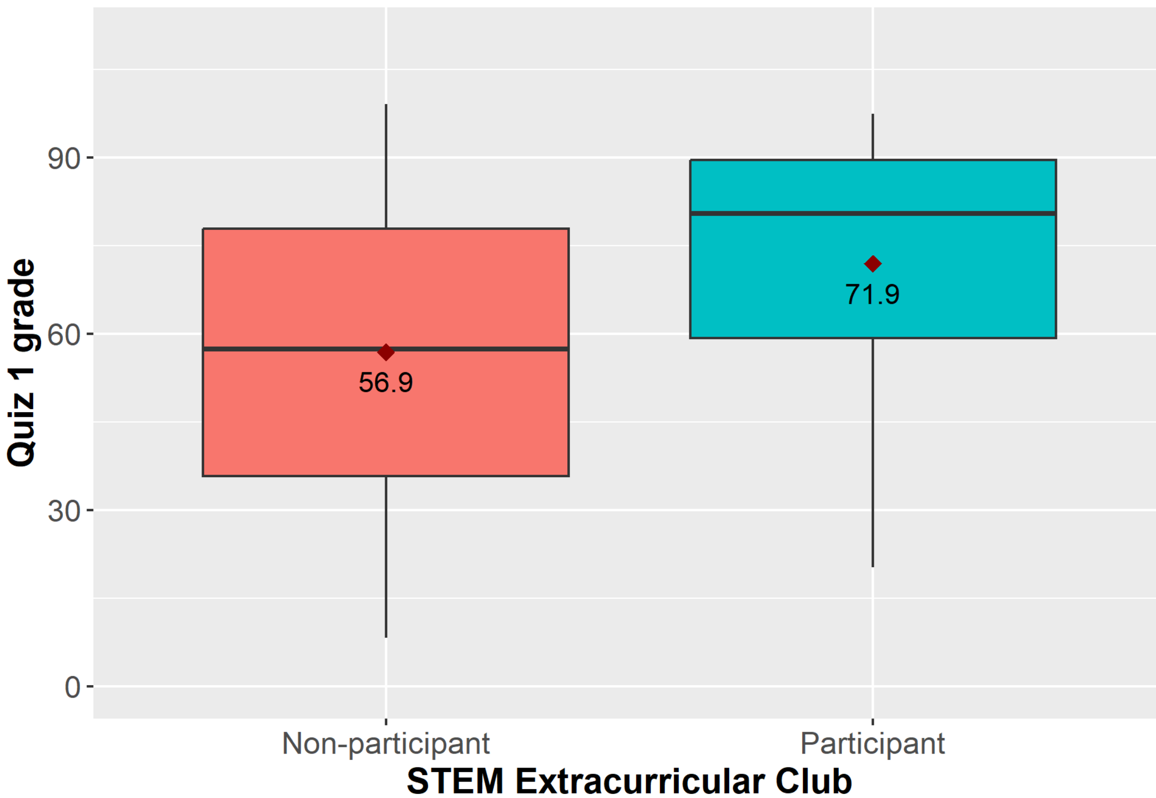

Figure 6: Boxplot showing Quiz 1 scores by STEM club participation