An Equity Analysis of STEM Enrollment in Broward County Schools

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Executive Summary

The underrepresentation of women and BIPOC is an ongoing problem in STEM, and progress has been too slow. To address this participation disparity, researchers have explored how to improve the “STEM pipeline” so that more students are exposed to STEM in high school.

This research analyzed racial and gender demographic data for elective STEM course enrollment of 31,000 students in all 31 high schools of Broward County Public Schools (BCPS). The research analyzed the data by creating a custom data analysis application using Python, along with the pandas, NumPy, and Streamlit libraries.

The analysis found substantial racial and gender disparities in STEM class participation. Notably, the average district STEM class was 73% male and only 27% female. Although classes were overall unequal, different schools had a wide range of enrollment diversity, with one school achieving 50% female enrollment, while others had as low as 15% female enrollment. In terms of racial diversity, STEM classes tended to be disproportionately White and Asian. However, both racial and gender disparities have trended lower over time. The research found that introductory courses, such as AP Computer Science Principles, had a much higher proportion of female students (35% female) compared to more advanced STEM classes (24%).

Following the completion of data analysis, the research built on existing literature to identify possible actions and policy solutions to make STEM course participation more inclusive. Schools should better promote introductory-level courses, such as AP Computer Science Principles, which are designed for students without prior CS experience. Offering after-school STEM clubs is another remedy, since studies conclude that these clubs appear to be more effective at engaging Black and Hispanic students. The school district should also publicly recognize when schools meet benchmarks in improving STEM representation.

Background

The underrepresentation of women and BIPOC in STEM fields is an ongoing problem. Despite making up half the U.S. workforce, women only make up about 27% of workers in STEM fields. Within STEM, females are even less represented in certain areas, such as computer science (25%) and engineering (16%) (Martinez & Christnacht, 2021). This has major implications for the STEM field. Research has shown that diversity leads to better decision making (Hong & Page, 2004), and consequently, a lack of (gender, racial, etc.) diversity will often lead to poorer decision making. Less diversity also can have harmful real-world consequences through less focus on designing algorithms to not embed human biases. For example, one of Google's photo algorithms classified images of a Black couple as "gorillas." (BBC, 2015). This mistake was likely due to a lack of planning about how the algorithm could embed systemic biases that may exist in user data. In 2015, only 4.6% of Google employees were Black, which indicates a potential lack of diversity in the groups that design algorithms (Google, 2021). As algorithms increasingly embed themselves into our lives, it is critical that we have a diverse group building these algorithms to better guard against bias. Achieving that goal starts with the workforce in STEM.

In addition, given that STEM careers are a rapidly expanding sector of the economy, with high demand and high median salaries, they provide substantial economic opportunities to people in the field. All demographics should have equal access to such opportunity. Public schools are critical to expanding such access, particularly for students who may not see themselves as STEM students or do not have a parent or mentor to guide them. Since access is unequal, society must work towards finding a remedy.

To improve diversity in the STEM field, a good place to start is by analyzing how new people enter the field. Since STEM work generally requires advanced education, we call the process that prepares prospective young STEM students for careers the "STEM pipeline." Although not every STEM professional will follow the same path of this pipeline, it is still a valuable metaphor for increasing the diversity of the STEM field when access to and retention in the pipeline is increased for unrepresented groups. If the pipeline becomes more diverse by enrolling and retaining more underrepresented students, then that will be positively reflected in the demographics of the STEM field. When looking at the pipeline, many may think it largely starts in college, when students are deciding majors and courses to take. However, a study of the factors that decide whether female students go into computer science found that 60% of the decision can be predicted by high school-related factors (Google, 2014). It is therefore imperative to scrutinize the pipeline in high schools and earlier, and whether the pipeline is inclusive of all genders and other demographics. This analysis can be accomplished by looking at demographics of students enrolled in STEM courses. If the enrollment in these courses is not inclusive, then we must find ways to widen the path to entering the STEM field.

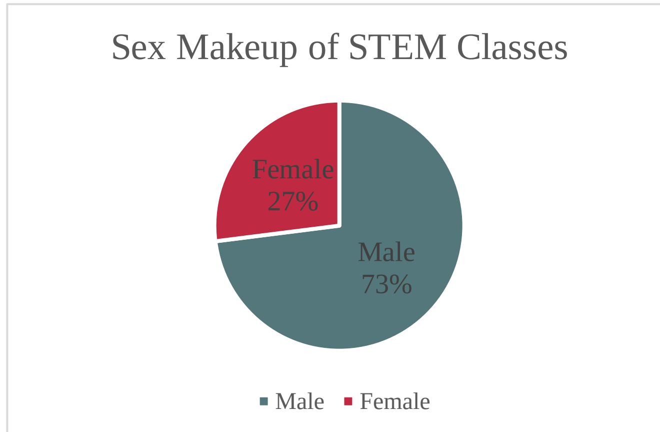
Methodology

To begin to uncover the issues with STEM equity in BCPS, the research required data on the students taking STEM in schools districtwide. This data needed to include all high schools in the district and include sufficient demographic information about individual students so concrete conclusions could be drawn on the extent to which a specific demographic group was underrepresented in STEM classes and at each high school. As a result, the author reached out to his school district's STEM Department and requested data for every time a student took an elective STEM class at a specific school over the past 8 years. This data included individualized demographic factors such as race/ethnicity, sex, and the school at which the student was enrolled. To preserve student privacy, the data did not include any names or other personally identifying information.

After requesting and receiving the data from the district, the research sought to figure out how to analyze it effectively and efficiently. While I could analyze some data visually or with easily generated excel charts, the size and scope of the data proved initially challenging. With 14 different pieces of information given every time a student took a course, and tens of thousands of students, the spreadsheet contained nearly 2.8 million cells. This meant using tools such as Excel were not helpful for specific questions such as whether high poverty schools had better or worse gender disparities. In addition, Excel was inadequate for creating well-designed dashboards that could effectively present data calculated to interested individuals and policymakers. For those reasons, the Python programming language provided a better way to analyze the data. I loaded and manipulated the data using the pandas library, with Streamlit to create the dashboards. These tools were able to accommodate the large size of the dataset, which more common tools like Excel could not.

For more effective data analysis, the research focused on high school students. The available data on middle school students was less granular in its information about the type of courses students take, and there was a smaller sample size of students. In addition, data about general science courses (e.g., chemistry or environmental science) was excluded due to these courses being part of a graduation requirement, which made them not indicative of a student's STEM interest. Other information in the dataset, such as whether students were English Language Learners (ELL) was not used due to the small proportion of students in each school who fall under each category, making analysis of these cohorts much more difficult, and likely would result in statistically insignificant results.

After performing a preliminary analysis of the data, the research prioritized looking at whether the representation of sex, and race/ethnicity in STEM classes was equitable across the district and between schools. To easily quantify the extent of the differences in enrollment levels between males and females, the research used a quantity we label as the sex ratio (or sRatio for short). The sRatio is calculated with the following equation: $sRatio = \frac{Total\ Males\ in\ STEM\ Classes}{Total\ Females\ in\ STEM\ Classes}$. This sRatio allows us to easily get a ratio of how many male students to female students are in classes at a specific school as a number. The research reports this ratio in percentage terms for easier interpretability in this report, but the Streamlit app reports statistics as an sRatio, including in the graphs used in this report.



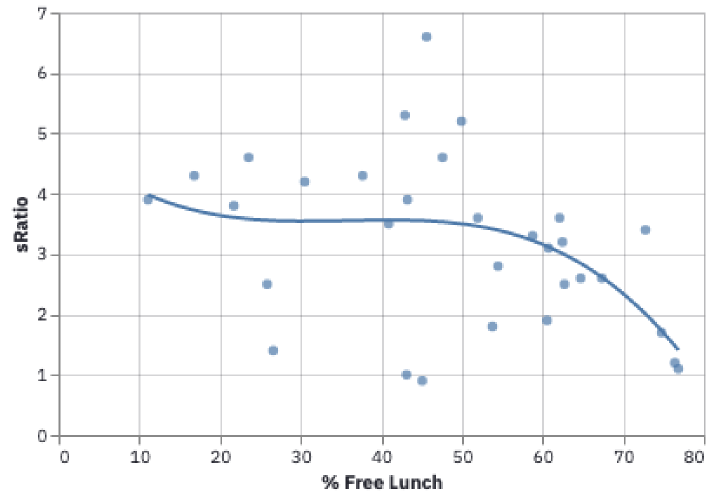
The research also used data from the U.S. Department of Education’s National Center for Education Statistics (NCES) to get information on high schools. The data included a school’s demographics, percent of students on free lunch, and whether the school was a public magnet school or schoolwide Title I institution (i.e., where at least 40% of the students are from low-income families).

Key Findings

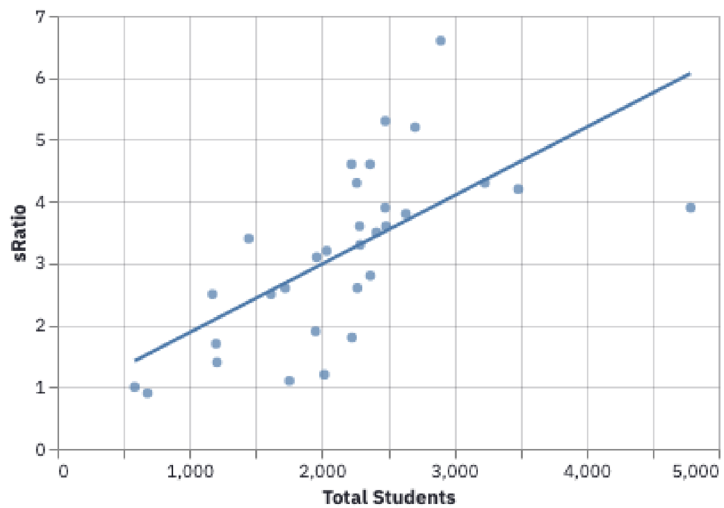
Quantitative Analysis

The most prominent disparities identified were along gender lines. As is common across the nation, male students were disproportionately represented in STEM classes, with about 73% of students being male and 27% being female on average. However, this ratio varies significantly across classes, meaning some classes had significantly fewer female students and some had more. This disparity was also not equal across schools. 4 schools had at least 45% of their classes made up of female students. One school had just 13% of their STEM classes made up of female students, which is a concerningly low number. The disparity is not explained by different proportions of male and female students in the overall student body at a high school; Broward high schools have about a 50% male, 50% female sex distribution, or close to it.

The next logical question was why some schools did so well with female student enrollment in STEM, but other schools did not. The research extracted data from the U.S. Department of Education and used it to see if any relationship existed between outside factors, such as demographics and gender inequities. While there appeared to be a relationship between the percent of the student body that was on free lunch or was Black, it negatively affected the sex ratio, with a correlation coefficient of -0.38 and -0.37 respectively. That is, STEM programs tended to have a higher proportion of female students in schools with more students on free lunch or with more Black students. While these correlations are only moderate and do not fully explain why some schools do better with gender equality, they are certainly notable, and thus demand closer examination.



The research also considered the total number of students at a school. There was a significant positive correlation (0.65) between the number of students at a school and the sex ratio. While it is unlikely that the number of students at a school is the direct cause of the effect on sex ratio, it is possible that underlying factors related to larger schools, such as less individual attention given to students, may be behind the disparity.



The research also studied the relationship between the number of STEM courses offered and socioeconomic/racial factors. There were weak negative correlations between the percentage of students on free lunch and the number of courses offered (-0.23) along with the percent of students that are Black, and the number of courses offered (-0.27). This indicates that schools that are more socioeconomically disadvantaged may be less likely to have as many STEM courses, although the effect is not a decisive one due to its weak correlation. Whether the racial demographics of a school actually cause less variety of STEM course offerings is a topic that requires further investigation.

Based on this data, while many factors have an impact on gender equality, such as a school's demographics or average socioeconomic status, these factors do not tell the full story of why some schools do better than others in terms of STEM equality due to their weak correlations. The reasons that explain the gender differences in STEM representation likely go beyond demographics.

Change Over Time

The data was further disaggregated by year, which revealed trends over time in racial and gender makeup. The most notable trend was that the STEM program, even if unequal, has shown progress in becoming more equal over time. The student population of Broward County High Schools is about 20% White (non-Hispanic), 39% Black, and 4% Asian, with Hispanic, Native American, Pacific Islander and Multiracial students making up the remaining 37% (BCPS Demographics & Enrollment Planning Department, 2020). If the STEM class offerings in Broward Schools were equitable, the proportion of all demographic groups in STEM classes should roughly match the student populations above. However, when looking at three major demographic groups in the table below, even in the last school year, the STEM program is still disproportionately White and Asian, with Blacks less represented in the program.

School Year	% White	% Black	% Asian	Intro % Male[1]	% Male
2013-2014	32%	27%	7%	N/A	81%
2014-2015	31%	26%	7%	N/A	82%
2015-2016	29%	28%	7%	N/A	78%
2016-2017	29%	28%	8%	72%	78%
2017-2018	27%	31%	8%	70%	74%
2018-2019	27%	29%	8%	66%	73%
2019-2020	27%	29%	8%	67%	73%
2020-2021	25%	31%	8%	65%	73%

As the table above indicates, there has been tangible progress since the start of the STEM program in racial diversity. While White students made up a 60% greater share of the STEM program than

[1] The sex ratio of students in the introductory computer science courses AP Computer Science Principles and Computer Science Discoveries. Intro courses were not offered until Fall 2016.

expected (32% vs. 20%) in the 2013-2014 school year, that has decreased to just a 25% greater share than expected (25% vs. 20%) in the most recent year. This is also the case for the gender balance in classrooms, which was initially incredibly high at 81% male (2013-2014) but has since significantly declined to 73% male. This strongly suggests the main students signing up at the beginning of STEM class offerings were those who traditionally took those classes (i.e., White/Asian males). As STEM classes become more mainstream, new participants are increasingly female or Black.

The research also considered the demographic makeup of STEM classes that are designed to be introductory and geared towards students with limited prior exposure to computer science. In the 2020-2021 school year,[2] these classes were only 65% male, which is a significant difference compared with the 76% male for non-introductory courses. However, this increased diversity in introductory STEM classes was not reflected in the race of the students. 27% of the students were White, 28% were Black and 9% were Asian, which is slightly worse than the overall diversity of STEM classes. This suggests that intro courses may be a useful entrance into the pipeline for increasing the gender equity in STEM classes, but perhaps not as effective at drawing in Black students. However, this issue could likely be helped by targeting racially underrepresented students with recruitment efforts or other outreach through teachers or guidance counselors.

Interviews

After analyzing the data, the research sought out a qualitative perspective to both help corroborate the data and provide additional perspective in hopes of determining what made schools successful or unsuccessful with equity. The next phase of the research hopes to include interviews with and surveys of STEM teachers across the district. Such interviews may help with understanding how STEM educators can best be supported in making their programs accessible to all students.

Conclusions

Based on the data, the district needs to improve STEM equity in its classes. Given that in 2021 about 73% of students in STEM classes are male, and the classes are also disproportionally White and Asian, there are still systemic inequities plaguing the County’s STEM program. Although

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[2] n=3006 students in introductory classes

these trends are likely reflected to an extent nationally, working to address them on a local level is vitally important, especially at certain schools within the district that had significantly lower enrollment than national or district averages.

It is not entirely clear from the data available why some schools had comparatively better gender equity than others. An analysis of school demographics and the socioeconomic situation did not establish any conclusive link to equity. School size may play a moderate indirect role. Interviews with staff at those schools may help answer this question. To improve diversity, schools can work on ways to make the classes more welcoming to underrepresented groups, and actively recruit underrepresented students into the programs.

Future areas of research should investigate individual schools on a more qualitative basis to see what factors could help or hinder the diversity of a school's STEM program. This could include analyzing the impact of STEM teacher diversity and support from school administration. Interviews with teachers would likely help answer these questions. Future research should also seek to answer more conclusively whether school size, "% Black" and "% Free Lunch" have a direct effect on the sex ratio, and if so, why that is.

Recommendations

Based on the data analysis and a review of the existing scientific literature, there are steps this district should take to increase the involvement of underrepresented groups in STEM classes and education. The following three recommendations proposed are based on the findings in scientific papers, data analyzed from in this study, or existing practices major organizations utilize to increase STEM involvement.

The first recommendation is to increase support for STEM clubs and organizations. While Broward has done a great job in offering computer science courses at all its high schools and many middle schools, that does not address the differences in where underrepresented groups learn computer science. One study concluded "CS groups and clubs at school outside of official classes could also engage more Black and Hispanic students. Both Black and Hispanic students (34% and 41%, respectively) are more likely than White students (18%) to say they learned CS in a group or club at school" (Google Inc. & Gallup Inc., 2016). Since studies show underrepresented students tend to learn STEM outside the classroom, the district should strongly consider promoting after school STEM clubs to reach these groups more effectively. It could do so by taking a page out of the playbook of the district's successful Debate Initiative and start a pilot program at a few schools to evaluate what forms of after school STEM education are most engaging and effective. If the program is successful, then it could be replicated in all high schools and middle schools. The county could work with community businesses like it did for debate to make the club free for all students, which may also increase diversity by removing barriers. As for the activities to include in these STEM clubs, there are a variety of groups that have created well-designed curricula that teachers could easily draw on, such as CS Unplugged or TechGirlz. There are even programs specifically designed to attract females, such as GEMS clubs or Girls Who Code. Since all these organizations offer free standardized resources for teachers, they would be easy to rapidly expand to many schools with low teacher training costs.

In addition to starting a STEM club program, the district should also work to make sure its classroom courses are more diverse as well through focusing on intro courses. One major finding of this research was that introductory computer science classes, such as AP Computer Science Principles (CSP), were much less disproportionately male than regular computer science courses. This finding is reflected in existing national data in the graph in Figure 1 (Wyatt, Feng, & Ewing, 2020). This increase in diversity is caused by the design of these courses so that they appeal to groups that aren't typically exposed to computer science. By attracting more diverse students due to their design, the courses can serve as a pathway through which underrepresented students enter STEM. Research by the College Board also shows that Black and Hispanic students who take AP CSP were both more likely to take it as their first STEM course, and that taking the course made them significantly more likely to major in computer science than students who did not take the course. Therefore, the county should work to promote the courses to more students, since the courses have a low barrier to entry, and will encourage a more diverse group of students to pursue STEM careers. The College Board provides resources and strategies on their website that can be shared with teachers. One way to encourage students to take introductory STEM courses would be to have guidance counselors provide better, targeted information about STEM course opportunities during the course selection process, so that knowledge of these courses is less dependent on the home environment.

Figure 1: Percentage Composition of AP CSP and AP CSA Students

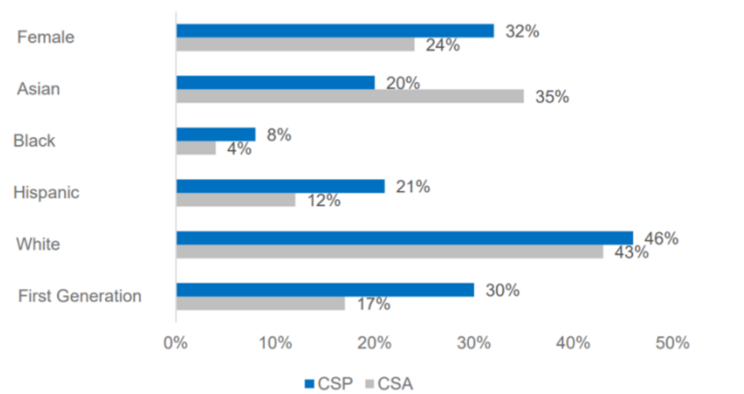
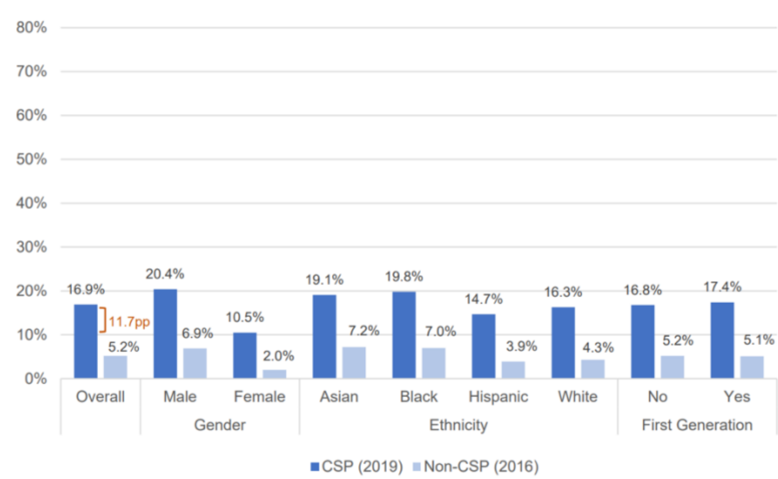


Figure 2: The Percentage of CSP and Non-CSP Students Who Major in CS



Finally, when schools increase the diversity of their STEM education programs, the county should recognize that progress. This recognition provides an incentive for schools to implement these initiatives. The district should set an award threshold between 35%-45% for the minimum percentage of female students in the STEM program. The threshold will ensure there is a critical mass of female students, and there could be continued recognition for sustained improvement. This is important for reducing isolation and possibly student attrition (Yi & Nie, 2020). The award can also have a threshold for representation of other underrepresented groups, such as Black and Hispanic students. The success of this type of award system has been demonstrated by the College Board's existing Female Diversity Award, which recognizes schools whose AP CS exam takers are at least 50% female. The College Board award program is similar to what the school district could offer, but with the benefit of being a more attainable goal than the College Board's while still preserving the benefits of increased representation.

These three initiatives offer a bold vision for how Broward Schools can become a leader in STEM equity and work to improve the inclusiveness of the STEM pipeline. By bringing students into introductory courses, supporting after school STEM clubs, and recognizing successful schools, the district has the opportunity to change the STEM program to better serve *all* students and improve the STEM field overall.

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