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COVID-19 Impact on College Algebra

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Abstract

Due to the COVID-19 pandemic, institutions across the nation were forced to rapidly change and modify the way things were taught and how they were taught. Research suggests that learning loss has occurred with students across all levels of education and is most prevalent in mathematics. Therefore, this study analyzes data of College Algebra students pre-pandemic and during pandemic at a four-year public institution in the southern United States to see how the pandemic has impacted the profile and academic performance of this population. In addition, it reports on significant differences in academic background and academic performance within and across cohorts with respect to gender and ethnicity of the groups. Results indicate that pass rates were higher during the pandemic compared to pre-pandemic. Results also suggest that women and Blacks were impacted most, evidence of a widening equity gap. Suggestions to address the findings are then made for improvement.

***Keywords*:** COVID-19, learning loss, math anxiety, equity gap, college algebra, post-secondary education

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Due to the COVID-19 pandemic, institutions across the nation were forced to rapidly modify the way things were taught and how they were taught. Professors were forced overnight to move to an online setting, something many were not comfortable with. The disruption to learning, change in formats, and fear of lives impacted all aspects of education. Schools were shut down, and the move to online learning took place not just in secondary schools, but also in higher education. This disruption impacted students' and teachers' professional and personal lives. Now that the world is post-pandemic, it is important to account for and research the learning of students that occurred or didn't occur during the pandemic.

While there are several subjects at risk of learning loss, including reading and English, this study focuses on mathematics. Mathematics has long been a subject of worry and stress for students in the K-12 curriculum and post-secondary setting. It is well known that students struggle with mathematics early on, and that this carries into secondary education and then well into higher education (Marks, 2022). According to The Hechinger Report, more than half a million students are coming to college underprepared, mostly in mathematics (Butrymowicz, 2017). Adding the pandemic to an already existing crisis of underprepared students expanded the issue. Therefore, there is a need to address how much the pandemic impacted learning in mathematics at the post-secondary level in order to gain understanding of what these effects could mean for the future of these students.

At the post-secondary level, College Algebra is a core course for many majors and is often described as a 'gateway' course in higher education. Thus, our study focuses on data from this course pre-pandemic and during pandemic to gain understanding and insight to discover the impact of the pandemic on these students and how it could influence post-pandemic learning. Specifically, the study will answer the following:

1. How has the pandemic impacted the profile of College Algebra students in terms of demographic and academic information?
2. Are there statically significant differences in academic background across cohorts with respect to gender and ethnicity of College Algebra students?
3. How has the pandemic impacted the academic performance of College Algebra students in terms of grades and pass rates?
4. Are there statistically significant differences in academic performance across cohorts with respect to gender and ethnicity of College Algebra students?

In the next section, we will give a review of the literature which revolved around three main themes as a result of the COVID-19 pandemic: learning loss, equity, and mathematics anxiety.

Literature Review

Learning Loss

According to Sanchez (2022), "many students whose last years of high school were disrupted by the pandemic are struggling in the foundational college courses they need to succeed later in their academic and professional careers" (p. 1). Students have reported that during the COVID-19 pandemic, standards were lowered in their high school classrooms or were

not present at all. In other cases, the pandemic has resulted in a higher rate of freshman students failing mathematics courses in college (Fawcett, 2022; Ludwig, 2021; Sanchez, 2022). In particular, Uri Treisman, a nationally known mathematics professor at the University of Texas at Austin, reported that about 25% of his students failed first year calculus during fall 2021 compared with about 5% any other pre-pandemic year (Sanchez, 2022). Many students were making basic errors on mathematics problems, and many even apologized for being underprepared (Sanchez, 2022). These circumstances could be due to students passing previous classes without knowing material due to emergency policies that schools and institutions implemented as the pandemic crisis unfolded. Some of these policies often included a pass/fail or credit/no credit option, which meant students making a letter grade of a "D" could be considered as a "pass" and be moved on to the next course (Sanchez, 2022).

Lowering the standard is a cause for concern since students moving on without being academically ready will not be prepared for the mathematics coursework that comes next (Fawcett, 2022). Since often times mathematical concepts build on one another, a strong foundation is necessary to continue each year (Sattem et al., 2022). Some states have reported standardized testing data for spring 2021, a year after the pandemic hit, which shows that unfinished learning due to the COVID-19 pandemic is in fact most pronounced in mathematics. In Texas, nearly 40% of students failed the state's mathematics exam in 2021, and in Indiana, 63% failed the state's mathematics exam for the same year (Sattem et al., 2022).

In addition, test scores from 5.4 million U.S. students in grades 3-8 were tracked to observe changes in mathematics and reading achievement from fall 2019, fall 2020, and fall 2021. During the first two years of the pandemic, mathematics achievement dropped the most, with the average 2021 mathematics test scores .20-.27 standard deviations lower relative to the same grade peers in fall 2019. Achievement gaps were also more noticeable in low income schools where students may not have the resources or technology at home to stay on top of their learning and work (Kuhfeld et al., 2022).

Equity

An educational equity gap, according to Higher Learning Advocates (2024), is "where there is a significant and persistent disparity in educational attainment between different groups of students" (p. 1). This is a common theme that emerged since the COVID-19 pandemic not only in the United States, but also around the world (Anand & Lall, 2022; Meyer & Wills, 2022; Ruef et al., 2022; Wanti et al., 2022). Students of low income and students of color were hit the hardest due to the lack of resources, differences in support from home, and varied access to technology (Ruef et al., 2022). Since STEM fields already often lack low income and minority students, there is now a concern that the pandemic could push more of these students' away from these fields (Sanchez, 2022).

In addition, during the COVID-19 pandemic, education in private schools seemed to go virtually uninterrupted; however, in public schools, there was a lack of reliable technology, home internet access, home and school support (Anand & Lall, 2022). According to Meyer and Wills (2022), camera policies were questioned as they could create vulnerability to students and teachers sharing personal space and collapsing boundaries that once were untouched. Ruef et al. (2022) collected data in fall 2021 for 3,331,943 students grades 1-8 who took an i-Ready Diagnostic in mathematics. Their scores were compared with a pre-pandemic historical average.

It was found that fewer students are ready for grade level work, particularly true in mathematics. Additionally, it was also found that fewer students in low income and in schools for predominately Black and Latino students started the 2021-22 school year grade level ready.

If students are underprepared for their grade, it can cause challenges in teaching as well as a strong sense of anxiety in students and teachers (Ruef et al., 2022). Findings from a survey from nine teachers from communities in the northwestern United States indicated that teachers did not feel prepared enough with training and resources to move to an online setting (Ruef et al., 2022). Therefore, they felt anxious when teaching in this new environment. For students, the new learning environment often meant learning from home, which for many meant seeking out parental help with mathematics. According to Nolting (2012), parents can be a main factor in causing anxiety in children. When the parents are more anxious than the children regarding mathematics, similar anxieties and negative feelings may then develop towards the subject in children (Öztop & Toptas, 2019). During the COVID-19 pandemic, inadequate parental support for homework in mathematics not only hindered students' learning at home, but also widened the equity gap, particularly for students who parents lacked education and the ability to assist (Herts et al., 2019).

Mathematics Anxiety

Akkaya and Polat (2022) collected quantitative and qualitative data from a sample of 204 parents whose children were in grades 1-8 to explore the relationship between the parents' mathematical literacy self-efficacy and mathematics anxieties during the participation of parents in mathematic teaching during the COVID-19 pandemic. It was found that mathematical literacy self-efficacy increases as the level of education increases and that parents' anxiety levels were high. Interestingly, parents with a higher self-efficacy tended to have a higher level of mathematics anxiety. It was also noted that many parents could not provide support to their children due to lack of spare time due to the increased workload during the COVID-19 pandemic (Akkaya & Polat, 2022).

While most studies revealed moderately high mathematics anxiety during the COVID-19 pandemic and remote learning (Delima & Cahyawati 2021; Ludwig, 2021), on the other hand, Doz and Doz (2023) found that during the pandemic, the distance learning helped high mathematics anxiety students by reducing feelings of anxiousness. There was, however, according to Doz and Doz (2023), no difference observed for moderate and low mathematics anxiety students. The results from 117 middle and high school students from North-Eastern Italy, were formed from an administered questionnaire which looked at self-reported mathematics anxiety before and during the COVID-19 pandemic.

Learning loss, equity, and mathematics anxiety are all major factors that have impacted students and teachers as a result of the pandemic. It is important to continue to figure out and research the impact of the COVID-19 pandemic in the classroom, not only at a K-12 level, but also at a post-secondary level. Since according to Meyer and Willis (2022), "Best practices in online learning require both rigorous training for instructors as well as substantial orientation sessions and support for students" (p. 2), neither which occurred due to the rapid onset and lack of preparation for a pandemic, it could take years to figure out and address the learning loss and consequences of this in K-12 and higher education (Dorn et al., 2020).

The existing literature has indicated that the pandemic has had mostly a negative impact on students' academic progress in mathematics, impacting learning loss, equity, and mathematics anxiety. Therefore, for this study, we want to analyze data to understand these implications reported and see if there are any additional findings from analysis that could impact undergraduate students now or in the future.

Methodology

This study took place at a mid-size public four-year institution located in the southern United States. It is an urban campus with an average age of 27. About half receive the Federal Pell Grant, a federal award to students with high financial need, and about half are first-generation students. At this institution, the course College Algebra is a core mathematics course which covers topics such as functions, including quadratic, polynomial, rational, logarithmic, and exponential; as well as systems of equations; and matrices. It is typically taken by students who are STEM majors enrolled as freshman.

Since this course enrolls hundreds of students each semester, there was a good sample size for analysis. Therefore, we collected data from the Office of Institutional Research (OIR) for students enrolled in College Algebra from spring 2018 to fall 2021 to compare performance and background pre-pandemic and during the pandemic. The data included demographic information, academic background, and academic performance in College Algebra. Demographic information included race and gender. Academic background included high school GPA and a variety of placement test scores including ACT, SAT, Accuplacer, and Compass. Academic performance included final grades in the College Algebra course. These data were readily accessible through the OIR, thus making it ideal information to be included.

To discover the impact of the pandemic, we split the data into two cohorts. The first cohort was considered pre-pandemic, which included spring 2018, summer 2018, fall 2018, spring 2019, summer 2019, and fall 2019. The second cohort was considered during pandemic[1] and included students enrolled in College Algebra for spring 2020 (onset of pandemic), summer 2020, fall 2020, spring 2021, summer 2021, and fall 2021. Therefore, each cohort collectively represented data from two calendar years.

For the College Algebra course, there was a shared syllabus for all instructors so the content, homework platform, and policies are the same. The Final Exam given at the end of the semester was also the same throughout sections. There are different instructors for each course section, and instructors may vary on delivery and set up. College Algebra is a pre-requisite to other mathematics courses such as Trigonometry and Pre-Calculus.

While the College Algebra content for the course sections was the same, it is important to note any differences in the instructional delivery and policies for the pre-pandemic cohort and pandemic cohort. For the pre-pandemic cohort, class delivery was mostly in person with an instructor in a traditional setting. There were typically one or two online courses offered per semester taught asynchronously. In spring 2020, when the pandemic hit, the University was abruptly closed on March 12, and effective immediately, all classes migrated to an online setting. At the discretion of the instructor, some courses went online asynchronously, and others went online synchronously using platforms such as Zoom. There was variation in whether the

[1] The during pandemic cohort will be referred to as the pandemic cohort throughout the paper.

instructors had taught College Algebra online or not. Those who had not taught online worked with those who had to develop the course in the online learning management system.

For the spring 2020 semester, a policy was implemented that allowed students to opt into a Credit/No Credit grade. Therefore, students making a grade of A, B, C, or D could opt into a grade of CR, and students making a grade of F could opt into a grade of NC. Students on academic probation were also not allowed to be dismissed. Summer 2020 continued online with the CR/NC grade policy, and then in fall 2020, the campus moved to a new phase, where classes were still offered mostly in a hybrid, online asynchronous, or online synchronous environment. However, the campus was open with social distancing measures in place, including the requirement of masks. There was no longer the option of the CR/NC course grade. This phase continued throughout the year of 2021, and in spring 2022, the campus opened was fully back open with face to face classes and mask optional. For purposes of this study, the pandemic cohort finished fall 2021, the last semester the COVID-19 pandemic policies were in place on campus with regards to class delivery and social distancing.

The quantitative analysis of the data were conducted using the statistical software package SPSS. Descriptive statistics, including frequencies, percentages, mean, and standard deviation, were computed to provide insights into the central tendency and variation within each group. Chi-Square tests were employed for categorical variables to facilitate group comparisons. For numerical data, *t*-tests and one-way analysis of variance (ANOVA), supplemented by Post Hoc tests, were utilized to ascertain the presence of significant relationships between groups. The primary data analysis was comparison of sample means in the study. With a sample size of n=2769, the distribution of sample means approximates a normal distribution.

Overall, a total of 2769 students were enrolled in College Algebra during the four-year time period. Among them, about 57% were freshmen, 25% were sophomores, 10% juniors, 6% seniors, and 2% post-baccalaureate. There were more female students, 59%, than male, 41%. There were more Caucasian students, 42%, than Black, 30%. In addition, there were 28% of Other Minority of which 17% of students identified as two or more races and 11% identified as American Indian, Asian, Hispanic, or unknown/refused to report. Students' academic background focused on ACT Math scores and high school GPA in this study. Overall, the sample had a mean score of 19 on ACT Math (n = 1809) and 3.0 for high school GPA (n = 1858).

Results

In this section, we will present the results for each research question. For more details of the statistical analysis reported on, see Appendix A for tables.

Changes in Demographic Background

First, we will report how the pandemic impacted the profile of College Algebra students in terms of demographic information. Out of the overall 2769 students, there were a total of 1540 students enrolled in College Algebra in the pre-pandemic cohort and 1229 enrolled in College Algebra in the pandemic cohort, indicating a 20% decrease. For the pre-pandemic cohort, 923 or 60%, identified as female, while 615 or 40%, identified as male. For the pandemic cohort, females decreased by 212 or 13.8%, more than double the decrease observed for males, which was 101 or 6.6%.

In terms of ethnic identification, in the pre-pandemic cohort, 493 or 32% identified as Black, 631 or 41% as White, and 405 or 27% as Other Minority[2]. In contrast, the pandemic cohort consisted of 348 or 28% Black, 531 or 43% White, and 345 or 29% Other Minority. The most noteworthy change occurred among Black students, with a reduction of 145 students or a 9.4% decrease, followed by White students with a reduction of 100 students or a 6.5% decrease.

Changes in Academic Background

Next, we will report on how the pandemic impacted the profile of College Algebra students in terms of academic information. We will also report on any statistically significant differences in academic background across cohorts with respect to gender and ethnicity. While there were not many, students who did not have an ACT Math score were excluded from the ACT Math analysis. The findings revealed that the pandemic cohort had slightly higher mean scores in ACT Math compared to the pre-pandemic cohort. However, an independent sample *t*-test demonstrated that there was no significant difference in the mean scores between the two groups, $t(1807) = -0.638$, $p=.524>.05$. This suggests that any observed difference in mean scores could be due to random variation rather than a meaningful distinction between the cohorts.

Regarding high school GPA, the pandemic cohort exhibited a statistically significant higher high school GPA than the pre-pandemic cohort, $t(1856) = -6.883$, $p < .001$. These results provide insights into the academic background changes among students in College Algebra, showing a notable increase in high school GPA during the COVID-19 pandemic period.

Further Analysis: Academic Background by Gender

Comparing ACT Math scores between genders, *t*-test results revealed that males in the pandemic cohort had slightly higher scores than the pre-pandemic cohort. In contrast, females had slightly lower ACT Math scores in the pandemic cohort than the pre-pandemic cohort. However, both differences were not statistically significant. This suggests that any observed gender-specific variations in ACT Math scores are likely due to chance rather than a systematic difference between cohorts.

For high school GPA, the mean scores showed significant increases in the pandemic cohort compared to the pre-pandemic cohort for both genders. Males demonstrated a substantial increase, $t(760) = -4.858$, $p<.01$, and females exhibited a notable increase as well, $t(1090) = -5.39$, $p<.01$. These findings suggest a general trend of improved high school GPA for both genders during the COVID-19 pandemic period, indicating a potential impact on students' academic performance.

Further Analysis: Academic Background by Ethnicity

Concerning different ethnicity groups, *t*-test results indicated that Whites had increased ACT Math mean scores in the pandemic cohort compared to the pre-pandemic cohort. However, the changes in mean scores were not statistically significant for Whites, $p = .297 > .05$, or the other ethnicity groups, Black $p = .417 > .05$, and Other Minority $p = .260 > .05$. This implies that

[2] Other Minority includes American Indian, Asian, Hispanic, Non-Resident Alien, and Two or More Races

any observed increase in ACT Math scores among Whites or other groups could be due to random variation rather than a meaningful difference linked to the pandemic.

On the other hand, high school GPA showed a significant increase during the pandemic for all three ethnicity groups: White, $t(685) = -4.25$, $p < .001$, Black, $t(569) = -3.682$, $p < .001$, and Other Minority, $t(590) = -3.207$, $p < .05$. These findings suggest a consistent improved high school GPA across various ethnicities during the COVID-19 pandemic period, indicating a potential impact on academic performance regardless of ethnic background. The significance of these changes underscores the need for further exploration into the factors contributing to GPA improvement during the pandemic for students from diverse ethnic groups.

Changes in Mean Scores

Next, we will report on how the pandemic impacted the academic performance of College Algebra students with respect to the grade received in College Algebra during this time period. We will also include results about any statistically significant differences in grades with respect to gender and ethnicity. Among the 1540 students in the pre-pandemic cohort, there were 225 with a grade of W, indicating a withdrawal, and 2 with a grade of NC, indicating No Credit. Among the 1229 students in the pandemic cohort, there were 182 with a grade of W, 19 with a grade of NC, and 4 with a grade of CR, indicating credit[3]. The remaining students received letter grades ranging from A to F. For the purposes of mean score calculations, letter grades A, B, C, D, and F were converted into numerical values: 4, 3, 2, 1, and 0, respectively. Withdrawals and no credits were excluded from the calculation since the focus was on performance. A grade of credit was considered a pass grade, so was given a numerical value of 2.

A *t*-test revealed a significant difference in mean scores between the pre-pandemic cohort and the pandemic cohort, $t(2250.108) = -5.993$, $p < .001$. The pandemic cohort scored higher on average compared to the pre-pandemic cohort. This suggests a notable improvement in mean scores for College Algebra during the COVID-19 pandemic period, indicating a positive impact on students' performance in the course.

Further Analysis: Mean Scores by Gender

The examination of mean score differences in College Algebra between the pre-pandemic and pandemic cohorts continued with a focus on gender, utilizing independent sample *t*-tests. The findings revealed that female students in the pandemic cohort achieved a higher mean score by 0.27 than their counterparts in the pre-pandemic cohort. This disparity in mean scores proved to be statistically significant among females in the two cohorts, $t(1286.978) = -3.698$, $p < .001$.

Likewise, a significant difference in mean scores was identified among male students across the two cohorts, $t(936.184) = -5.049$, $p < .001$. Male students in the pandemic cohort achieved, on average, 0.47 higher mean score compared to their counterparts in the pre-pandemic cohort.

[3] See Methodology for more information about pandemic grading and CR/NC

Further Analysis: Mean Scores by Ethnicity

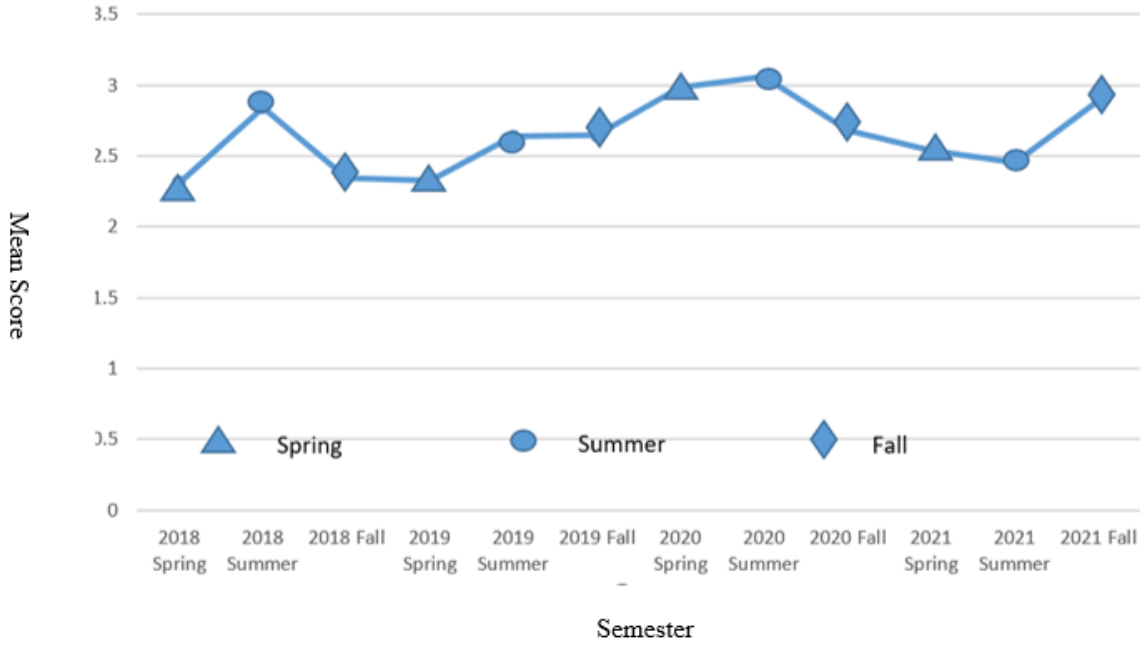
Furthermore, an investigation into mean score differences by ethnicity between the two cohorts was conducted. The results indicated that, across all three ethnic groups, mean scores in the pandemic cohort surpassed those in the pre-pandemic cohort. However, the difference proved to be statistically significant only for the White group between the pre-pandemic cohort and the pandemic cohort, $t(982.458) = -4.221$, $p < .001$.

Further Analysis: Mean Scores by Semester

The researchers then conducted an in-depth analysis of the data set to investigate mean score disparities across various semesters. Notably, summer 2020 recorded the highest mean score in College Algebra, closely followed by spring 2020. Employing one-way ANOVA and Post Hoc tests, notable mean score differences were identified between spring 2020 and seven other semesters, including spring 2018, fall 2018, spring 2019, summer 2019, fall 2020, spring 2021, and summer 2021. Moreover, the mean score difference between summer 2020 and six other semesters, incorporating spring 2018, fall 2018, spring 2019, summer 2019, spring 2021, and summer 2021, was statistically significant. These outcomes suggest that summer 2020 and spring 2020 exhibited unusually higher scores in College Algebra. Even with the exclusion of these two semesters, discernible increasing patterns in mean scores persisted from the pre-pandemic to the during pandemic period in spring and fall semesters, respectively (Figure 1).

Figure 1

College Algebra Mean Scores by Semester



Changes in Pass Rate

Lastly, we analyzed the data with respect to pass rates of College Algebra for the two cohorts. The pass rate was defined as the ratio of the number of students who received a grade of C or above to the total number of students who completed College Algebra with a grade of A through F. We also report on any statistically significant differences of pass rates with respect to gender and ethnicity.

In the pre-pandemic cohort, 982 out of 1313 students passed, resulting in a 74.8% pass rate. Contrarily, for the pandemic cohort, 855 out of 1025 students passed, reflecting an 83.4% pass rate. Chi-square tests were conducted, and the results indicated that the pandemic cohort had a significantly higher pass rate than the pre-pandemic cohort, χ^2 (1) = 25.31, $p < .01$.

Further Analysis: Pass Rate by Gender

Chi-square results further revealed that females in the pandemic cohort achieved a significantly higher pass rate than those in the pre-pandemic cohort, χ^2 (1) = 18.96, $p < .001$. Likewise, for male students, Chi-square results demonstrated that males in the pandemic cohort attained a significantly higher pass rate than those in the pre-pandemic cohort, χ^2 (1) = 9.132, $p < .01$.

Further Analysis: Pass Rate by Ethnicity

Upon comparing pass rates based on ethnicity across the two cohorts, it was found that 426 out of 542 or 78.6% of White students passed in the pre-pandemic cohort, while 394 out of 453 or 87% of White students passed in the pandemic cohort. Chi-square results indicated that the White group in the pandemic cohort achieved significantly higher pass rates than those in the pre-pandemic cohort, χ^2 (1) = 11.95, $p < .05$. In the case of Black students, 269 out of 399 or 67.4% passed in the pre-pandemic cohort, and 208 out of 267 or 77.9% of Black students passed in the pandemic cohort. Chi-square results revealed that Black students in the pandemic cohort achieved a significantly higher pass rate than those in the pre-pandemic cohort, χ^2 (1) = 8.650, $p < .05$. For Other Minority students, 277 out of 361 or 76.7% passed in the pre-pandemic cohort, and 250 out of 302 or 82.8% passed in the pandemic cohort. Chi-square results showed no significant difference for Other Minority students between the pre-pandemic and pandemic cohorts, χ^2 (1) = 3.692, $p = .055>.05$.

Discussion

There is no question that the COVID-19 pandemic impacted the learning of students not only in secondary education, but in post-secondary education as well. Many institutions were suddenly forced to shut down and move online, despite little technological training and development of many college faculties. Students at home were now trying to juggle health, financial implications, family, as well as other stressors while attending class in an online synchronous or asynchronous setting. Now that institutions have moved back to in person learning and the pandemic is behind us, it is important to look at how this time period impacted students and what this means for the future of higher education.

In particular, it is important to look at how the pandemic impacted students in mathematics. Mathematics is already known to be a challenging subject to many students, and thus students could be at risk of learning loss and heightened student anxiety. This research focused on College Algebra students enrolled at a mid-size urban four-year institution. Data were analyzed from two years pre-pandemic and two years during the pandemic to look for ways in which the pandemic has impacted the profile of College Algebra students, the academic performance of College Algebra students, and any statistically significant differences between cohorts with respect to gender and ethnicity. There were several important findings to discuss that were noted in the results, as well as suggestions for the future.

First, enrollment in College Algebra decreased 20% from the pre-pandemic cohort to the pandemic cohort. This is not surprising considering many students stopped attending classes and had to withdraw from classes due to family obligations, health concerns, and other factors (Ludwig, 2021; Minkos & Gelbar, 2021). More specifically, however, it is important to note that female students and Black students decreased in enrollment the most from pre-pandemic to pandemic. This could suggest that women and Black students were impacted more by the pandemic than males, Whites, and Other Minority, causing these students to drop classes. Since students in the K-12 setting also moved to online learning, many women may have had to take on more responsibility at home with children, leaving less time for studying. Students of color, especially Blacks, have historically faced larger disadvantages to earning a degree (Fawcett, 2022), and now with a decrease in enrollment, earning a degree could get more difficult.

Academically, the pandemic cohort had a statistically significant higher high school GPA than the pre-pandemic cohort. It is believed that high school standards were lowered during the COVID-19 pandemic, which could result in a higher high school GPA for this cohort (Fawcett, 2022; Sanchez, 2022). ACT Math was also a higher mean score; however, it was not significant. It is important to note that many schools became test optional during the COVID-19 pandemic, and therefore, there were fewer students overall taking the ACT, which could impact the data sample as a limitation. Since this data were collected, this institution now places students in College Algebra based on multiple measures, including high school GPA, ACT or equivalent test score, and years since high school graduation.

Second, the results suggest that overall, the pandemic cohort had better academic performance in College Algebra than the pre-pandemic cohort. The pandemic cohort had a statistically significant higher pass rate than the pre-pandemic cohort, and it follows that the pandemic students also had a statistically significant higher mean score, with spring 2020 and summer 2020 as the highest in the entire sample. If we remove these two semesters, there is still an overall increase in mean scores; however, these two semesters are outliers. This means that more students were passing College Algebra and at a higher rate during the first two semesters of the pandemic than any other time. This is an unusual finding considering all the stressors and anxiety that increased during the COVID-19 pandemic (Ruef et al., 2022). It is possible to suspect that students were passing during this time without actually having a full grasp of the material because of lower standards and teacher anxiety that spilled over into the classroom (Ruef et al., 2022; Sattem et al., 2022). As Fawcett (2022) mentioned, professors during the pandemic were “whittling their syllabuses and lowering their expectations” (p.2).

In addition, since most courses went fully online, there was a lack of rigorous assessment, and academic dishonesty became more prevalent (Kirkman et al., 2022). Students could have been passing without knowing the material, something that could cause backlog in learning in

subsequent mathematics courses (Sanchez, 2022). It may be that the learning loss, so heavily noted in the literature review, was masked by passing grades. Therefore, it is important for teachers in the classroom to be aware of the skill set of incoming students in order to address potential academic skill deficits. One way teachers can address potential academic skill deficits is by administering a pre-test at the beginning of the semester in mathematics courses based on pre-requisite knowledge for the course. Administration of a pre-test will allow teachers to identify these skill gaps, and to alter curriculum to better fit the needs of the class. Minkos and Gelbar (2021) suggest using flexible grouping where students are grouped in the classroom based on ability. This way, lessons can be planned to meet the learners needs. This allows faculty to then target review plans for those who need it and alternatives for those who do not.

Lastly, there has been a lot of research about how the COVID-19 pandemic has widened the equity gap that already existed (Anand & Lall, 2022; Meyer and Wills, 2022; Minkos & Gelbar, 2021; Ruef, Willingham, & Ahearn, 2022). Therefore, it is important to note any significant differences in academic performance with respect to gender and ethnicity. With regard to gender difference, there was a statistically significant increase in mean score and pass rate for both males and females; however, as noted, female enrollment decreased the most between pre-pandemic and pandemic, more than double that of males. So even though the pass rates and mean scores were higher for both genders during the pandemic, females were impacted most by the low number of enrollment.

With regard to ethnicity, there were increases of mean score and pass rates for all groups; however, only White students had a statistically significant increase of mean scores. It is also worth to note that Black students had significantly lower mean scores and pass rates than White and Other Minority groups both in the pre-pandemic and pandemic cohorts. Even more so, the performance gap in College Algebra between Black, White, and Other Minority increased more in the during pandemic cohort. This evidence, in addition to the lower enrollment for Blacks during the pandemic, suggest that not only is there an equity gap, but it has widened as previous research suggests (Anand & Lall, 2022; Meyer & Wills, 2022; Minkos & Gelbar, 2021; Ruef et al., 2022). Therefore, it is important look for ways to begin to close in the equity gap. Tang et al. (2017) suggest ways in which active learning can support equity in the classroom. They report that fostering an inquiry-based learning environment can lead to a more equitable classroom (Tang et al.; 2017). Sattem et al. (2022) suggest institutions need to prioritize professional development of faculty. Professional development will provide faculty with tools of how to foster an equitable learning environment (Sattem et al., 2022). Outside of the classroom, many states have implemented programs and initiatives to help accelerate students learning and address deficiencies brought on by the COVID-19 pandemic (Governor Gavin Newsom, 2022; Lawson, 2022), and many school districts at the K-12 level are looking for ways to use the federal funding before the 2024 deadline, with an uptick in tutoring hiring and efforts (Dickler, 2023).

Conclusion

The COVID-19 pandemic brought many difficulties to the higher education landscape, including learning loss (Fawcett, 2022; Ludwig, 2021; Sanchez, 2022), equity issues (Anand & Lall, 2022; Meyer & Wills, 2022; Ruef et al., 2022; Wanti et al., 2022), and mathematics anxiety (Delima & Cahyawati, 2021; Ludwig, 2021). The rapid onset to online learning caused disruption to all aspects of students and teachers lives. Burnout became evident as the pandemic went on (Kirkman et al., 2022). These challenges spilled over into the higher education

landscape as enrollment dropped and the equity gap widened, both evidenced in this study. However, this study found that during the COVID-19 pandemic, more students passed College Algebra compared to before, suggesting that the widely discussed learning loss was not evident or was obscured in this context. It will be important for future research to follow these students into their subsequent mathematics courses, which for most is Trigonometry, Pre-Calculus, and Calculus, to see if performance drops.

There are several limitations in this study. For one, when COVID-19 happened, many things changed and began to vary by instructor. This means instructors who never taught online all of a sudden were forced to learn how. Meanwhile, there were instructors who were already teaching online who did not have to change or modify. This created discrepancy in how the course was taught. In addition, the pandemic also influenced mental health including happiness, fear, and stress for not just students, but also teachers. This influenced how the course was taught since different instructors were able to provide varying levels of interaction and student support. This can directly impact the pass rate and grades of the course. In addition, there are just two years of data for each cohort studied. Results may vary if more years were included.

Future research is suggested to continue to understand what occurred during the COVID-19 period and how we can address students' needs now that this time period has passed. Although there were many challenges brought forth with the COVID-19 pandemic, it is important to end with a note of opportunity. Faculty and students now seem more open to change, better equipped and familiar with new technologies, new styles of teaching, and more convenient ways of meeting not only with peers, but also with students (Kirkman et al., 2022). This offers the opportunity of more inclusiveness as we strive to continuously be open to change and to work harder towards reducing mathematics anxiety and closing the gap of learning loss and equity once and for all.

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Appendix A

Supporting Tables

Table A1

Demographic Information by Cohort

Pre-Pandemic (*N*=1540)		Pandemic (*N*=1229)		Changes	
	Frequency		Frequency	Frequency	Percentage
		Terms			
2018 Spring	314	2020 Spring	288	-26	-1.7%
2018 Summer	90	2020 Summer	53	-37	-2.4%
2018 Fall	420	2020 Fall	337	-83	-5.4%
2019 Spring	284	2021 Spring	186	-98	-6.4%
2019 Summer	59	2021 Summer	45	-14	-0.9%
2019 Fall	373	2021 Fall	320	-53	-3.4%
		Ethnicity			
American Indian	8	American Indian	12	4	0.3%
Asian	28	Asian	24	-4	-0.3%
Black	493	Black	348	-145	-9.4%
Hispanic	62	Hispanic	44	-18	-1.2%
Non-Resident Alien	64	Non-Resident Alien	48	-16	-1.0%
Two or More Races	243	Two or More Races	217	-26	-1.7%
Unknown or Refused to Report	11	Unknown or Refused to Report	5	-6	-0.4%
White	631	White	531	-100	-6.5%
		Gender			
Female	923	Female	711	-212	-13.8%
Male	615	Male	514	-101	-6.6%
Unknown	2	Unknown	4	2	0.1%
		Age			
Under 20	725	Under 20	622	-103	-.6.7%
20-29	515	20-29	370	-145	-9.4%
30-39	191	30-39	144	-47	-3.1%
40-49	56	40-49	66	10	0.6%
50-59	35	50-59	14	-21	-1.4%
60 or above	18	60 or above	13	-5	-0.3%

Table A2

Academic Background Across Cohorts by Gender

	Pre-Pandemic			Pandemic			
	N	*M*	*SD*	*N*	*M*	SD	*p*-value
				ACT Math			
Males	394	19.51	3.51	342	19.91	3.91	.155
Females	614	18.59	3.34	455	18.38	3.23	.316
				High School GPA			
Males	394	2.81	.56	368	3.02	.59	-4.86***
Females	620	3.02	.64	472	3.21	.53	-5.39***

***p < .01

Table A3

Academic Background Across Cohorts by Ethnicity

	Pre-Pandemic			Pandemic			
	N	*M*	*SD*	*N*	*M*	SD	*p*-value
				ACT Math			
Black	346	17.53	2.86	215	17.33	2.55	.42
Other Minority	312	19.47	3.21	267	19.15	3.50	.26
White	347	19.85	3.67	313	20.16	3.95	.30
				High School GPA			
Black	339	2.77	0.63	232	2.97	0.58	-3.682***
Other Minority	307	3.02	0.55	285	3.22	0.52	-3.21***
White	366	2.97	0.64	321	3.17	0.52	-4.25***

***p < .01

Table A4

College Algebra Mean Scores Across Cohorts by Gender

	Pre-Pandemic			Pandemic			
	N	*M*	*SD*	*N*	*M*	SD	*p*-value
Males	514	2.28	1.48	432	2.75	1.36	-5.049***
Females	796	2.56	1.39	588	2.83	1.34	-3.698***

***p< .01