2023 Annual Conference & Exposition
Baltimore Convention Center, MD | June 25 - 28, 2023
The Harbor of Engineering Education for 130 Years
ASEE
Paper ID #37741

Analysis of the COVID-19 Impact on Students' Enrollment, Performance, and Retention

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Abstract:

The COVID-19 pandemic brought a significant impact on society and the academic field. Many colleges and universities faced an enrollment drop during the pandemic years from the Spring of 2020. According to the Research Center's Stay Informed report series, institutions have had a total two-year enrollment drop of 4.2 percent since 2020. The Computer Systems Technology (CST) Department at New York City College of Technology (City Tech) of the City University of New York (CUNY) experienced a similar drop. At the same time, in the Spring 2020, most universities and colleges moved their teaching online. The decrease in enrollment numbers and shift to online teaching, combined with multiple reports of cheating in the wake of COVID-19, present an interesting case for studying the students' performance at different phases of COVID-19. The City Tech is a Hispanic Serving Institution (HSI), and many of our students come from low-income households and underrepresented communities which were dramatically affected by the pandemic. For the CST Department, the portions of students with economic disadvantages from the total enrolled numbers are around 72.5% in Fall 2019 and around 64% in Fall 2020. This project investigates how the changes in the learning environment (i.e., in-person to virtual and virtual to in-person) affected different student groups at City Tech at various phases of the pandemic. Our work concentrates on the students who take courses in the CST department. The analysis is performed by aggregating multiple institutional and departmental data sets from Spring 2019 to Spring 2022. The student's performance is examined for the sequence of the first three programming courses at the CST Department. It is analyzed along several dimensions, including major, gender, ethnicity, etc., throughout the different phases of the COVID-19 pandemic. This project investigates the performance of the students who take the CST courses as mandatory courses for the three CST majors as well as the performance of the students (non-CST majors) who take the CST courses as a general education computing requirement. The presented findings show the trends in courses enrollment, passing, failing, and withdrawing from the courses. In addition to a core three-course sequence, the project examines the general department retention numbers.

1. Introduction

The COVID-19 pandemic had a profound effect on college enrollment across the United States. "Enrollment reductions were largest among black and Latinx students" [1]. This work presents an analysis of how COVID-19 affected the enrollment numbers in City Tech in general and at the CST department in particular. The CST department offers three degree programs: an Associate degree (AAS) in Computer Information Systems, a Bachelor of Technology degree (BTech) in Computer Systems, and a Bachelor of Science degree (BS) in Data Science [2]. It must be pointed out that the BS in Data Science program was launched in Spring 2020, two months before City Tech moved all its classes online.

In the analysis, special attention is paid to a sequence of three introduction-level CST courses, the so-called CS1, CS2, and CS3 courses [3]. The first course (CS1) is a mandatory course for all CST students as well as for students from many STEM departments. CS1 can also be taken by any City

Tech students who want to familiarize themselves with the foundations of computer programming. CS2 is a mandatory course for all CST students and students from several STEM departments. CS3 course is mandatory for all CST students. The time span included in this study is from Fall 2019 to Spring 2022. Fall 2019 was the last semester before COVID-19 forced City Tech and other colleges to move their classes online. Spring 2022 is the semester where many CST courses were moved back to in-person teaching.

Our conclusions are two-fold. On the one hand, indeed, City Tech in general, and CST, in particular, were hit hard by the COVID-19 pandemic. The enrollment numbers decreased, and we can already project a long-term effect on the number of future graduates, which will necessarily decrease in the next couple of years due to the decreased number of students enrolled in the introduction-level courses during the Spring 2020 – Spring 2022 semesters. On the other hand, we observe an increased interest in STEM degrees that provide the skills that are currently in high demand. We demonstrate an increasing trend of student enrollment in one of the CST majors (BS in Data Science). Thus, we believe that in the modern economy where computers are ubiquitous and progress is driven by computer-assisted processing of massive data sets, the interest in STEM majors will be growing. The demand for CST graduates will increase despite the projected decrease in graduates in the next couple of years.

2. Enrollment trends before, and throughout COVID-19.

Table 1 presents the City Tech and the CST enrollment numbers from Fall 2019 to Spring 2022.[1] The number decreased significantly from Fall 2019 to Spring 2022 for both City Tech (by 30%) and CST (by 28.5%). It must be pointed out that the CST department is the largest department at City Tech in terms of the students majoring in one of its degrees and has twice as many students assigned to it as the second largest department.

According to the Brookings "Middle-Class Mobility" report,[2] City Tech is among the leaders "in lifting low-income students into the middle class." According to the City Tech AIRE office, more than 70% of the CST students are listed as coming from economically disadvantaged households in the City of New York.

Based on the analysis of Table 1, throughout the time span from Fall 2019 to Spring 2022, the number of CST students as a percentage of the City Tech students stayed around 13.5%. Thus, we believe that in terms of enrollment numbers, the CST department represents a good sample for the analysis of the entire City Tech population. Also, given that the CST department is the largest department at City Tech by a significant margin, the analysis of the effect of the COVID-19 pandemic on the CST student body can be extrapolated to the overall City Tech student body.

Interestingly, despite the overall decrease in enrollment throughout City Tech and CST, the new CST program, BS in Data Science, kept growing even throughout COVID-19. The BS in Data Science major was launched in Spring 2020 with its first students, all of whom transferred into this

[1] These are publicly available numbers that could be downloaded from the City Tech Office of Assessment, Institutional Research and Effectiveness (AIRE): http://air.citytech.cuny.edu/data-dashboard/

[2] https://www.brookings.edu/research/opportunity-engines-middle-class-mobility-in-higher-education/

major from either other City Tech majors or from other colleges. All of these students came with a background in mathematics and programming and were eager to start taking the Data Science courses designed specifically for the Data Science program. Thus, the first seven students who graduated with BS in Data Science degree in December 2022 had already completed the CS1, CS2, and CS3 sequence by the time City Tech moved to remote teaching in Spring 2020.

According to the presented numbers and despite the outlier (BS in Data Science), the analysis of the CST department enrollment and performance of the CST students in the introductory level courses could provide an insight into how City Tech was affected by COVID-19.

Table 1. Student Enrollment in City Tech and CST from Fall 2019 through Spring 2022.

	City Tech	CST	CST students as % of all City Tech students	CST BTech	CST AAS	CST BS
Fall 2019	17,036	2,285	13.41%	1,798	487	NA
Spring 2020	14,873	2,078	13.97%	1,688	384	6
Fall 2020	15,513	2,015	12.99%	1,578	422	15
Spring 2021	13,174	1,773	13.46%	1,411	336	26
Fall 2021	14,277	1,913	13.40%	1,417	446	50
Spring 2022	11,927	1,634	13.70%	1,252	330	52

3. Analysis of the student body outlook throughout COVID-19

As mentioned in Section 2, this work concentrates on the analysis of the three introduction-level courses at the CST department and tracks how the enrollment for these courses was affected by COVID-19.

CST CS1 course (CST 1101[3]) assumes that the students who take this course do not have any prior programming experience. This course provides an overview of the foundations of problem-solving using computers and introduces the basic concept of variables, basic data types and data structures, control sequences, etc. This course is a mandatory course for all CST students as well as many City Tech STEM-major students. Also, CS1 is frequently completed by many other City Tech students who want to familiarize themselves with the foundations of computer programming.

CST CS2 course (CST 1201) builds upon the foundations taught in CS1 and teaches user-defined methods, concepts of object-oriented programming, use of libraries, introduction to project management, etc. CS2 is a mandatory course for all CST majors as well as several other STEM majors.

[3] The official descriptions of the CST courses could be found on the official CST web site: https://www.citytech.cuny.edu/computer-systems/course-listing.aspx

CST CS3 course (CST 2309) builds upon the foundations taught in CS2 and introduces the concepts of web programming. CS3 is a mandatory course for all CST majors.

For the pre-COVID-19 CS1, CS2, and CS3 courses, it was typical that the Fall semesters have higher enrollment for CS1 than the following Spring semester as all the CST students are advised to take CS1 in the very first semester the students enter college. For each of the terms and each of the courses, we grouped together all the CST students and non-CST students.

3.1 Analysis of the gender distribution across the CS1, CS2, and CS3 courses.

Table 2 shows the enrollment numbers for the CS1, CS2, and CS3 courses with the split of the overall numbers between female and male students. For example, in Fall 2019 the overall 769 students who took the CS1 course were split into 255 male non-CST students, 170 female non-CST students, 282 male CST students, and 62 female CST students[4]. Figure 1 summarizes Table 2 across all the students: both male and female, CST and non-CST students. Figure 2 summarizes the gender information encoded in Table 2 across all CST and non-CST students. Figure 3 concentrates on CST students. Table 2 demonstrates a decrease in enrollment numbers across all four categories of students after the beginning of COVID-19. However, in Fall 2021, a year and a half after the pandemic hit New York when life in the city started coming back to normal, there was a jump in the enrollment numbers for CS1, especially among male CST students.

Figure 1 shows that the enrollment increase in Fall 2021 happens only for CS1 but not for CS2 or CS3. We explain it by the fact that the CST department has a strict order of prerequisites. To take CS3, one must successfully complete CS2; to take CS2 one must successfully complete CS1. Thus, due to the decreased number of students who completed CS2 in previous semesters, the number of students who could enroll in CS3 decreased. The same conclusion was made based on the enrollment numbers reported in earlier semesters. Thus, our overall conclusion is that COVID-19 will have a lingering effect on colleges, and we will see a decreased number of CST graduates in the next couple of years.

In Table 2 and supporting Figures 1, 2, and 3, one can see the decreasing horizontal trend: the number of students taking CS3 is less than the number of students taking CS2, and the number of students taking CS2 is less than the number of students taking CS1. This decreasing trend is expected as the pool of students who are required to take CS1, CS2, and CS3 decreases throughout this course sequence for non-CST majors. This jump in enrollment is demonstrated in Figure 1. It must be pointed out that the pattern of higher enrollment for CS1 in the Fall semesters and lower enrollment for CS1 in the Spring semesters was a typical pattern before COVID-19. It looks like this pattern holds in post-COVID-19 terms as well. However, further analysis beyond Spring 2022 is necessary for reliable conclusions. Figure 1 summarizes Table 2 and demonstrates that enrollment was affected for both male and female students.

Interestingly, the enrollment for female students starts recovering faster than the enrollment for male students. This is especially visible for CST female students. In Fall 2020, we can see the number of female students enrolled in CS1 jumps even higher than it was in pre-COVID Fall 2019. This trend is supported by the increased number of female students enrolled in CS2 in Spring 2020.

[4] The City Tech AIRE gender assignment for students is binary: male or female.

Table 2. Student Enrollment in City Tech and CST from Fall 2019 through Spring 2022 Split Across the CST and Non-CST as well as Male and Female Students.

	Non-CST		CST		All students		All students		All students
	Men	**Women**	**Men**	**Women**	**Men**	**Women**	**non-CST**	**CST**	
	CS1								
Fall 19	147	85	252	53	399	138	232	305	537
Sp 20	155	107	201	48	356	155	262	249	511
Fall 20	150	70	184	64	334	134	220	248	468
Sp 21	150	78	168	46	318	124	228	214	442
Fall 21	161	84	250	42	411	126	245	292	537
Sp 22	143	63	137	30	280	93	206	167	373
	CS2								
Fall 19	49	31	193	37	242	68	80	230	310
Sp 20	46	22	201	40	247	62	68	241	309
Fall 20	43	31	164	46	207	77	74	210	284
Sp 21	43	35	169	54	212	89	78	223	301
Fall 21	57	34	143	53	200	87	91	196	287
Sp 22	35	23	174	29	209	52	58	203	261
	CS3								
Fall 19	11	6	166	29	177	35	17	195	212
Sp 20	10	8	166	30	176	38	18	196	214
Fall 20	8	4	147	34	155	38	12	181	193
Sp 21	12	5	135	40	147	45	17	175	192
Fall 21	8	4	146	34	154	38	12	180	192
Sp 22	10	6	115	36	125	42	16	151	167

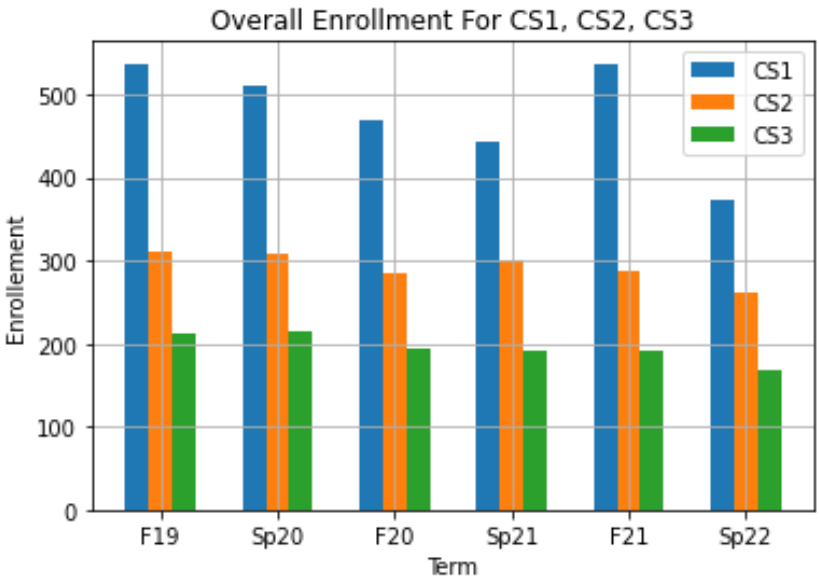

Figure 1. Overall Enrollment For CS1, CS2, and CS3.

3.2 Analysis of the gender distribution across the CS1, CS2, and CS3 courses

This work also analyzes the impact of COVID-19 on students of different ethnicities. The City Tech divides the students into the following eight ethnic groups: American Indian or Alaskan Native, Asian, Black or African American, Hispanic/Latino, Native Hawaiian or Other Pacific Islander, Nonresident alien, Two or more races, White. However, in several cases, American Indian or Alaskan Native, Native Hawaiian or Other Pacific Islander, and Two or more races, the number of enrolled students can be small to the degree that reporting these numbers separately might affect the anonymity of our data. Thus, to avoid this issue, we combine these four groups of students under the Other category.

Table 3 demonstrates the enrollment numbers for the CS1, CS2, and CS3 courses with the split of the overall numbers across different ethnic groups identified by City Tech. According to Table 3, students from all ethnic groups were affected by COVID-19. Though it must be pointed out that this Table demonstrates that for the CS3 course, the decrease in the enrollment numbers for non-CST majors is much more pronounced than for the CST majors, this phenomenon can be explained by the fact that only for the CST majors the CS3 course is a mandatory one. Also, no recovery after the end of the pandemic (in Fall 2021) is recorded for the CS3 enrollment numbers.

Figure 4 summarizes Table 3 and demonstrates that COVID-19 affected the enrollment numbers for students across all ethnicities. However, it can be observed that different ethnicities have different patterns of when students of those ethnicities were affected most. We cannot explain why the timelines of the changes in the enrollment numbers for different ethnicities vary. However, this is an interesting phenomenon that we plan to investigate in our future work.

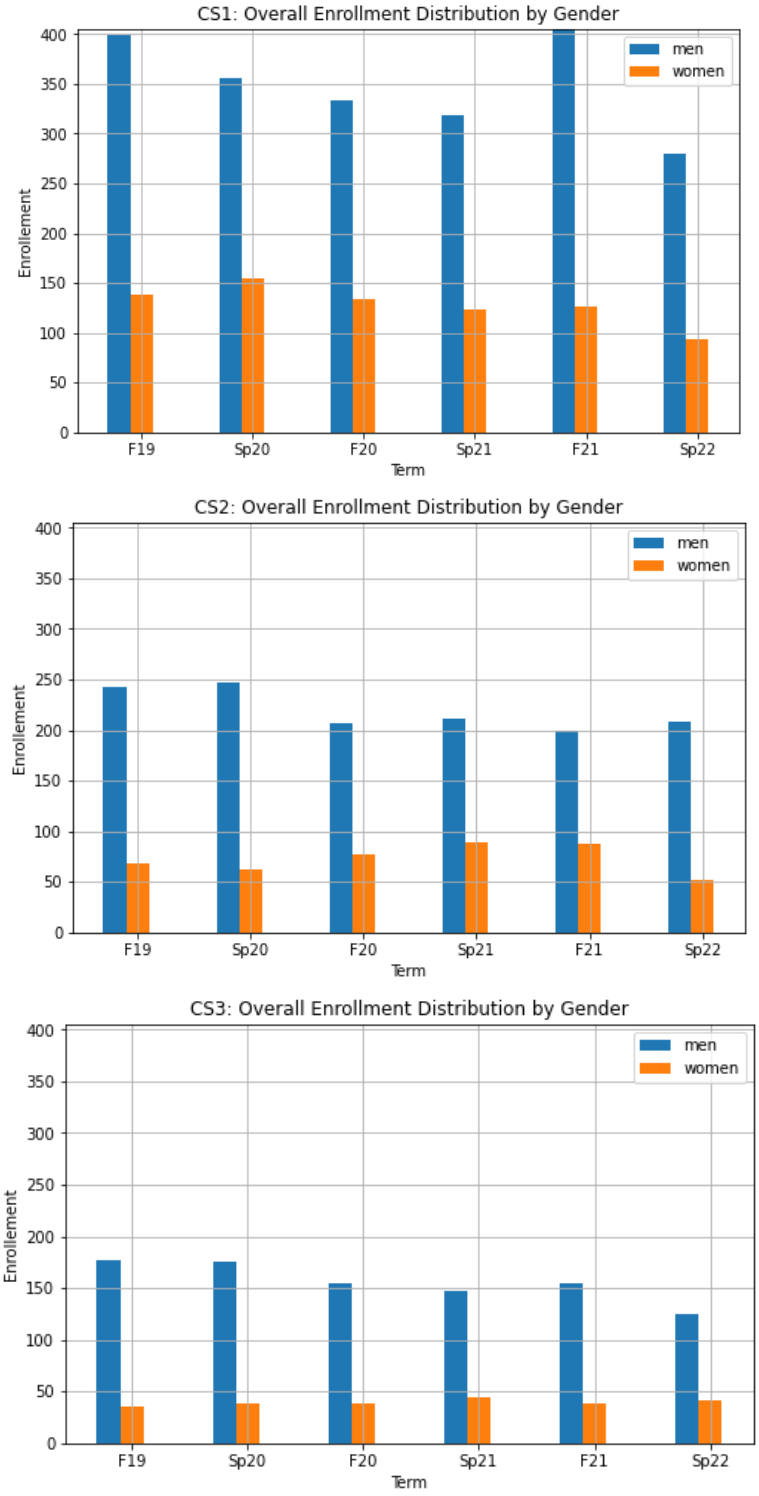

Figure 2. Enrollment For CS1, CS2, and CS3 Courses for Men and Women: Overall Enrollment for CST and non-CST Students

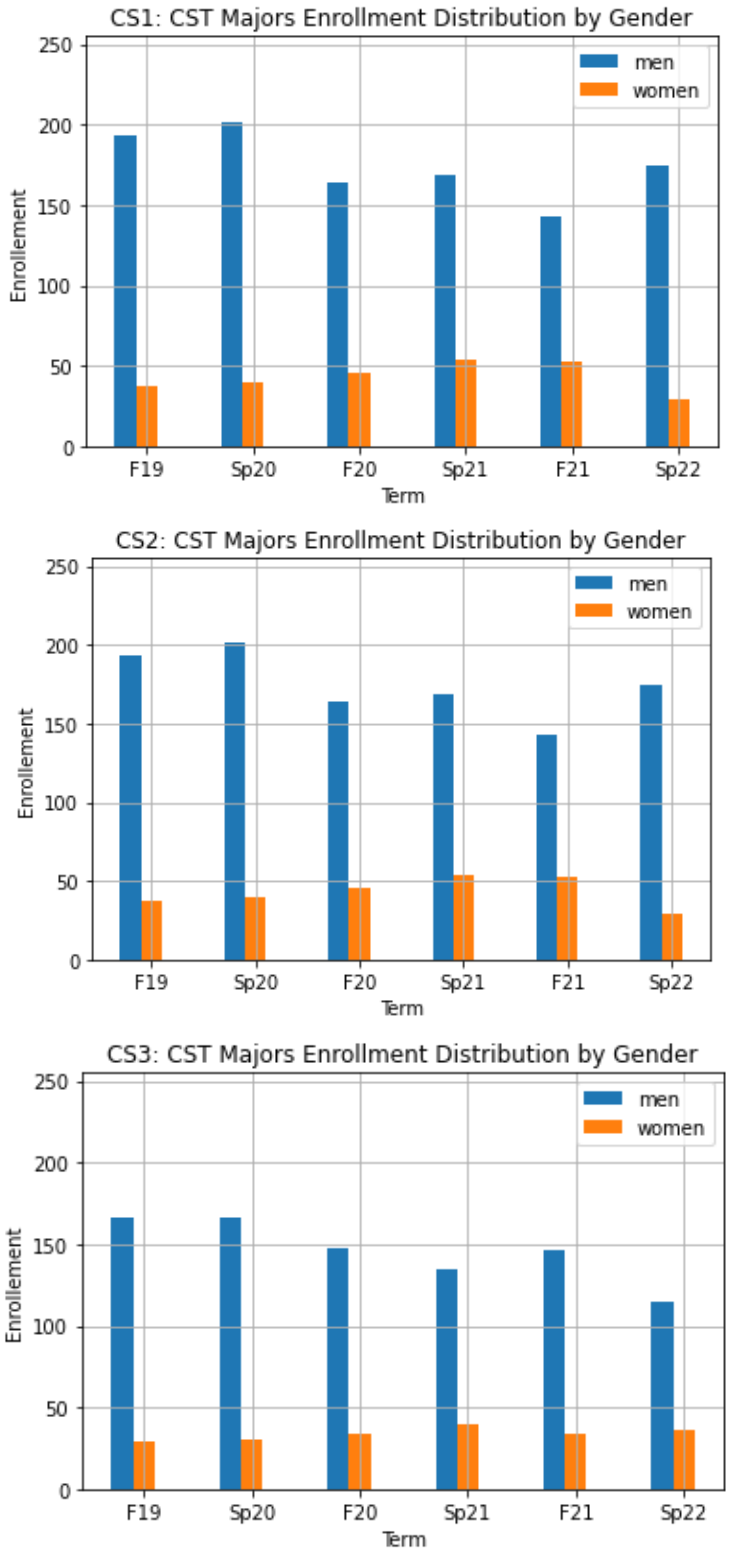

Figure 3. Enrollment For CS1, CS2, and CS3 Courses for Men and Women: Enrollment for CST Students

Table 3. Student Enrollment in City Tech and CST from Fall 2019 through Spring 2022 Split Across the CST and Non-CST as well as Students' Ethnicities.

	Asian		**Black or African American**		**Hispanic/ Latino**		**White**		**Other**	
	Non-CST	CST	Non-CST	CST	Non-CST	CST	Non-CST	CST	Non-CST	CST
CS1										
Fall 2019	53	93	66	68	74	101	22	24	19	19
Sp 2020	61	74	67	81	86	66	35	17	16	11
Fall 2020	64	81	49	54	68	84	19	14	20	15
Sp 2021	63	57	50	57	76	76	27	17	12	7
Fall 2021	68	79	66	84	69	84	33	28	9	17
Sp 2022	55	50	67	49	50	47	27	13	7	8
CS2										
Fall 2019	11	74	36	55	19	71	11	16	4	14
Sp 2020	11	77	19	56	20	69	13	24	7	15
Fall 2020	16	69	20	59	25	57	9	12	6	13
Sp 2021	22	70	14	55	20	62	17	19	5	17
Fall 2021	14	58	15	48	25	60	30	16	7	14
Sp 2022	10	68	11	40	17	61	17	19	3	15
CS3										
Fall 2019	0	47	12	49	3	66	1	19	1	14
Sp 2020	0	60	9	50	5	62	3	12	2	12
Fall 2020	1	62	8	39	0	46	3	26	0	8
Sp 2021	4	63	6	55	2	36	4	12	1	9
Fall 2021	0	65	1	44	6	37	4	15	1	19
Sp 2022	0	57	8	23	3	51	5	11	0	9

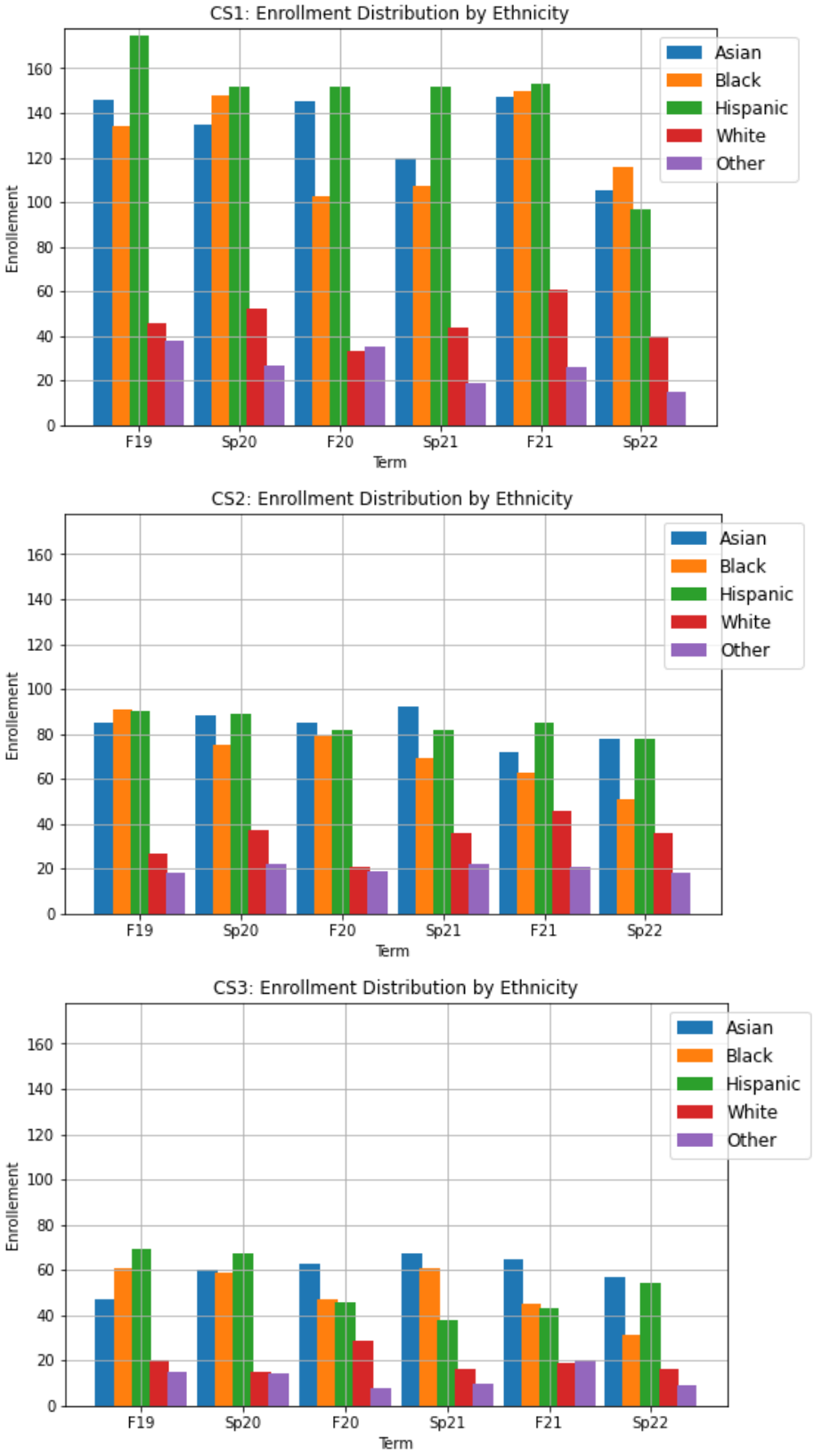

Figure 4. Overall Enrollment For CS1, CS2, and CS3 Across Students' Ethnicities.

3.3 Analysis of the grades throughout COVID-19

COVID-19 affected not only the college enrollment numbers but also the mode of material delivery: in the middle of Spring 2020, all the CST classes were moved online. It has been reported that an "online learning environment can be effective but presents additional challenges with regard to academic integrity compared to in-person education" [4] [5]. Table 4 contains the statistics regarding the CS1, CS2, and CS3 grades: how many students passed the class, how many students failed the class, how many students withdrew from the class, and what is the average grade. To compute the average grade across all the students who passed the class, we use the standard letter grade to number conversion shown below:

A	A-	B+	B	B-	C+	C	C-	D+	D
4	3.7	3.3	3	2.7	2.3	2	1.7	1.3	1

It must be noted that for a non-CST student CS1, CS2, and CS3 passing grade is D. However, a CST student should get C or higher to successfully pass the class.

Table 4 and Figure 5 specify the percentage of students who withdrew from each course during the period under analysis. As expected, the greatest number of withdrawals from CS1, CS2, and CS3 courses happened in the first semester affected by COVID-19, namely Spring 2020. The greatest percentage of students withdrew from CS1: 61% of non-CST students withdrew from CS1 in Spring 2020. Afterward, students adjusted to the COVID situation, and the percentage of withdrawal in the following terms across CS1, CS2, and CS3 among both non-CST and CST students are now stable, though a little higher than before COVID-19.

Figure 6 summarizes the average grades for the CST majors. In Spring 2020, when the situation with COVID-19 was most difficult in the country and affected both the City Tech students and faculty alike, City Tech adopted a CUNY policy of credit / no credit grade (see Table 4) when students had a choice of using credit / no credit grade instead of a letter grade in the transcript.[5] Though the introduction of this option was understandable for Spring 2020, the CST department was among those City Tech departments that decided not to continue with this practice beyond the Spring 2020 semester. In Fall of 2021, City Tech stopped offering this option college-wide.

Given the results in Table 4, we notice an increase in the average grade, especially for the non-CST students who take CS1. We believe that this phenomenon corresponds to the general phenomenon of increased grades in US universities that corresponds to the proliferation of online resources that can be used for the help with homework assignments [5]. This phenomenon requires further investigation and we plan to track the average grade for the CS1, CS2, CS3 courses over the next semesters to see if the average grades converge to the pre-COVID numbers.

[5] https://www.citytech.cuny.edu/registrar/credit-no-credit-policy.aspx

Table 4. Grade Distribution for CS1, CS2, and CS3 from Fall 2019 through Spring 2022.

		CS1		CS2		CS3	
		non-CST	CST	non-CST	CST	non-CST	CST
Fall 2019	Pass	194	220	73	170	12	177
	Fail	21	59	3	41	3	13
	Withdraw	19 (8%)	26 (9%)	5 (6%)	19 (8%)	2 (12%)	5 (3%)
	Avg. Grade	**3**	**2.82**	**2.98**	**2.97**	**3.25**	**3.36**
Spring 2020	Pass	181	159	43	173	16	157
	Fail	12	45	12	16	2	14
	Withdraw	51 (61%)	34 (38%)	11 (37%)	28 (41%)	1 (33%)	9 (23%)
	Credit	13	5	5	15	0	9
	No Credit	8	6	2	9	0	7
	Avg. Grade	**3.25**	**3.35**	**2.95**	**3.15**	**2.88**	**3.39**
Fall 2020	Pass	160	165	60	149	11	152
	Fail	22	43	4	30	1	9
	Withdraw	38 (17%)	40 (16%)	12 (16%)	31 (15%)	0 (0%)	20 (11%)
	Avg. Grade	**3.12**	**3.37**	**3.01**	**3.23**	**3.18**	**3.59**
Spring 2021	Pass	155	130	63	159	17	144
	Fail	32	41	10	39	0	16
	Withdraw	41 (18%)	43 (20%)	5 (6%)	25 (11%)	0 (0%)	15 (9%)
	Avg. Grade	**3.28**	**3.32**	**2.9**	**3.06**	**3.21**	**3.42**
Fall 2021	Pass	176	194	64	140	9	153
	Fail	24	57	10	26	2	9
	Withdraw	45 (18%)	41 (14%)	17 (19%)	30 (15%)	1 (8%)	18 (10%)
	Avg. Grade	**3.01**	**3.18**	**3**	**3.26**	**2.54**	**3.47**
Spring 2022	Pass	140	113	41	152	13	130
	Fail	27	24	7	30	3	10
	Withdraw	39 (19%)	30 (18%)	10 (17%)	21 (10%)	0 (0%)	11 (7%)
	Avg. Grade	**3.12**	**3.27**	**2.5**	**3.27**	**2.43**	**3.35**

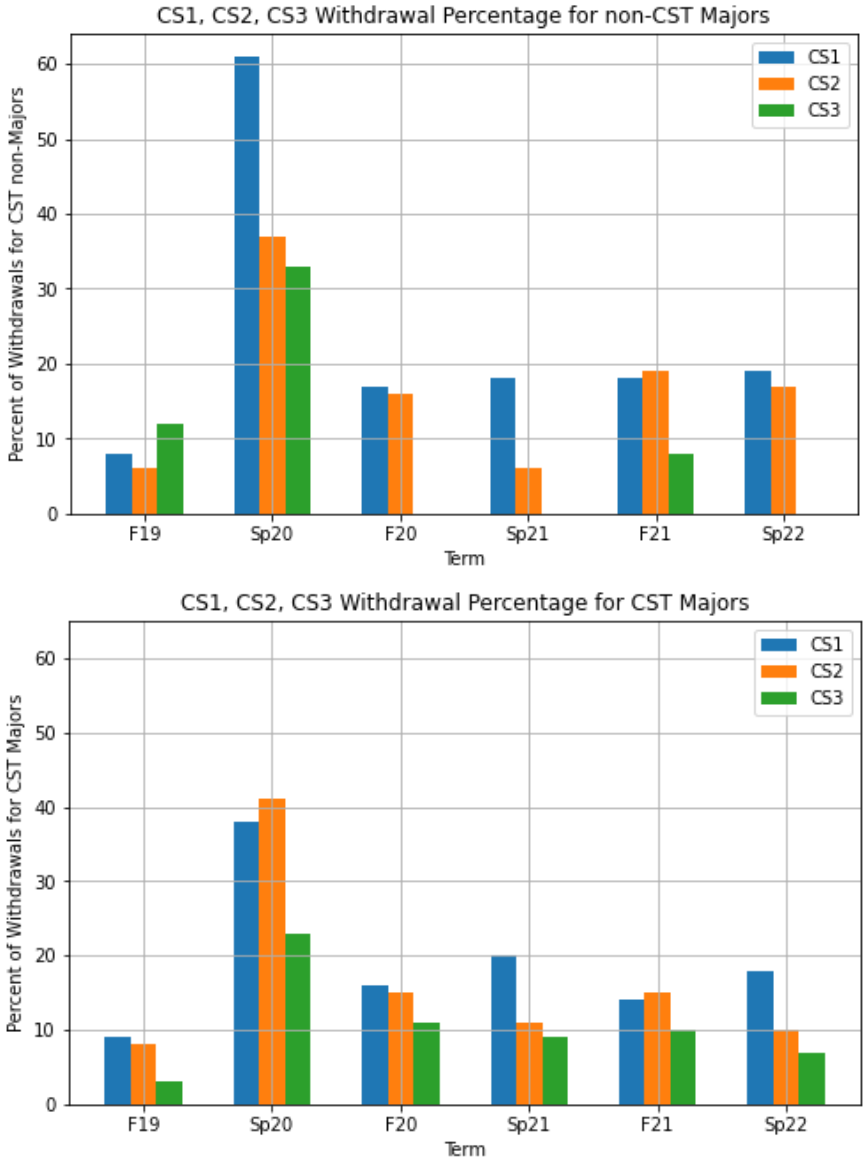

Figure 5. Percentage of Students Who Withdrew from CS1, CS2, and CS3. Top Cell: non-CST Majors; Bottom Cell: CST majors

4. Conclusions

According to observations presented in this paper, we project that in the next couple of years the number of graduates with CST majors will be negatively affected by COVID-19 and the decreased enrollment in the CS1, CS2, and CS3 courses during the period of Spring 2020 through Fall 2021 semesters. However, the STEM majors provide the skills that are in demand in the data-driven economy. In our paper, we demonstrate a growing number of students who enroll in the CST majors post-COVID. This trend corresponds to the overall trend for all the US colleges, as summarized by The National Student Clearinghouse Research Center. [6]

[6] https://nscresearchcenter.org/stay-informed/

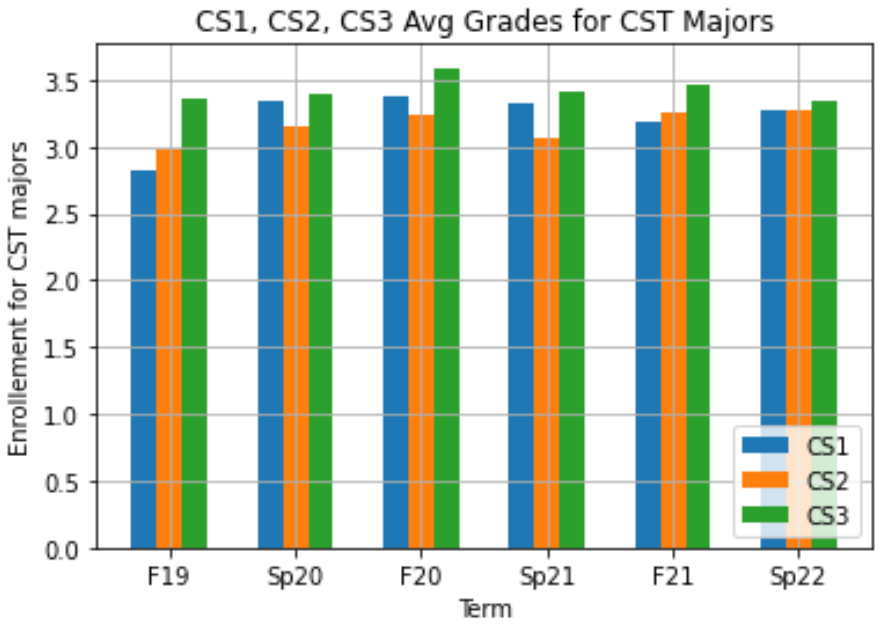

Figure 6. Average Grade for CST Majors.

5. Acknowledgment

This project was supported by the Data Diagnostic Grant by the Center for Inclusive Computing from Northeastern University.

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