

Student Success Analysis from Running a Pre-College Computer Science and Math Summer Program

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Abstract—This Research to Practice Work in Progress Paper studies the high attrition rate problem of first-time computer science Freshmen students at most universities. The problem is worsened given the growing demand of Information Technology workers and due to the limited instruction of computer science related content being taught within the high school education curriculum. The result is that incoming college students who are majoring in computer science or in related STEM fields are unprepared. Additionally, the means to adequately meet the employment demand is less likely with the low percentage of workers from under-represented minority (URM) groups in jobs within the computer science related industry. Much research has been done on predicting and improving student's success, particularly with the first programming and algorithms course known as CS1 and being ready to take Calculus. The problem is difficult to understand due to the many factors that exists, such as students having different education backgrounds, not knowing what a computer science education entails, and student support systems at a new school. At our university, for three summers, we offered our incoming engineering students a pre-college 4-week summer experience to better prepare them for their first year. The student population targeted were from under-represented minority groups, first-generation, low-income, and women. The goal of the program was to better prepare the students for success by engaging and advising them with both, computer science and math content by bringing them together as a cohort, which is essential during their first critical year in a computer science engineering field of study.

The goal of this paper is to study the attrition rates and gain insight on student success predictors for entering Computer Science students. Research has shown that pre-college programs can benefit student success. By targeting students from under-represented minority groups our summer program integrates computer science and math concepts to better prepare students for "Day 1" of college. The research work employs the student involvement theory to promote student success and retention. With COVID-19 restricting students to online learning, challenges in student-faculty and student-student contact have significantly made an impact. In addition to online survey/interview data, math and computer science course completion rates were collected from our 87 summer cohort participants to compare with the rest of the students. Triangulation of all the data collected yielded some insights and confirmed others on predictors for student success and persistence. Specifically, the summer students were disproportionately affected by COVID-19, compared to the

general population (i.e., they were readily not able to collaborate with their peers and approach faculty).

Keywords—*retention, summer program, computer science, COVID-19, student success*

I. INTRODUCTION

Much research work exists in understanding the causes that lead to a low success rate of students majoring in computer science [8]. One cause is that computer science is a new field which is generally not being taught in high school, especially in under-served school districts. Students just do not know what the field entails. In other cases, the cause may be weak study habits and a lack of aptitude. Both causes are likely to be experienced during the transition into a student's first year of college education.

Prior to the COVID-19 pandemic, much research in online education had taken place. For example, online laboratories have shown to be effective within the computer science field by fostering collaboration and reducing costs [17]. And with more accessible web-based dissemination tools, the delivery of flipped classrooms has become timelier and more cost-effective, which has led to improved student success. However, with the impact of the COVID-19 pandemic being so quick and uncertain, many academic institutions were not able to adapt thus, causing a tremendous impact on the learning process of millions of college students [4, 7].

Implementing computer science summer camps to increase diversity in STEM fields has shown to be effective. Students from under-represented groups in computer science such as women, Hispanics, Black Americans, and Native Americans are exposed to technology to engage them into pursuing a STEM career. Building cohort relationships is also a key component to promote inclusiveness [9].

Between the summers of 2018-20, California State University (CSU), Chico has partnered with Google to run the Computer Science Summer Institute (CSSI) – Extension program developed by Google. This pre-college program exposes Freshmen students to important computer science concepts in addition to soft skills as resume building plus community building. [5, 14]. Incoming engineering freshmen students were targeted, especially students from historically underrepresented groups in technology (i.e., women,

underrepresented minorities in STEM, first-generation, and from low-income households). During these three summers, a total of 87 students participated.

From the three cohorts of 87 students, 38 are female and 49 are male. And based on their ethnicities, they consist of 56 Hispanic/Latino, 19 White, 6 Black/African American, 4 Asian, and 2 having two or more races/ethnicities. We were fortunate not to decline participation to any student applicant who heard of the program through word of mouth and who was interested in attending. The goal was to establish a welcoming theme where all the students felt a great sense of belonging to their new campus atmosphere.

This paper initially presents an overall study of the COVID-19 pandemic impact at CSU, Chico followed by an examination of the student success metrics from the 87 summer participants as they proceeded through their college work.

II. STUDENT SUCCESS METRICS

A. Enrollment

Six months into the pandemic, Table I shows the overall Chico State Freshmen applicant yields dropped by roughly 6,000 students. To compensate this lower number, the university increased the acceptance rate. Hence, for the 2020-21 year, the impact was: i) a decrease in the number of applications. ii) an increase in the acceptance rate. iii) still, a decrease in the number of Freshmen students enrolled.

TABLE I. FRESHMEN APPLICANT YIELDS

	2017-18	2018-19	2019-20	2020-21
Number Applications	23,305	23,963	25,908	19,999
Number Admitted	15,796	15,639	18,740	18,034
Admitted Rate	67.8%	65.3%	72.3%	90.2%
Number Enrolled	2,805	2,725	2,561	2,316
Enrollment Yield	17.8%	17.4%	13.7%	12.8%

Chico State is not alone in experiencing a decrease in enrollment. According to the National Student Clearinghouse Research Center, the Spring 2021 undergraduate enrollment fell 5.9 percent compared to the previous year. The enrollment in community colleges had the greatest impact with an enrollment decrease of 11.3 percent, further down with a 9.5 percent decrease from the previous Fall 2020 semester [16].

Table II shows the total trend enrollment from only the College of Engineering and Computer Science, which is one of the five colleges within the CSU, Chico university. A direct relationship exists by comparing the drop rate between the first and second semesters of freshmen students to the acceptance rate. By admitting less prepared students in the Fall, the likelihood that students will continue to the following Spring semester is less. To accurately compare enrollments between the Fall and Spring semesters, the individual students were tracked in order to consider the same actual students between semesters.

This was necessary to distinguish the incoming community college transfer students who enrolled in the Spring semester.

TABLE II. ENGINEERING COLLEGE ENROLLMENT TREND

YEAR	FALL	SPRING	CHANGE	ACCEPTANCE
2015-16	2458	2408	-2.0%	64.6%
2016-17	2619	2542	-2.9%	65.2%
2017-18	2701	2553	-5.5%	67.8%
2018-19	2741	2585	-5.7%	65.3%
2019-20	2678	2502	-6.6%	72.3%
2020-21	2616	2361	-9.8%	90.2%

The next Table III further details by student class level the enrollment data for the 2020-21 school year, which is the critical year during the COVID-19 pandemic. The freshmen class enrollment was the most affected. Again, to accurately create this table, the same students were tracked from the Fall to Spring semester. The lower enrollment impact was similar between students in the computer science major compared with the other engineering majors within the Engineering College.

TABLE III. ENGINEERING COLLEGE ENROLLMENT BY LEVEL

LEVEL	FALL	SPRING	CHANGE
Freshmen	472	304	-35.6%
Sophomore	385	345	-10.4%
Junior	561	556	-0.9%
Senior	1167	1118	-4.2%
Post-BS	31	38	+22.6%

B. Withdrawal Rates

Within the Engineering College, the student withdrawal trend rate from the previous five years is shown in Table IV. The withdrawal rate spiked during the Spring 2020 semester when the pandemic began.

TABLE IV. ENGINEERING COLLEGE WITHDRAWAL

YEAR	SEMESTER	PERCENT OF STUDENTS WITH ONE OR MORE WITHDRAWS
2016	Fall	6.4%
2017	Spring	7.2%
	Fall	7.1%
2018	Spring	7.2%
	Fall	5.9%
2019	Spring	7.3%
	Fall	7.0%
2020	Spring	11.1%
	Fall	18.8%

C. What type of student is withdrawing?

This study then focused on the type of student which was withdrawing from his/her courses. An initial report was generated as shown in Table V which breaks down the percentage withdrawal rate by class level for each of our 4 core programming classes. Unfortunately, this data does not contribute much since generally, students advance in class level as they continue through the core classes. In other words, no freshman and sophomores enrolled in the CS4 course. However, it is of interest to note that most students withdrawing from the CS3 and especially from CS4 are Seniors as opposed to lower-level students. The author suggests that the reason is because the students who struggle tend to have accumulated more units from either transfer units or from repeating courses. The stronger students tend to quickly complete the core curriculum. A further in-depth study is needed to validate this behavior.

TABLE V. FALL/SPRING 2020 WITHDRAWAL

COURSE	CLASSIFICATION	PERCENT
CS1	Freshmen	62.5%
	Sophomore	8.3%
	Junior	25%
	Senior	4.2%
CS2	Freshmen	18.5%
	Sophomore	25.9%
	Junior	29.6%
	Senior	25.9%
CS3	Freshmen	5.6%
	Sophomore	16.7%
	Junior	33.3%
	Senior	44.4%
CS4	Junior	22.2%
	Senior	77.8%

To further examine student success, the DFW rate was used, which is defined as students earning non-passing grades D (60-69%), F (<60%) or W (course withdraw). The DFW rate is a key factor that is used to influence the retention and graduation rate at CSU, Chico [11]. The analysis is shown in Fig 1. The most affected type of student was Computer Science Freshman.

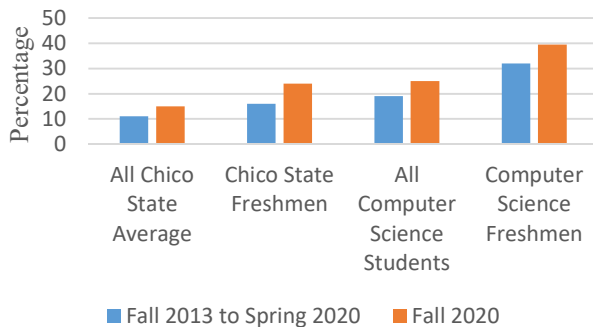


Fig. 1. Comparison of DFW rates.

D. Student success impact on the summer participants.

With the initial two cohorts of summer participants, as shown in Table VI, the overall success rate achieved was a lower DFW rate compared to all Freshmen Computer Science students who started the same year. The author had suspected that the students who participated in the summer program were more likely to succeed since they showed more interest in school by investing their summertime to get ready for their college experience. However, during the pandemic year, *the inverse trend occurred* with the DFW rate comparison of Cohort #3.

TABLE VI. FIRST YEAR COMPARISON

	DFW Rate
Cohort #1 (2018-19)	18%
All CS Majors (2018-19)	33%
Cohort #2 (2019-20)	22%
All CS Majors (2019-20)	32%
Cohort #3 (Fall 2020 only)	48%
All CS Majors (Fall 2020 only)	39.5%

To more closely examine the higher DFW rate of Cohort #3, a survey was given to the students in Cohort #3 (and to a control group) to assess their living situation. As shown in Table VII, 87% of the Cohort #3 students chose to continue living at their parent's home for their first 2020-21 school year and not relocate to the campus area. It was much convenient and cheaper to remain at home given we were in the middle of the pandemic and all classes would be online. Research has shown there are many struggles from online education during this COVID-19 pandemic which include psychological readiness, Internet accessibility equity, and family distractions [6, 12]. The lower student involvement in schoolwork with their peers has a great impact on student success [1].

TABLE VII. SURVEY QUESTION

For the Fall 2020 semester did you continue living at home rather than relocating to Chico	Cohort #3	Control Group
yes	87%	52%
no	6%	43%
both	7%	5%

III. DISCUSSION

Effective and timely instructor-student communication in online learning environments has shown to be most critical to student success. Any miscommunication and uncertainty in delivery is likely to lead students loss of attention and become dissatisfied with online instruction [15]. So even if the instructor did well, the impact from uncertainties with the COVID-19 pandemic in achieving student success becomes more challenging [15].

Prior to the Fall 2020 semester, Chico State non-URMs had a 10.2% DFW rate while the URM rate was 14.3% (41% higher). URM is defined as students from under-represented minority groups. In Fall 2020 the non-URM rate increased to 13.3% (30% higher) while the URM rate increased to 19.6% (37% higher). Thus the URM DFW rate equity gap increased from 4.1 percentage points to 6.3 percentage points. And, if only the URM effect on Freshmen is measured, it increased to 27% in the Fall 2020. The URM graduation equity gap is likely to continue to increase with the Spring 2021 and potentially Fall 2021 semesters [2]. Research work has found that men of color were most affected by COVID-19. Enrollment for Black and Hispanic men in academia fell 14.3 percent and 12.6 percent, respectively. Specifically, at community colleges, the impact was greater with a 21.5 percent drop for Black men and a 19.4 percent drop for Hispanic men [16].

The results from the data analyzed in this paper has shown that the impact on the summer camp students has been affected more than the general student population at our university. The author has alluded that the living conditions has made an impact. Moreover, all though the online summer 2020 program provided some cohort building success unfortunately, it was not as strong as in previous years. Mooney and Becker have found that the COVID-19 has had an impact on the sense of belonging [10]. Moreover, Biggers, Brauer, and Yilmaz have investigated that a sense of belonging is critical in the computer science field which if missing, is likely to cause women to drop from the major [3].

While undergraduate enrollment declined, particularly at community colleges, enrollment at the graduate education level rose. The National Student Clearinghouse Research Center found master's degree and doctoral degree enrollment increased 5.2 and 3.6 percent, respectively. In comparison, associate and bachelor's degree enrollment declined 10.9 and 2.2 percent, respectively [16]. The work by [13] discusses a similar growing divergence such that undergraduate enrollment dropped 5.9% from the start of the pandemic, while graduate level enrollment increased 4.4%. A similar trend was experienced at Chico State between students in their first two years of college who tended to struggle more compared to students in their last two years of college. The more mature students were better able the shift to online demands. One possible reason is that more than 50% of incoming freshmen decided to stay at home during the Fall 2020 semester compared to 17% of ongoing upper division students.

IV. CONCLUSION AND FUTURE WORK

The impact from the COVID-19 pandemic has been devastating to many students, especially incoming computer science freshmen students from under-represented groups. Less students enrolled and furthermore, the quantity of withdrawals from courses increased dramatically.

Even by providing a summer camp experience to students, the success rate did not improve but instead, the inverse happened. The cause may well be that students from under-deserved groups tended to remain living at home during the first critical year. There is indeed more research needed to understand the impact more. Other factors may be emotional stresses in going through uncertain times, and/or possibly the financial impact that especially affected under-served communities. Based on the current findings, it would be

beneficial to investigate the predictors more thoroughly. Plus, another area of further investigation is to examine any long-lasting effects on student success for different class grade levels.

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