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Student Characteristics and Academic Variables Associated with STEM Transfer Students from Community College

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Abstract:

The Obama administration has been investing and promoting science, technology, engineering and math (STEM) education. In the federal 5-year STEM strategic plan, community colleges are proposed to play a key role in recruiting and preparing future scientists and engineers, especially among students from traditionally underrepresented ethnic backgrounds. Through a grant from the Hispanic-Serving Institutions (HSI) Education Grants Program, the STEM Center was established at a community college in Northern California. The STEM Center integrated all STEM student support services within STEM academic study. Through leveraging multiple grants, the STEM Center provides a set of comprehensive student support services, including study groups, tutoring, STEM-specific academic counseling and career exploration, and information on internships and scholarships. The STEM support services are strategically planned and provided with the goal of increasing the number of STEM students at the college, and preparing them for transferring to 4-year institutions. This paper presents results from an exploratory examination of the impact that the STEM Center has had on increasing the number of STEM students who are transfer-ready and who transferred to a 4-year institution over a 5-year period (from 2009-10 to 2014-15 academic years). The results indicated that Cañada has increased the number of transfer-ready STEM students, particularly of minority students, male students, and students ages 18-24. In addition, results from three logistic regression analyses examining which specific academic and student support services were important in getting a student to transfer, indicated that transfer-ready STEM students who were younger, have earned transferable credits between 60 and 90, and have accessed some level of STEM-specific support services were more likely to transfer to a 4-year institution within a reasonable time frame.

1. Introduction

According to a federal report issued in 2012, the U.S. needs to have an additional one million STEM graduates by 2022 in order retain historical preeminence in science and technology[1]. This is an increase of about 34 percent annually over the current rates. The report, along with the federal 5-year STEM strategic plan released in 2013[2], also proposes that improving retention at community colleges (or 2-year institutions) is a promising and cost-effective strategy to address this need. Moreover, due to its open access and significantly lower tuition cost, community colleges are well positioned to recruit, retain, and prepare STEM students who are from traditionally underrepresented ethnic backgrounds.

STEM Centerat Cañada

Cañada, located in the San Francisco Bay Area, CA is a member of the California Community Colleges system and is a federally-designated Hispanic-Serving Institution. During the 2014-15 academic year, the college enrolled 11,368 unique students, with Hispanic students as the largest single ethnic group at 35.2%, followed by white students at 27.6%, and Asians at 12.2%. Like all California Community Colleges, Cañada is an open-enrollment institution, designed to welcome students of all backgrounds.

In 2008, Cañada was awarded a Minority Science and Engineering Improvement Program (MSEIP) grant by the U.S. Department of Education. The project, entitled Student On-ramp Leading to Engineering and Sciences (SOLES), aimed to increase the participation, retention, and success of underrepresented and educationally disadvantaged students interested in pursuing careers in STEM fields. Among the strategies developed for this project is the Summer Math Jam – a one-week intensive mathematics program designed to improve students' preparation for college-level math courses. When the SOLES grant ended in 2011, the college received an HSI-STEM grant from the U.S. Department of Education to expand and develop more programs and supports in an effort to increase enrollment and transfer in STEM fields. Current supports and services provided in STEM include study groups, tutoring, STEM-specific academic counseling and career exploration, and information about STEM internships and scholarships.

While the success of the STEM Center's individual programs is specifically linked to program objectives and outcomes, gauging success of the STEM Center as a successful transfer institution from community college to 4-year institution has not been examined. This paper presents findings from an exploratory study to determine the relationship between student academic preparation of STEM students, use of STEM support services, and transfer to 4-year institutions. The objective of this study is to understand the impact the STEM Center has had on increasing the number of STEM students who are transfer-ready and who transfer to 4-year institutions.

2. Background and literature review

Previous research on transfer of community colleges to 4-year institutions have suggested that student characteristics, background, and academic preparations are significant factors contributing to a student's successful transfer. Student characteristics that consistently contribute to higher transfer rates include being younger, having higher socioeconomic status, and better academic preparation in high school[3]. Specifically, Clotfelter and colleagues found that community college students from low-income backgrounds are less likely to succeed in transfer programs than are those from higher income families[4]. Related to socioeconomic status, the ability to work less or go to school full-time with fewer commitments outside of school have also been associated with higher transfer success[5,6,7].

In terms of academic preparation, grade point average (GPA) earned at the community college has been suggested as a strong predictor of higher transfer rates[8], as well as retention and success in undergraduate studies in science and engineering[9]. For transfer students from community colleges, the number of credits earned in engineering courses at the community college is important in the likelihood of transfer students completing a bachelor degree in engineering[9]. Levin and Wychoff have also identified success in Physics 1 and Calculus 1 as best indicators of a student completing a bachelor's degree in engineering[10].

3. Research questions

To understand the impact the STEM Center has had on preparing transfer-ready STEM students and transfer rates of those STEM students, the following research questions are addressed.

1. What are the numbers of transfer-ready STEM students at baseline year of 2009-10 and students in cohort year 2011-12?
2. What are the transfer rates of transfer-ready STEM students in 2009-10 compared to 2011-12?
3. What are characteristics of students who are transfer-ready in 2009-10 compared to 2011-12?
4. What types of services and supports did the 2009-10 and 2011-12 transfer-ready STEM students receive?
5. What are the academic preparations of transfer-ready STEM students in 2009-10 and 2011-12?
6. What are the associations between transfer-ready STEM students' characteristics, general academic preparation and receipt of support services, and likelihood of a student transferring to a 4-year institution?
7. What are the associations between transfer-ready STEM students' characteristics, grade in foundation STEM courses and receipt of support services, and likelihood of a student transferring to a 4-year institution?
8. What are the associations between transfer-ready STEM students' characteristics, academic preparation in engineering courses and receipt of support services, and likelihood of a student transferring to a 4-year institution?

4. Method

A compilation of data from Cañada's institutional database, program services data collected by the STEM Center, and the National Student Clearinghouse were used to create an analysis sample and dataset. A description of the sample, and data elements are given below.

Analysis sample of transfer-ready study

Transfer-ready students in STEM are defined as those students who have completed at least 60 or more transferable credits by the end of spring term of a given year and have completed at least one transferable course in either biology, chemistry, computer information system, engineering, math, or physics. Transferable courses are indicated in the course catalog as transferable to either University of California or California State University institutions. Cohorts of transfer-ready STEM students were further identified as those who have earned 60 or more transferable credits in a given year and have not been included in the previous cohorts.

Student characteristics

Cañada institutional database provided information regarding student's age at cohort year, ethnicity, gender, and receipt of income-based or need-based financial aid as a proxy to gauge student's socioeconomic background.

Academic preparation

For each cohort of students, student's academic course history was examined and the following variables created:

- total number of transferable credits earned
- cumulative transferable GPA calculated from all transferable credits earned
- grade (in GPA) in physics 1

- grade (in GPA) in calculus 1
- total number of credits in engineering earned
- GPA in engineering courses

Student grades were converted to a grade point scale as follows:

Letter grade	Grade Point Equivalent
A	4.0
A -	3.7
B+	3.3
B	3.0
B-	2.7
C+	2.3
C	2.0
C-	1.7
D+	1.3
D	1.0
D-	0.7
F	0.0

Student support services
The STEM Center membership form and participation in Math Jam were used as indicators of usage of student support services at the STEM Center. Math Jam is the longest student support services program offered by the STEM Center and has attendance data dating back to the baseline year of 2009-10. The total number of Math Jam sessions a student has attended since 2009 was calculated from currently available program data. STEM Center membership data since 2012-13 were used to create a dichotomous variable of engagement with the Center. Other STEM Center support services, including tutoring, study groups, Physics Jam, were developed after 2011 and were not fully implemented until 2013; therefore, those data were not included in the current analysis.

Transfer to a 4-year institution
Data for each cohort of transfer-ready STEM students at Cañada were matched with the National Clearinghouse Data (NCHD) postsecondary database. A dichotomous variable was created based on NCHD data about whether a student has transferred to a 4-year institution. A student is determined to have transferred to a 4-year institution if there was a match to enrollment at a 4-year institution after the cohort year.

Analysis
A combination of descriptive and logistic regressions were used to address the research questions. Logistic regressions are appropriate to understand the association between the predictors and a dichotomous outcome. In this study, the dichotomous outcome variable is transfer to a 4-year institution.

5. Findings

Descriptive analysis comparing cohorts 2009-10 and 2011-12 was used to address research questions 1 to 5. Logistic regressions, combining both cohorts of data, were conducted to answer research questions 6 to 8. Results for each research question are presented as follows.

Transfer-ready STEM students and transfer rates (research questions 1 and 2)
From 2009-10 to 2011-12, the number of students enrolled at Cañada who have earned 60 or more transferable credits and have completed a transfer-level course in STEM increased from 351 to 390, and among these students, the percent of students who transferred to a 4-year institution increased by 10 percentage points from 28 to 38 percent (Table 1).

Table 1. Number of transfer-ready STEM students and their transfer percentage

Cohort Year	Number of STEM students with 60 or more transferable credits in each cohort year	Number of STEM students in each cohort year who transferred to a 4-year institution by fall 2015	Percent of STEM students in each cohort year who transferred to a 4-year institution by fall 2015
2009-10	351	99	28.2%
2011-12	390	149	38.2%

Student characteristics (research question 3)
Minority status was determined based on a student's ethnicity. Minority students included students who are African American, American Indian or Alaska Native, Hispanic, Native Hawaiian or Pacific Islander, and multi-race; and non-minority students included students who are White Non-Hispanic, Asian or unknown. Between the baseline year of 2009-10 and 2011-12 year, the number of transfer-ready minority STEM students increased from 110 to 154, an increase of 40 percent. The largest increases were observed in the number of multi-racial students (an increase of 26 students), followed by Hispanic students (an increase of 17). In contrast, the number of non-minority transfer-ready STEM students decreased slightly from 241 to 236 (Table 2), with increases observed in White non-Hispanic students and decreases observed in students whose ethnicity is unknown.

Table 2. Distribution of transfer-ready student's ethnicity, by cohort year.

Ethnicity	2009-10 cohort Number	2011-12 cohort Number	Difference	Percent of change
Minority	110	154	44	40.0%
American Indian/ Alaskan Native	3	0	-3	-100.0%
Black – Non-Hispanic	3	5	2	66.7%
Hispanic	92	109	17	18.5%
Multi Races	9	35	26	288.9%
Pacific Islander	3	5	2	66.7%
Non-Minority	241	236	-5	-2.1%
White Non- Hispanic	98	111	13	13.3%
Asian	95	96	1	1.1%
Unknown	48	29	-19	-39.6%
Total	**351**	**390**	**39**	

In terms of gender, the number of female transfer-ready STEM students remained consistent between the two cohort years; whereas the number of male transfer-ready STEM students increased by nearly 30 percent over the same time period (Table 3).

Table 3. Distribution of transfer-ready student's gender, by cohort year.

Gender	2009-10 cohort Number	2011-12 cohort Number	Difference	Percent of change
Female	185	187	2	1.1%
Male	150	191	41	27.3%
Unknown	16	12	-4	-25.0%
Total	**351**	**390**	**39**	

Table 4 presents data on age of transfer-ready students at cohort year. An increase of over 70 percent from baseline year are observed in the youngest age group, ages 18 to 24; whereas the percent remained constant for ages 30 to 39, decreased by nearly 30 percent from baseline for ages 25 to 29, and decreased by 70 percent from baseline for ages 50 and older (Table 4).

Table 4. Distribution of transfer-ready student's age group, by cohort year.

Age Group	2009-10 cohort Number	2011-12 cohort Number	Difference	Percent of change
Ages 18-24	116	200	84	72.4%
Ages 25-29	116	84	-32	-27.6%
Ages 30-49	96	97	1	1.0%
Age 50 or older	20	6	-14	-70.0%
Unknown	3	3		
Total	**351**	**390**	**39**	

The number of transfer-ready STEM students who received need-based financial aid at Cañada have increased slightly from 177 in 2009-10 baseline year to 201 in 2011-12 cohort year (Table 5), an increase of 14 percent.

Table 5. Receipt of need-based financial aid, by cohort year

Receipt of need-based financial aid	2009-10 cohort Number	2011-12 cohort Number	Difference	Percent of change
Yes	177	201	24	13.6%
No	174	189	15	8.6%
Total	**351**	**390**	**39**	

STEM Center Support Services (research question 4)

To gauge engagement with and access to support services provided at the STEM Center, students were matched to Math Jam data as far back as 2010 and STEM Center membership information dating back to year 2012-13 (Table 6). Although the numbers are small and should be interpreted with caution, the data provide a general sense of number of students accessing the STEM Center.

Table 6. Receipt of STEM Center services by cohort year

STEM Center services	2009-10 cohort Number	2011-12 cohort Number	Difference	Percent of change
Math Jam Participant	3	15	12	400.0%
STEM Center member	3	29	26	866.7%
Total	**351**	**390**	**39**	

Academic preparation of transfer-ready STEM students (research question 5)
In terms of the academic preparation of transfer-ready STEM students, GPA remained the same, regardless of subject of study (Table 7). Average GPA for all transferable courses, grade in Calculus 1, grade in Physics 1 ranged from 3.0 to 3.2, a solid B grade. Average GPA in engineering courses was consistent at 3.4 (a grade of B+) for both years. Total transferable credits decreased slightly, but the total number of credits earned in engineering courses increased by 3 credits, almost a full class (Table 7).

Table 7. Academic preparation of transfer-ready STEM students, by cohort year

	2009-10 cohort				2011-12 cohort			
	N	**Min.**	**Max.**	**Mean**	**N**	**Min.**	**Max**	**Mean**
Total transfer credits earned	351	60.0	213.0	87.0	390	60.0	189.0	82.3
Transfer GPA	351	1.5	4.0	3.1	390	2.4	4.0	3.2
GPA in Calculus 1	153	2.0	4.0	3.0	162	2.0	4.0	3.0
GPA Physics 1	232	2.0	4.0	3.1	248	2.0	4.0	3.2
GPA in engineering courses	76	2.0	4.0	3.4	72	2.0	4.0	3.4
Total credits earned in engineering	76	1.5	26.0	12.2	72	1.0	33.0	15.1

Likelihood of transfer-ready STEM students transferring to a 4-year institution (research questions 6 to 8)
Three logistic regression models were fitted to the data to test the research hypotheses regarding the relationship between the likelihood that a transfer-ready STEM student transfers to a 4-year institution and the student's characteristics, academic preparation and engagement in STEM Center activities. As shown in Table 8 variables related to student characteristics and STEM Center participation were included in each logistic model. To explore the likelihood of a student transferring to a 4-year institution, three sets of distinct academic preparation variables were used in each model—overall transferable courses, specific STEM courses (i.e., Physics 1 and Calculus 1), and overall engineering courses.

The overall fit of all three models, as indicated by χ^2 statistic, shows that all three models demonstrate an improvement over the intercept-only model or the null model (Table 8). The statistical test of individual predictors in each model suggests that while holding all other variables fixed in the model, age is a strong predictor of the likelihood of a student transferring, being significant in all three models. In terms of academic preparation, only total transferable credits earned is a significant predictor. Membership in the STEM Center also emerged as a significant predictor of transferring. Worth noting are minority status and gender as possible significant predictors at $p < 0.10$.

Table 8. Summary of logistic regression analysis for variables predicting transfer to 4-year institutions by fall 2015

	Model with all transfer course preparation (n=735)			Model with Physics 1 or Calculus 1 course (n=141)			Model with engineering courses (n=144)		
Variables	Beta Coeffi-cient	S.E.	$e^{(B)}$ (odds ratio)	Beta Coeffi-cient	S.E.	$e^{(B)}$ (odds ratio)	Beta Coeffi-cient	S.E.	$e^{(B)}$ (odds ratio)
Age Group	-0.67***	0.11	0.51	-0.92***	0.28	0.40	-0.70*	0.29	0.50
Minority Status (Minority =0, Non-Minority=1)	0.31^	0.19	1.36	-0.05	0.42	0.95	0.41	0.41	1.50
Gender (Male=1, Female =2)	-.186	0.15	0.83	-0.18	0.34	0.83	-0.84^	0.44	0.43
Need-based financial aid (Yes=1, No=0)	.003	0.18	1.00	0.08	0.39	1.08	-0.20	0.40	0.82
Total Transfer Credits	-0.029***	0.01	0.97	--	--	--	--	--	--
Transfer GPA	.281	0.23	1.32	--	--	--	--	--	--
Physics 1 or Calculus 1 GPA	--	--	--	-0.16	0.40	0.85	--	--	--
Engineering GPA	--	--	--	--	--	--	.46	0.37	1.59
Total engineering Credits	--	--	--	--	--	--	-0.01	0.03	0.99
Math Jam	-.031	0.33	0.97	-0.31	0.52	0.73	0.32	0.81	1.38
STEM Center member	0.72*	0.31	2.04	0.72	0.47	2.05	1.2*	0.49	3.31
Constant	2.08	0.90	8.01	1.70	1.71	5.48	2.08	1.64	0.76
χ^2	121.09***			16.02*			25.08***		
df	8			7			8.00		

Note: Those students who concurrently attended a 4-year institution and community college were excluded from the analysis. Dependent variable of transferred is coded as 1 = transferred to a 4-year institution and 0= not transferred by fall 2015.

^ p < .10. *p < .05. **p < .01. ***p < .001.

In all three models, being in the younger age group was predicted to have greater probability of transferring than those in the older age group (Table 8). As displayed in Table 9, the percent of transfer-ready STEM students who transfer decreases with increase in each age group.

Table 9. Transfer status of transfer-ready STEM students, by age group

	Transferred		
Age Group	**No**	**Yes**	**Percent of transferred within each age group**
Ages 18-24	154	162	51.3%
Ages 25-29	155	45	22.5%
Ages 30-49	155	38	19.7%
Age 50 or older	24	2	7.7%
Total	**488**	**247**	

In regards to STEM Center membership, even though only 32 students were matched to the STEM Center membership data from 2012-13, holding all other variables constant, being associated with STEM Center is a significant predictor of transfer. Data presented in Table 10 show that of the transfer-ready STEM students who are members of the STEM Center, 63% transferred by fall 2015, compared with only 32% for those who are not members. This finding suggests that STEM Center services and supports at Cañada can significantly impact and improve a student's likelihood of transfer.

Table 10. Transfer status of transfer-ready STEM students, by STEM Center membership

	Transferred		
STEM Center member	**No**	**Yes**	**Percent of transferred within each group**
Yes	12	20	62.5%
No	481	228	32.2%
Total	**493**	**248**	

Finally, the only academic preparation indicator emerging as a significant predictor of transfer is the total number of transferrable credits (Table 8). Similar to age, the beta coefficient for this indicator is negative, indicating a negative relationship with transfer outcome. In other words, an increase in the number of transferable credits earned decreases the odds of a student transferring. Data with the full sample shows that more students with total transferable credits of 60 to 89.5 transfer (81%), compared with those students with total transferal credits of over 90 (31%, Table 11).

Table 11. Transfer status of transfer-ready STEM students, by total transferable credits earned

Total transferable credits earned	Transferred		
	No	Yes	Percent of transferred within each total credit range
60 to 75.5	171	142	45.4%
76 to 89.5	123	67	35.3%
90 to 109.5	136	29	17.6%
110 or more	63	10	13.7%
Total	**493**	**248**	

6. Conclusion

Overall, results presented indicate that the STEM Center at Cañada has increased the number of transfer-ready STEM students and the number of those students transferring to 4-year institutions. Between baseline year of 2009-10 and 2011-12 cohort year, the number of minority transfer-ready STEM students have increased, as well as more male students and students in the 18-24 age group. Furthermore, logistic regression analyses examining factors predicting transfer indicated that transfer-ready STEM students who are younger, have earned 60 to 90 transferable credits, and have accessed some level of STEM-specific support are more likely to transfer within a reasonable time frame. These findings suggests that STEM-specific support services do impact a student's chance of transferring, and that it is important for students to receive guidance on transferring before and during the optimal transferable credit range of 60 to 90.
The limitations of this study include the small sample size of those students with grades in physics, calculus and engineering. CañadaIt would be important for those factors to be explored further in future studies. Additionally, as the STEM Center at Cañada expands, it is important to examine subsequent cohorts of transfer-ready STEM students and assess the aggregated impact of all STEM Center supports and services, as well as the contribution of individual programs to the overall impact of the STEM Center.

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