Program Review - Overall Report

Instructional: Computer Information Systems & Computer Science

2021 - 2024

Overall Trends

What overall trends do you see in success, retention, program of study, educational planning, and awards over the past 3 or more years?

Overall CIS and CSC

Overall, students in Computer Information Systems (CIS) and Computer Science (CSC) courses) have a success rate which stayed virtually flat ranging from 71.76% to 69.5% to 69.9% over the last three full academic years.

Academic Year	2017-18					2018-19					2019-20				
Gender	Enrolled	Success	Success Rate	DI	Close Gap	Enrolled	Success	Success Rate	DI	Close Gap	Enrolled	Success	Success Rate	DI	Close Gap
Female	**573**	**397**	**69.3%**	**0**	**21**	**572**	**407**	**71.2%**	**0**	**0**	**616**	**432**	**70.1%**	**0**	**0**
African American	44	17	38.6%	0	21	44	30	68.2%	0	0	30	17	56.7%	0	0
Asian	85	70	82.4%	0	21	63	47	74.6%	0	0	86	69	80.2%	0	0
Hispanic	300	205	68.3%	0	21	335	239	71.3%	0	0	335	234	69.9%	0	0
Native American	1	1	100.0%	0	21	1	0	0.0%	0	0	4	1	25.0%	0	0
Pacific Islander	4	2	50.0%	0	21	1	0	0.0%	0	0				0	0
Two or More	5	3	60.0%	0	21	9	6	66.7%	0	0	8	4	50.0%	0	0
Unknown	6	5	83.3%	0	21	8	7	87.5%	0	0	9	5	55.6%	0	0
White	128	94	73.4%	0	21	111	78	70.3%	0	0	144	102	70.8%	0	0
Male	**1,071**	**781**	**72.9%**	**0**	**0**	**1,123**	**771**	**68.7%**	**0**	**29**	**1,090**	**761**	**69.8%**	**0**	**4**
African American	53	38	71.7%	0	0	51	26	51.0%	0	29	55	37	67.3%	0	4
Asian	179	140	78.2%	0	0	178	124	69.7%	0	29	169	131	77.5%	0	4
Hispanic	507	351	69.2%	0	0	548	363	66.2%	0	29	518	337	65.1%	0	4
Native American	1	1	100.0%	0	0	2	2	100.0%	0	29	2	2	100.0%	0	4
Pacific Islander	1	0	0.0%	0	0	8	7	87.5%	0	29	6	3	50.0%	0	4
Two or More	24	20	83.3%	0	0	16	12	75.0%	0	29	18	8	44.4%	0	4
Unknown	10	7	70.0%	0	0	8	6	75.0%	0	29	31	17	54.8%	0	4
White	296	224	75.7%	0	0	312	231	74.0%	0	29	291	226	77.7%	0	4
Total	**1,644**	**1,178**	**71.7%**	**0**	**0**	**1,695**	**1,178**	**69.5%**	**0**	**0**	**1,706**	**1,193**	**69.9%**	**0**	**0**

In Fall 2019 the success rate was 74.6 % then fell to 62.6% in Spring 2020 which is likely due to the effects of the pivot to online due to the Covid pandemic. In Fall 2020 the success rate rose to 67.6%.
Retention has decreased from 84.3% to 81.2% to 78.6% over the past 3 years. PreCovid, in Fall 2019, the retention rate was 85%. In Spring 2020 the retention rate dropped to 68.2%. In Fall 2020 the retention rate bounced back to 81.1%

Both success rates and retention rates are rising back to precovid levels.
In terms of student subgroups, African American Females and Hispanic Males are showing gaps in success that are concerning. Hispanic Males are also showing gaps in retention that are concerning.

CIS-5/CSC-5 Success and Retention

Data Review

Because CIS-5, Introduction to Programming Methodology using C++, is the entry level high enrollment computer programming course, the success and retention data is presented apart from the overall CIS/CSC data.

Overall, students enrolled in CIS-5/CSC-5 have a success rate which increased from 57.8% to 62.2% to 64.4% over the last three full academic years. PreCovid, in Fall 2019, the success rate for CIS-5 rose to 69.5% then fell to 61.3% in Spring 2020 which we attribute to the pivot to online when the pandemic hit.

Academic Year	2017-18					2018-19					2019-20				
Gender	Enrolled	Success	Success Rate	DI	Close Gap	Enrolled	Success	Success Rate	DI	Close Gap	Enrolled	Success	Success Rate	DI	Close Gap
Female	**75**	**37**	**49.3%**	**0**	**9**	**60**	**37**	**61.7%**	**0**	**1**	**87**	**55**	**63.2%**	**0**	**2**
African American	3	1	33.3%	0	9	4	3	75.0%	0	1	3	1	33.3%	0	2
Asian	19	9	47.4%	0	9	13	11	84.6%	0	1	12	9	75.0%	0	2
Hispanic	34	19	55.9%	0	9	27	11	40.7%	0	1	45	25	55.6%	0	2
Native American				0	9				0	1	1	0	0.0%	0	2
Pacific Islander				0	9				0	1				0	2
Two or More				0	9	2	1	50.0%	0	1	2	2	100.0%	0	2
Unknown	1	1	100.0%	0	9				0	1	2	1	50.0%	0	2
White	18	7	38.9%	0	9	14	11	78.6%	0	1	22	17	77.3%	0	2
Male	**228**	**138**	**60.5%**	**0**	**0**	**239**	**149**	**62.3%**	**0**	**0**	**244**	**158**	**64.8%**	**0**	**0**
African American	6	4	66.7%	0	0	7	4	57.1%	0	0	7	3	42.9%	0	0
Asian	46	30	65.2%	0	0	44	27	61.4%	0	0	42	30	71.4%	0	0
Hispanic	108	61	56.5%	0	0	111	65	58.6%	0	0	121	75	62.0%	0	0
Native American				0	0				0	0				0	0
Pacific Islander				0	0	1	1	100.0%	0	0	1	0	0.0%	0	0
Two or More	4	2	50.0%	0	0	4	4	100.0%	0	0	1	1	100.0%	0	0
Unknown	3	3	100.0%	0	0	1	1	100.0%	0	0	8	5	62.5%	0	0
White	61	38	62.3%	0	0	71	47	66.2%	0	0	64	44	68.8%	0	0
Total	**303**	**175**	**57.8%**	**0**	**0**	**299**	**186**	**62.2%**	**0**	**0**	**331**	**213**	**64.4%**	**0**	**0**

Females erolled in CIS-5 increased from a success rate of 49.3% to 61.7% to 63.2% in the 2019 - 2020 academic year. PreCovid, in Fall 2019, females enrolled in CIS-5 had a success rate of 68.3%

Hispanic females are showing a gap in success rate which is concerning.

Academic Year	2017-18					2018-19					2019-20			
Gender	Enrolled	Success	Success Rate	DI	Close Gap	Enrolled	Success	Success Rate	DI	Close Gap	Enrolled	Success	Success Rate	DI
Female	**75**	**37**	**49.3%**	**0**	**0**	**60**	**37**	**61.7%**	**0**	**0**	**87**	**55**	**63.2%**	**0**
African American	3	1	33.3%	0	0	4	3	75.0%	0	0	3	1	33.3%	0
Asian	19	9	47.4%	0	0	13	11	84.6%	0	0	12	9	75.0%	0
Hispanic	34	19	55.9%	0	0	27	11	40.7%	0	0	45	25	55.6%	0
Native American				0	0				0	0	1	0	0.0%	0
Pacific Islander				0	0				0	0				0
Two or More				0	0	2	1	50.0%	0	0	2	2	100.0%	0
Unknown	1	1	100.0%	0	0				0	0	2	1	50.0%	0
White	18	7	38.9%	0	0	14	11	78.6%	0	0	22	17	77.3%	0
Total	**75**	**37**	**49.3%**	**0**	**0**	**60**	**37**	**61.7%**	**0**	**0**	**87**	**55**	**63.2%**	**0**

Overall, for CIS-5, students have a retention rate of 79.9%, 76.4% and 75.5% over the past year. PreCovid, in Fall 2019, the retention rate for CIS-5 was 88.0%.

Data Review

In terms of student subgroups, the retention rate for females increased from 60.4% to 76.7 to 78.2% over the last three full academic years. PreCovid, in Fall 2019, the retention rate for females rose to 85.4%.

Academic Year	2018-19					2019-20					2020-21				
Gender	Enrolled	Retained	Retention Rate	DI	Close Gap	Enrolled	Retained	Retention Rate	DI	Close Gap	Enrolled	Retained	Retention Rate	DI	Close Gap
Female	**60**	**46**	**76.7%**	**0**	**3**	**87**	**68**	**78.2%**	**0**	**0**	**52**	**35**	**67.3%**	**0**	**6**
African American	4	3	75.0%	0	3	3	2	66.7%	0	0	5	3	60.0%	0	6
Asian	13	12	92.3%	0	3	12	11	91.7%	0	0	8	8	100.0%	0	6
Hispanic	27	18	66.7%	0	3	45	31	68.9%	0	0	23	13	56.5%	0	6
Native American				0	3	1	0	0.0%	0	0	1	0	0.0%	0	6
Pacific Islander				0	3				0	0				0	6
Two or More	2	1	50.0%	0	3	2	2	100.0%	0	0	2	1	50.0%	0	6
Unknown				0	3	2	2	100.0%	0	0	1	1	100.0%	0	6
White	14	12	85.7%	0	3	22	20	90.9%	0	0	12	9	75.0%	0	6
Male	**239**	**193**	**80.8%**	**0**	**0**	**244**	**185**	**75.8%**	**0**	**6**	**164**	**128**	**78.0%**	**0**	**0**
African American	7	7	100.0%	0	0	7	4	57.1%	0	6	11	8	72.7%	0	0
Asian	44	34	77.3%	0	0	42	35	83.3%	0	6	33	26	78.8%	0	0
Hispanic	111	86	77.5%	0	0	121	88	72.7%	0	6	71	51	71.8%	0	0
Native American				0	0				0	6				0	0
Pacific Islander	1	1	100.0%	0	0	1	0	0.0%	0	6	4	2	50.0%	0	0
Two or More	4	4	100.0%	0	0	1	1	100.0%	0	6	6	6	100.0%	0	0
Unknown	1	1	100.0%	0	0	8	5	62.5%	0	6	3	3	100.0%	0	0
White	71	60	84.5%	0	0	64	52	81.3%	0	6	36	32	88.9%	0	0
Total	**299**	**239**	**79.9%**	**0**	**0**	**331**	**253**	**76.4%**	**0**	**0**	**216**	**163**	**75.5%**	**0**	**0**

CB01
is CIS-5

College
is NC

Term
is Summer 2018, Fall 2018, Winter 2019, Spring 2019, Summer 2019, Fall 2019, Winter 2020, Summer 2020, Fall 2020, or Spring 2020

ay
is 2015-16, 2016-17, 2017-18, 2018-19, 2019-20, or 2020-21

disc
is CIS

gender
is Female or Male

Hispanic females and African American males are showing gaps in retention that are concerning.

CIS-1A Success and Retention

Because CIS-1A (Introduction to Computer Information Systems) is an entry-level high-enrollment course, the success and retention data for CIS-1A is presented apart from the overall CIS/CSC data.

Overall, students enrolled in CIS-1A had success rates of 70.4%, 70.0% and 71.2% over the last three years. The success rate is slightly increasing.

Academic Year	2017-18					2018-19					2019-20				
Gender	Enrolled	Success	Success Rate	DI	Close Gap	Enrolled	Success	Success Rate	DI	Close Gap	Enrolled	Success	Success Rate	DI	Close Gap
Female	**352**	**249**	**70.7%**	**0**	**0**	**329**	**231**	**70.2%**	**0**	**0**	**368**	**266**	**72.3%**	**0**	**0**
African American	33	13	39.4%	0	0	36	25	69.4%	0	0	21	13	61.9%	0	0
Asian	27	25	92.6%	0	0	24	18	75.0%	0	0	45	36	80.0%	0	0
Hispanic	203	142	70.0%	0	0	198	145	73.2%	0	0	213	156	73.2%	0	0
Native American	1	1	100.0%	0	0				0	0	2	1	50.0%	0	0
Pacific Islander	2	0	0.0%	0	0	1	0	0.0%	0	0				0	0
Two or More	4	2	50.0%	0	0	6	4	66.7%	0	0	3	0	0.0%	0	0
Unknown	2	2	100.0%	0	0	4	3	75.0%	0	0	2	2	100.0%	0	0
White	80	64	80.0%	0	0	60	36	60.0%	0	0	82	58	70.7%	0	0
Male	**364**	**255**	**70.1%**	**0**	**3**	**418**	**292**	**69.9%**	**0**	**2**	**445**	**313**	**70.3%**	**0**	**9**
African American	21	14	66.7%	0	3	25	12	48.0%	0	2	29	20	69.0%	0	9
Asian	50	39	78.0%	0	3	39	29	74.4%	0	2	53	41	77.4%	0	9
Hispanic	183	121	66.1%	0	3	228	155	68.0%	0	2	228	150	65.8%	0	9
Native American				0	3	2	2	100.0%	0	2	1	1	100.0%	0	9
Pacific Islander	1	0	0.0%	0	3	3	3	100.0%	0	2	4	2	50.0%	0	9
Two or More	7	5	71.4%	0	3	4	2	50.0%	0	2	10	4	40.0%	0	9
Unknown	2	1	50.0%	0	3	5	4	80.0%	0	2	12	7	58.3%	0	9
White	100	75	75.0%	0	3	112	85	75.9%	0	2	108	88	81.5%	0	9
Total	**716**	**504**	**70.4%**	**0**	**0**	**747**	**523**	**70.0%**	**0**	**0**	**813**	**579**	**71.2%**	**0**	**0**

CB01
is CIS-1A

College
is NC

Term
is Summer 2017, Fall 2017, Winter 2018, Spring 2018, Summer 2018, Fall 2018, Winter 2019, Spring 2019, Summer 2019, Fall 2019, Winter 2020, or Spring 2020

ay
is 2015-16, 2016-17, 2017-18, 2018-19, 2019-20, or 2020-21

Over all the retention rates are decreasing at 84.2%, 81.8%, and 78.7% over the past 3 academic years.

Data Review

In Fall 2019, preCovid, the retention rate for CIS-1A rose to 84.4% then dropped to 69.3%

Academic Year	2017-18					2018-19					2019-20				
Gender	Enrolled	Retained	Retention Rate	DI	Close Gap	Enrolled	Retained	Retention Rate	DI	Close Gap	Enrolled	Retained	Retention Rate	DI	Close Gap
Female	**352**	**293**	**83.2%**	**0**	**7**	**329**	**267**	**81.2%**	**0**	**4**	**368**	**295**	**80.2%**	**0**	**0**
African American	33	20	60.6%	0	7	36	31	86.1%	0	4	21	15	71.4%	0	0
Asian	27	27	100.0%	0	7	24	22	91.7%	0	4	45	39	86.7%	0	0
Hispanic	203	167	82.3%	0	7	198	163	82.3%	0	4	213	174	81.7%	0	0
Native American	1	1	100.0%	0	7				0	4	2	2	100.0%	0	0
Pacific Islander	2	0	0.0%	0	7	1	1	100.0%	0	4				0	0
Two or More	4	3	75.0%	0	7	6	5	83.3%	0	4	3	0	0.0%	0	0
Unknown	2	2	100.0%	0	7	4	3	75.0%	0	4	2	2	100.0%	0	0
White	80	73	91.3%	0	7	60	42	70.0%	0	4	82	63	76.8%	0	0
Male	**364**	**310**	**85.2%**	**0**	**0**	**418**	**344**	**82.3%**	**0**	**0**	**445**	**345**	**77.5%**	**0**	**12**
African American	21	16	76.2%	0	0	25	18	72.0%	0	0	29	21	72.4%	0	12
Asian	50	41	82.0%	0	0	39	30	76.9%	0	0	53	44	83.0%	0	12
Hispanic	183	154	84.2%	0	0	228	189	82.9%	0	0	228	172	75.4%	0	12
Native American				0	0	2	2	100.0%	0	0	1	1	100.0%	0	12
Pacific Islander	1	1	100.0%	0	0	3	3	100.0%	0	0	4	2	50.0%	0	12
Two or More	7	6	85.7%	0	0	4	2	50.0%	0	0	10	5	50.0%	0	12
Unknown	2	1	50.0%	0	0	5	4	80.0%	0	0	12	8	66.7%	0	12
White	100	91	91.0%	0	0	112	96	85.7%	0	0	108	92	85.2%	0	12
Total	**716**	**603**	**84.2%**	**0**	**0**	**747**	**611**	**81.8%**	**0**	**0**	**813**	**640**	**78.7%**	**0**	**0**

In terms of student subgroups, success rate gaps for African American females and Hispanic males are concerning. Retention rates for Hispanic males are concerning.

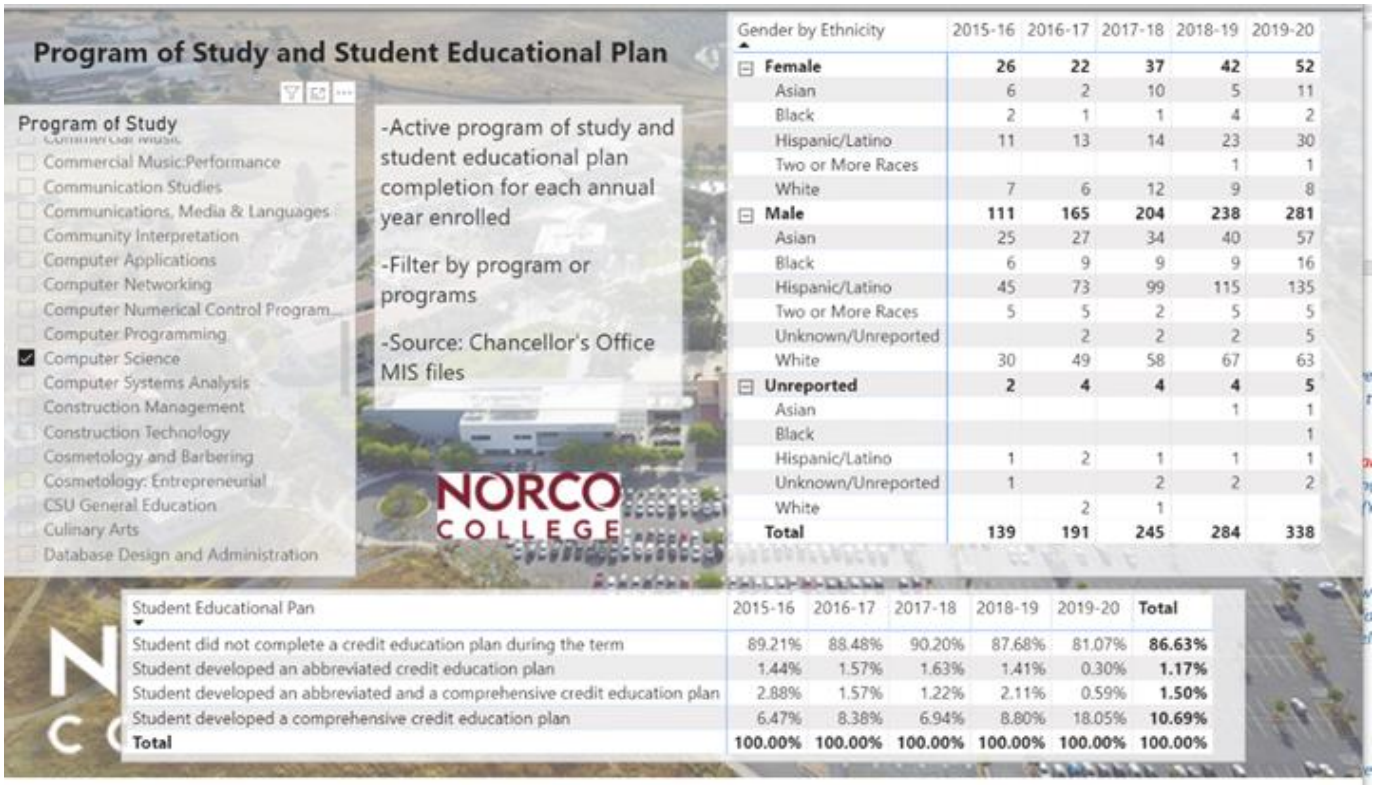
The overall trends show that CIS is improving success rates and retention rates over time, with the exception of the Spring 2020 semester. In Fall 2020 both success rates and retention rates are beginning to bounce back.

Program of Study and Program Awards in Computer Science and CIS

COMPUTER SCIENCE

The number of students who have declared a program of study in Computer Science went from 245 to 284 to 338 in 3 years. This represents increased growth for this program. The percent of students who have met with a counselor and developed a comprehensive education plan has increased from 7% to 9% to 18%.

Data Review

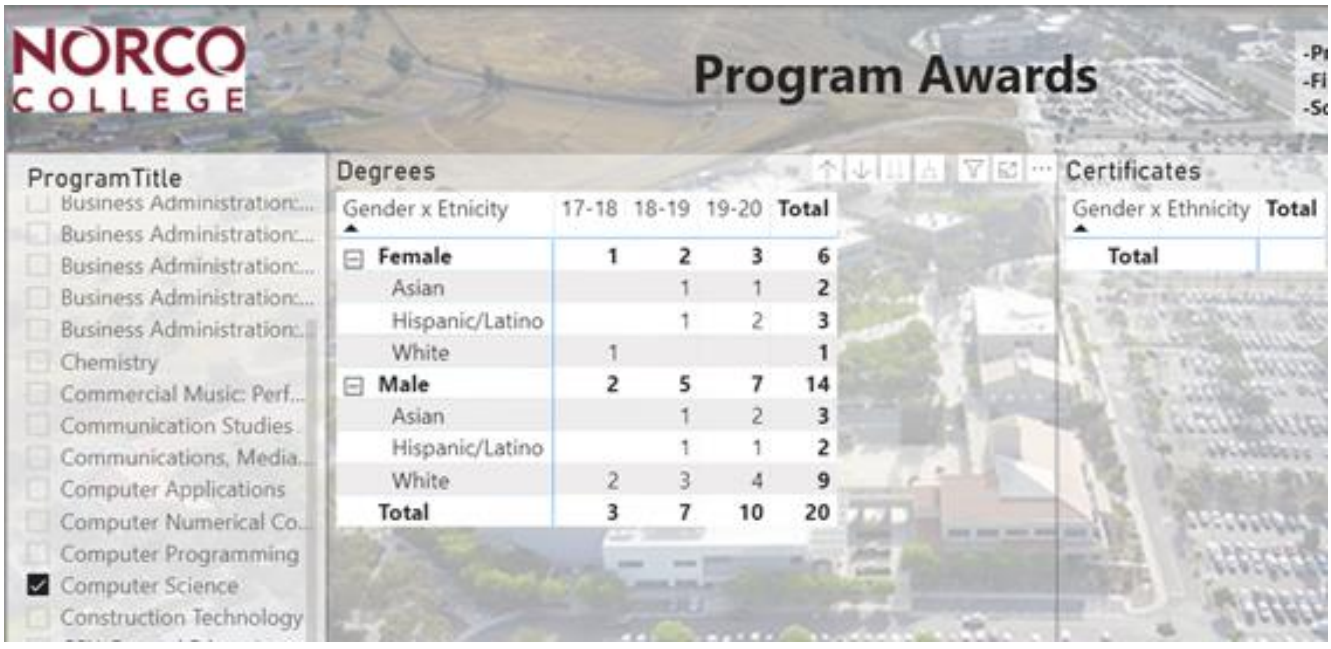


Gender by Ethnicity	2015-16	2016-17	2017-18	2018-19	2019-20
Female	**26**	**22**	**37**	**42**	**52**
Asian	6	2	10	5	11
Black	2	1	1	4	2
Hispanic/Latino	11	13	14	23	30
Two or More Races				1	1
White	7	6	12	9	8
Male	**111**	**165**	**204**	**238**	**281**
Asian	25	27	34	40	57
Black	6	9	9	9	16
Hispanic/Latino	45	73	99	115	135
Two or More Races	5	5	2	5	5
Unknown/Unreported		2	2	2	5
White	30	49	58	67	63
Unreported	**2**	**4**	**4**	**4**	**5**
Asian				1	1
Black					1
Hispanic/Latino	1	2	1	1	1
Unknown/Unreported	1		2	2	2
White		2	1		
Total	**139**	**191**	**245**	**284**	**338**

Student Educational Pan	2015-16	2016-17	2017-18	2018-19	2019-20	Total
Student did not complete a credit education plan during the term	89.21%	88.48%	90.20%	87.68%	81.07%	**86.63%**
Student developed an abbreviated credit education plan	1.44%	1.57%	1.63%	1.41%	0.30%	**1.17%**
Student developed an abbreviated and a comprehensive credit education plan	2.88%	1.57%	1.22%	2.11%	0.59%	**1.50%**
Student developed a comprehensive credit education plan	6.47%	8.38%	6.94%	8.80%	18.05%	**10.69%**
Total	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**

The number of students who have completed the ADT Computer Science went from 3 to 7 to 10 for a total of 20 over the past three years. With 338 students in the pipeline in the most recent year, and 10 graduates, this means that 328 are in the pipeline. Assuming that 20% of students in the program will graduate in the most recent year, this means we should expect 66 graduates per year.

[image]



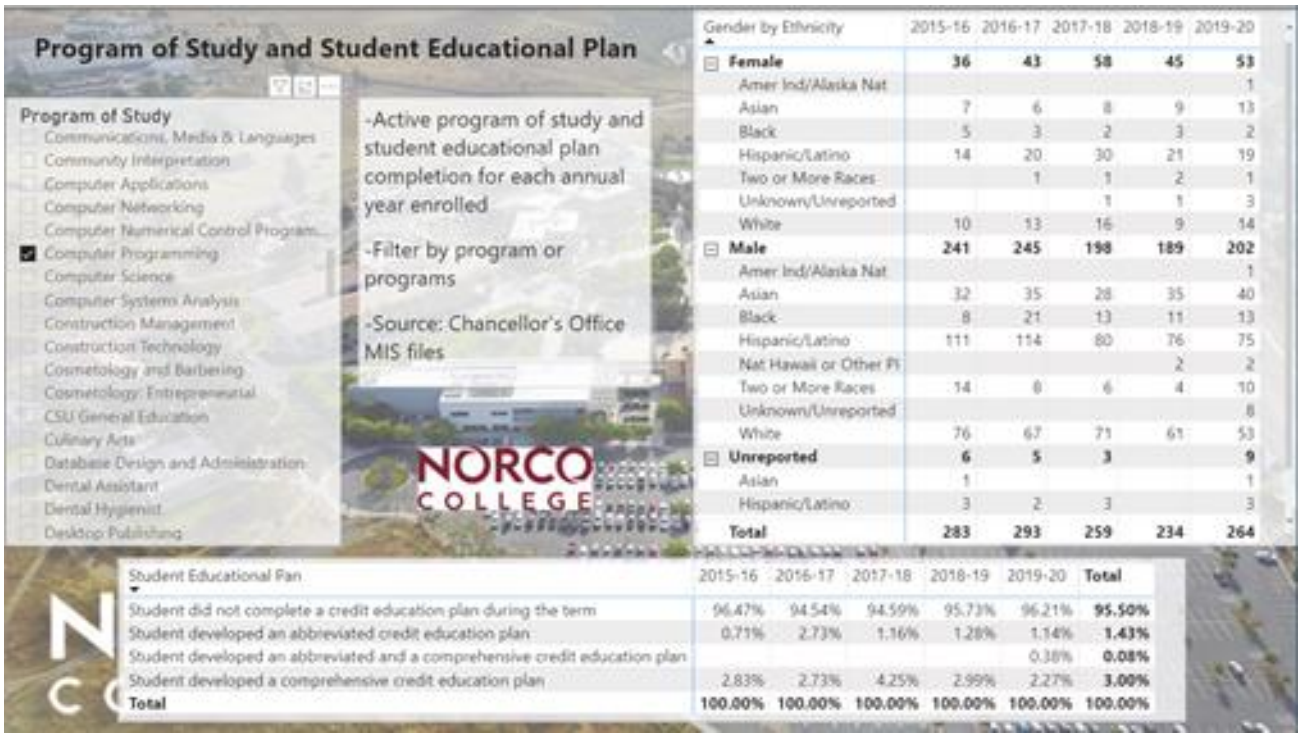
Gender x Etnicity	17-18	18-19	19-20	Total
Female	**1**	**2**	**3**	**6**
Asian		1	1	**2**
Hispanic/Latino		1	2	**3**
White	1			**1**
Male	**2**	**5**	**7**	**14**
Asian		1	2	**3**
Hispanic/Latino		1	1	**2**
White	2	3	4	**9**
Total	**3**	**7**	**10**	**20**

Gender x Ethnicity	Total
Total	

Data Review

COMPUTER PROGRAMMING

The number of students who have declared a program of study for a certificate in Computer Programming program went from 259 to 234 to 264 in three years. This represents flat growth for this program. The percent of students who have developed a comprehensive education plan is 3%.



Gender by Ethnicity	2015-16	2016-17	2017-18	2018-19	2019-20
Female	**36**	**43**	**58**	**45**	**53**
Amer Ind/Alaska Nat					1
Asian	7	6	8	9	13
Black	5	3	2	3	2
Hispanic/Latino	14	20	30	21	19
Two or More Races		1	1	2	1
Unknown/Unreported			1	1	3
White	10	13	16	9	14
Male	**241**	**245**	**198**	**189**	**202**
Amer Ind/Alaska Nat					1
Asian	32	35	28	35	40
Black	8	21	13	11	13
Hispanic/Latino	111	114	80	76	75
Nat Hawaii or Other PI				2	2
Two or More Races	14	8	6	4	10
Unknown/Unreported					8
White	76	67	71	61	53
Unreported	**6**	**5**	**3**		**9**
Asian	1				1
Hispanic/Latino	3	2	3		3
Total	**283**	**293**	**259**	**234**	**264**

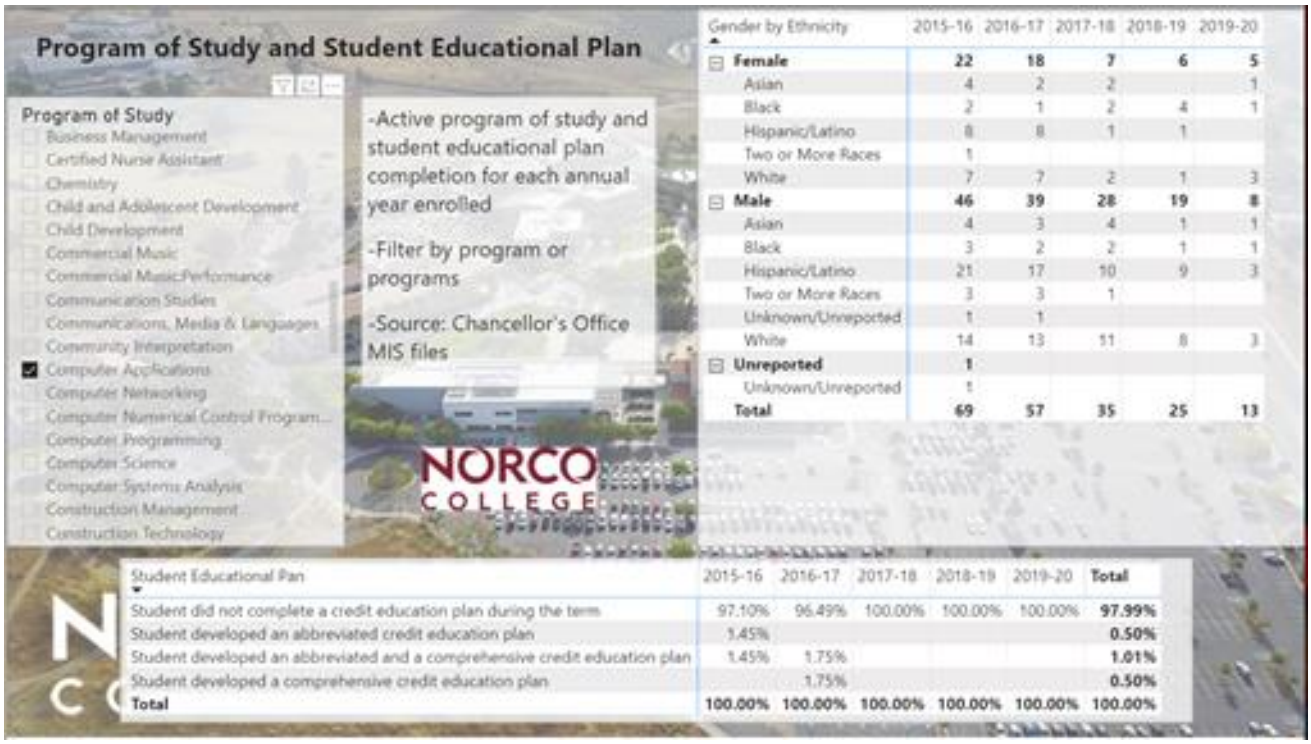
Student Educational Pan	2015-16	2016-17	2017-18	2018-19	2019-20	Total
Student did not complete a credit education plan during the term	96.47%	94.54%	94.59%	95.73%	96.21%	**95.50%**
Student developed an abbreviated credit education plan	0.71%	2.73%	1.16%	1.28%	1.14%	**1.43%**
Student developed an abbreviated and a comprehensive credit education plan					0.38%	**0.08%**
Student developed a comprehensive credit education plan	2.83%	2.73%	4.25%	2.99%	2.27%	**3.00%**
Total	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**

In the most recent year 2 students were awarded a certificate in Computer Programming. The expected number of students who should get a degree would be approximately 45 or 20% of Program of Study number in most recent year. The gap in the pipeline is approximately 219 more students to graduate with a degree or certificate.

Data Review

COMPUTER APPLICATIONS

The number of students who have declared a program of study for a certificate in Computer Applications is 35, 25 and 13 in the last three years. This represents declining growth for this program. The percent of students who have developed a comprehensive education plan is 0.5%

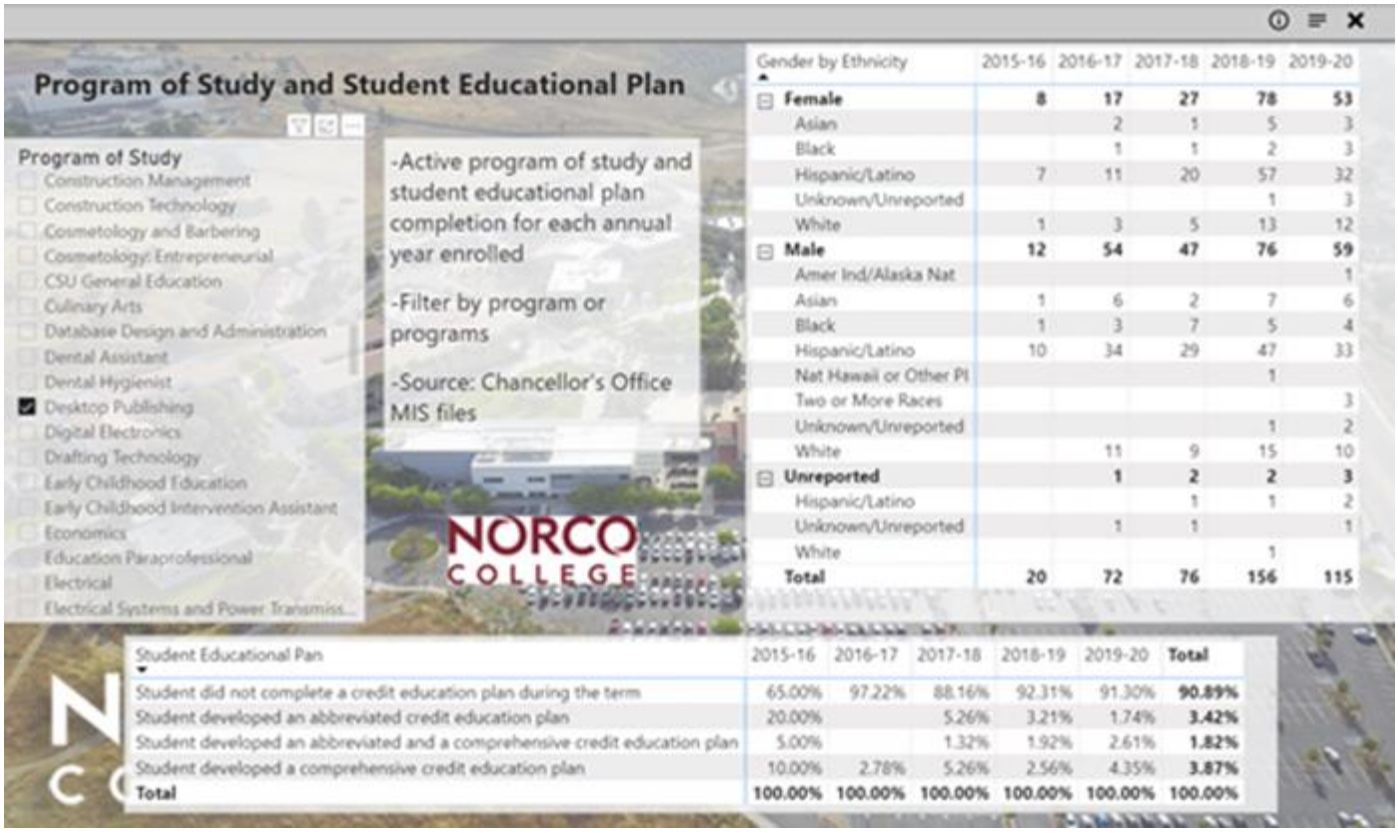


In the last three years, 4 students were awarded a certificate in Computer Applications. The expected number of students who should get a degree would be approximately 4 or 20% of Program of Study number in most recent year. No data exists for program awards for the most current year so a gap analysis is not viable.

Data Review

DESKTOP PUBLISHING

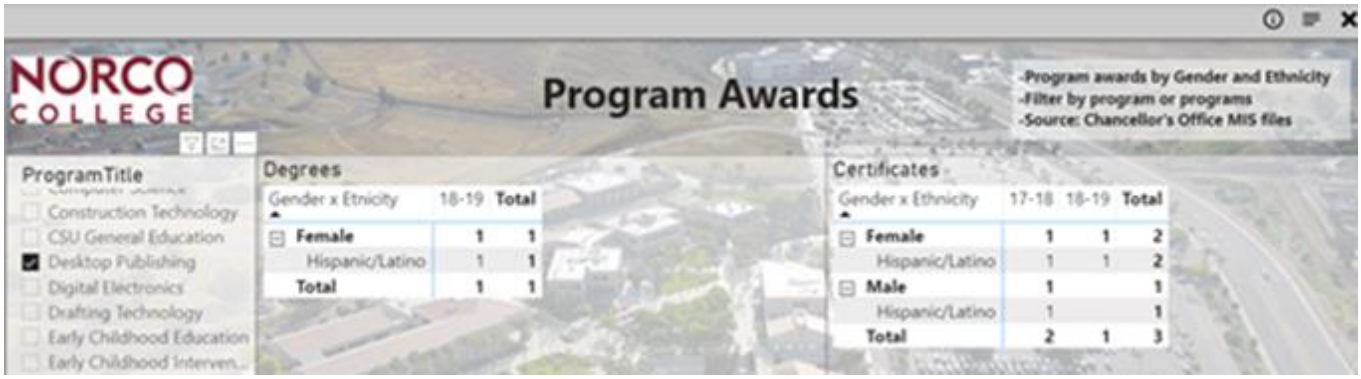
The number of students who have completed a certificate in Desktop Publishing is 76, 156, and 115 the last three years. This represents unstable growth for this program. The percent of students who have developed a comprehensive education plan is 3.87%



In the last three years, 3 students were awarded a certificate in Computer Applications. The expected number of students who should get a degree would be

Data Review

approximately 26 or 20% of Program of Study number in most recent year. This represents 112 students in the pipeline who have not yet been awarded a certificate.



Disaggregated Student Subgroups

Look at the disaggregated student subgroups in success, retention, program of study, educational planning, and awards for your area. Are there any equity gaps that you will address in the next 3 years?

Overall CIS and CSC

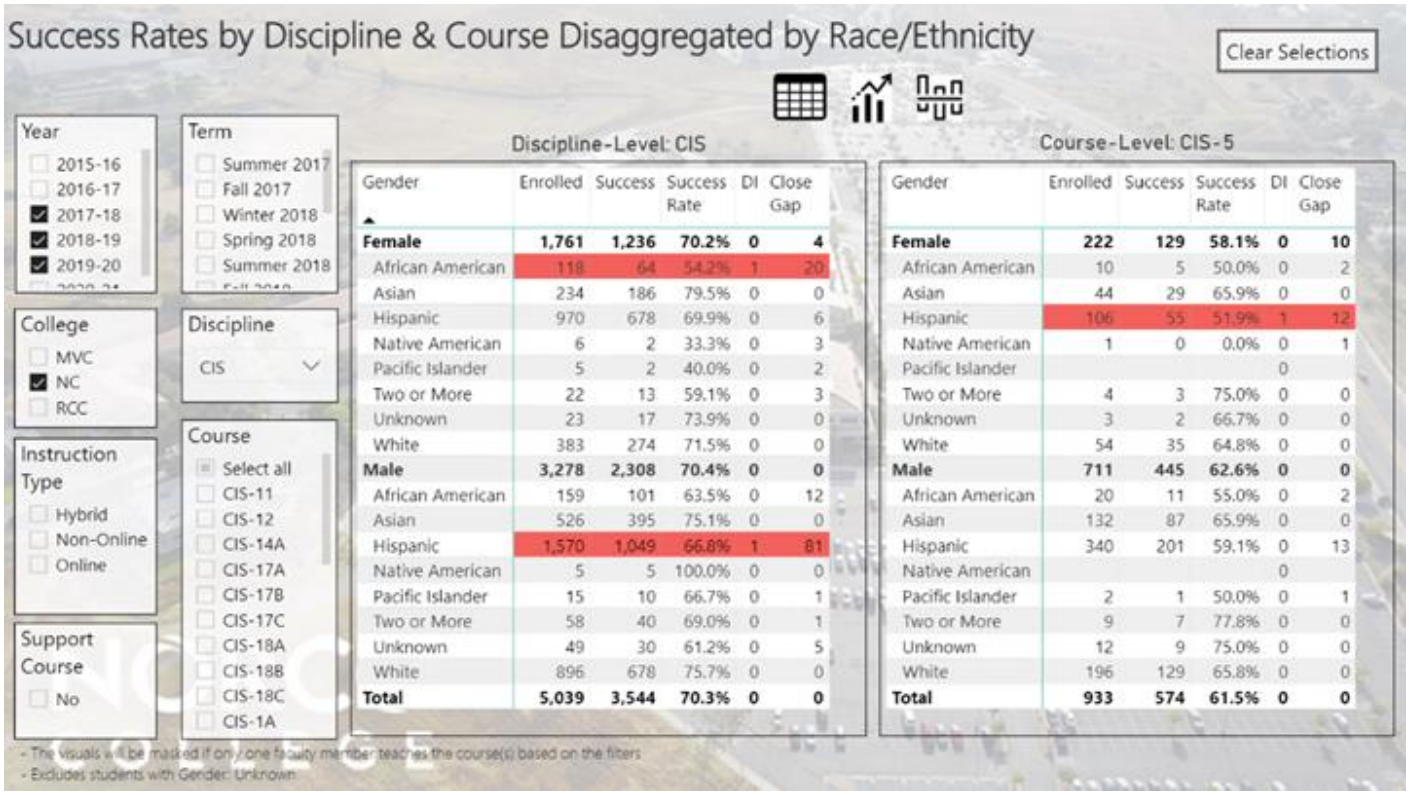
In terms of student subgroups, African American Females and Hispanic Males are showing gaps in success that are concerning. And Hispanic Males are showing gaps in retention that are concerning.

CIS-5/ CSC-5

In terms of student subgroups, the retention rate for females increased from 60.4% to 76.75 to 77.2% over the last three years. Likewise the success rate for females increased over the last three years from 49% to 63% and is now on par with male success rates. This is a gap that we have worked to close through faculty attention, research and implementation of Pair Programming and collaborative exercises. Here is one article which summarizes this approach.
https://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.208.8243&rep=rep1&type=pdf
Additionally, we have employed female embedded tutors in many CIS-5 sections funded through the Title V: Here to Career grant with CSUSB and believe this has contributed to increased success and retention of females in CIS-5.

Data Review

Through this data analysis we have identified that Hispanic females and African American males are showing gaps in retention that are concerning.



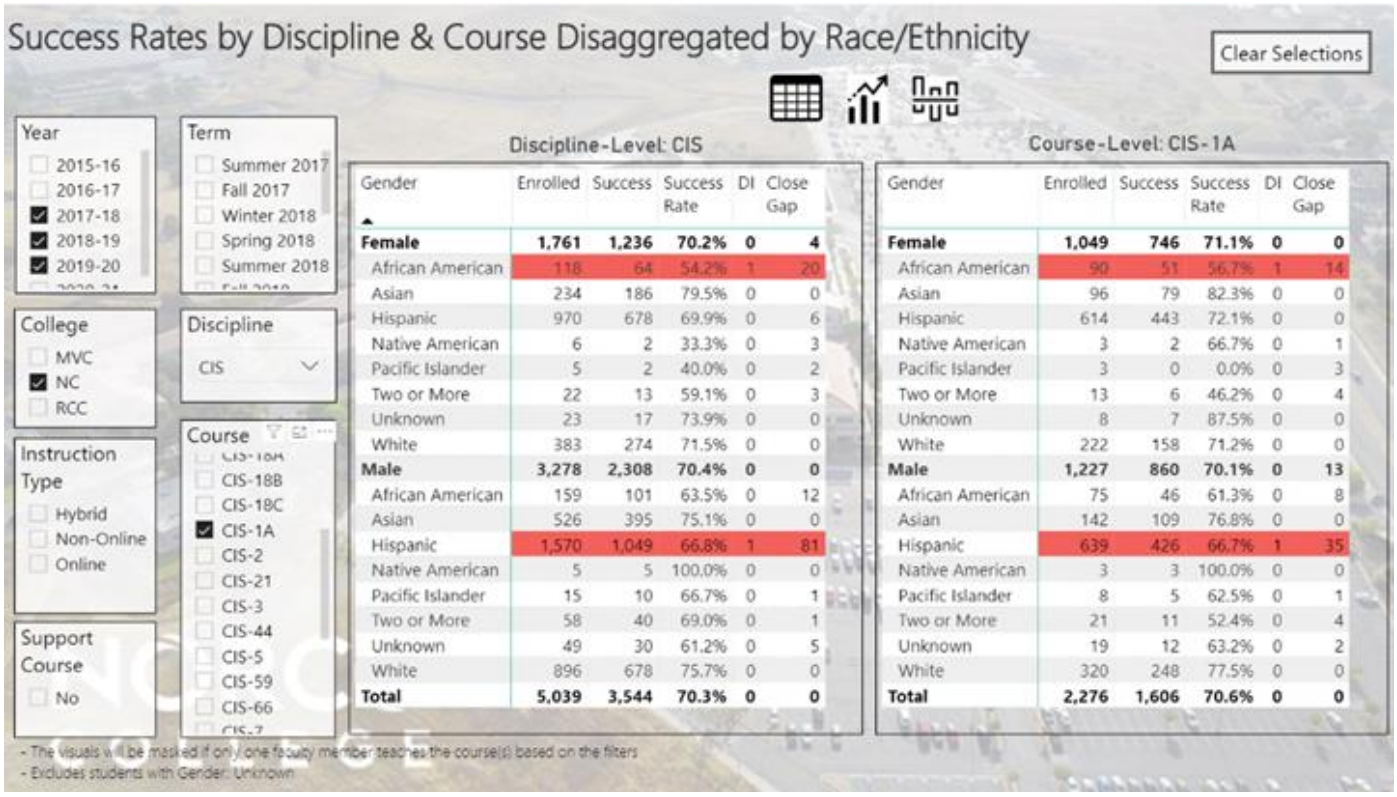
Gender	Enrolled	Success	Success Rate	DI	Close Gap
Female	**1,761**	**1,236**	**70.2%**	**0**	**4**
African American	118	64	54.2%	1	20
Asian	234	186	79.5%	0	0
Hispanic	970	678	69.9%	0	6
Native American	6	2	33.3%	0	3
Pacific Islander	5	2	40.0%	0	2
Two or More	22	13	59.1%	0	3
Unknown	23	17	73.9%	0	0
White	383	274	71.5%	0	0
Male	**3,278**	**2,308**	**70.4%**	**0**	**0**
African American	159	101	63.5%	0	12
Asian	526	395	75.1%	0	0
Hispanic	1,570	1,049	66.8%	1	81
Native American	5	5	100.0%	0	0
Pacific Islander	15	10	66.7%	0	1
Two or More	58	40	69.0%	0	1
Unknown	49	30	61.2%	0	5
White	896	678	75.7%	0	0
Total	**5,039**	**3,544**	**70.3%**	**0**	**0**

Gender	Enrolled	Success	Success Rate	DI	Close Gap
Female	**222**	**129**	**58.1%**	**0**	**10**
African American	10	5	50.0%	0	2
Asian	44	29	65.9%	0	0
Hispanic	106	55	51.9%	1	12
Native American	1	0	0.0%	0	1
Pacific Islander				0	
Two or More	4	3	75.0%	0	0
Unknown	3	2	66.7%	0	0
White	54	35	64.8%	0	0
Male	**711**	**445**	**62.6%**	**0**	**0**
African American	20	11	55.0%	0	2
Asian	132	87	65.9%	0	0
Hispanic	340	201	59.1%	0	13
Native American				0	
Pacific Islander	2	1	50.0%	0	1
Two or More	9	7	77.8%	0	0
Unknown	12	9	75.0%	0	0
White	196	129	65.8%	0	0
Total	**933**	**574**	**61.5%**	**0**	**0**

CIS-1A

In terms of student subgroups, success rate gaps for African American females and Hispanic males are concerning. Retention rates for Hispanic males are concerning.

Data Review



Gender	Enrolled	Success	Success Rate	DI	Close Gap
Female	**1,761**	**1,236**	**70.2%**	**0**	**4**
African American	118	64	54.2%	1	20
Asian	234	186	79.5%	0	0
Hispanic	970	678	69.9%	0	6
Native American	6	2	33.3%	0	3
Pacific Islander	5	2	40.0%	0	2
Two or More	22	13	59.1%	0	3
Unknown	23	17	73.9%	0	0
White	383	274	71.5%	0	0
Male	**3,278**	**2,308**	**70.4%**	**0**	**0**
African American	159	101	63.5%	0	12
Asian	526	395	75.1%	0	0
Hispanic	1,570	1,049	66.8%	1	81
Native American	5	5	100.0%	0	0
Pacific Islander	15	10	66.7%	0	1
Two or More	58	40	69.0%	0	1
Unknown	49	30	61.2%	0	5
White	896	678	75.7%	0	0
Total	**5,039**	**3,544**	**70.3%**	**0**	**0**

Gender	Enrolled	Success	Success Rate	DI	Close Gap
Female	**1,049**	**746**	**71.1%**	**0**	**0**
African American	90	51	56.7%	1	14
Asian	96	79	82.3%	0	0
Hispanic	614	443	72.1%	0	0
Native American	3	2	66.7%	0	1
Pacific Islander	3	0	0.0%	0	3
Two or More	13	6	46.2%	0	4
Unknown	8	7	87.5%	0	0
White	222	158	71.2%	0	0
Male	**1,227**	**860**	**70.1%**	**0**	**13**
African American	75	46	61.3%	0	8
Asian	142	109	76.8%	0	0
Hispanic	639	426	66.7%	1	35
Native American	3	3	100.0%	0	0
Pacific Islander	8	5	62.5%	0	1
Two or More	21	11	52.4%	0	4
Unknown	19	12	63.2%	0	2
White	320	248	77.5%	0	0
Total	**2,276**	**1,606**	**70.6%**	**0**	**0**

If there are any concerning trends over the past 3 or more years, or if equity gaps exist, what is your action plan to address them?

Overall, the success and retention trends are positive, if we consider the Spring 2020 data is an outlier due to Covid. The CIS discipline appears to be well on its way to recovering to preCovid levels.

We are seeing growth in the ADT Computer Science program year after year with a robust interest in the Computer Programming certificate. We are concerned about the low number of completers and plan to address that with a coordinated faculty messaging system including consistent Announcements, Reminders, and Discussions of the advantages to completing a pathway. In addition, we'd like to work with Institutional Research to survey or hold focus groups with students who have declared a program of study with the goal of identifying reasons for the low completion rate and devising a targeted action plan.

The Computer Applications certificate low number of students is concerning and we have begun discussions to address this through marketing, outreach, and possibly fast track scheduling.

Desktop Publishing/Graphic Design is an area that may best be served by moving to a Commercial Art discipline rather than a CIS discipline. The ADT Graphic Design has been delayed for a number of reasons. Once it is finalized, we propose that Norco College adopt the curriculum and revisit how to best serve graphic design students including, but not limited to, a move to a new discipline.

To address equity gaps we propose the folowing action plan:

Data Review

- **Additonal Tutorial, Supplemental Instruction, and LRC support** -- In our experience, those who are disproportionally impacted or underprepared for computer courses benefit the most from tutorial support. Embedding tutors in the courses creates a relationship between the class and tutors which we believe makes students more likely to reach out and utilize the services, sometimes for a quick question on Discord, sometimes for a scheduled Zoom session. We recently reached out to the LRC regarding increasing support for CTE courses and had a positive response. In fact, a plan to provide increased embedded tutoring for courses with success rates less than 70% is proposed and we plan to take advantage of it.
- **Equity Minded Syllabus Training** - All full-time faculty will complete this training, participate in group discussions related to this training and then modify our syllabi and classroom practices. We will encourage our part-time faculty to complete this training and modify their syllabi as well. Our goal is to create a culture of ongoing conversations regarding equity practices.
- **CORA trainings on Black MInds Matter, Racial Microagressions and Teaching Men of Color in Community Colleges** -- All full-time faculty will complete these training and participate in group discussions related to concrete ways to utilize the training to close the gaps. We will encourage our part-time faculty to complete equity trainings.

Is there a resource request associated with this Data Review? (If yes, please complete a Resource Request, which you can access from the main menu to the left)
No

Assessment Review

2021 - 2024

Section 1: SLO Assessment Status (Based on Dashboard - Assessment Status)

Which Disciplines are included in this Assessment?
CIS and CSC and CAT

What percent of SLOs in the disciplines you identified above have been assessed?
100%

Which SLOs have not been assessed and why? Identify both the Course and the associated SLO(s).
none

Section 2: Mapping Status (Based on Dashboard - Mapping Status)

Are all SLOs mapped to at least one PLO?
No

If all SLOs are not mapped to at least one PLOs, please explain why.
73.1% of SLOs are mapped to PLOs. The missing ones are simply an oversight or in some cases don't map to a program (a stand alone course)

Are the appropriate SLOs mapped to GELOs? (If you have a course that is listed in any general education area, it should have at least one SLO mapped to at least one GELO)
Yes

If the appropriate SLOs are not mapped to GELOs, please explain why.
The appropriate SLOs are mapped to GELOs

Section 3: PLO Analysis (Based on Dashboard - Analysis: PLO Direct Assessment)

Which Programs are included in this Assessment?
ADT CSC, Computer Programming, No data for Computer Applications and Desktop Publishing

Please identify the PLO(s) - and name the associated Program(s) - that achieved benchmarks.
ADT CSC achieved all benchmarks for all PLOs, Computer Programming achieved all benchmarks,

To what to you attribute this success?
Stellar instruction, cohesive caring faculty, and tutorial support

Please identify the PLO(s) - and name the associated Program(s) - that did not achieve benchmarks.
none

If there are PLOs that did not achieve benchmarks, what do you plan on doing to improve benchmark attainment?
n/a

Assessment Review

Section 4: Alignment to Career and Transfer

Describe the process used in this area to ensure programs (PLOs) align with career and transfer needs.
Regular consultation with advisory committees as well as individual consultations with industry professionals ensures that the curriculum is current and meets the needs of both transfer students and those students who wish to enter industry. Curriculum is regularly updated based on the feedback and input from the advisory committe and industry contacts. The ADT CSC ensures that students have pathways for transfer. Soon the ADT Graphic Design will be available and we anticipate a major curriculum update at that time. Based on industry feedback, we are in the process of adding a Python Certificate which lead directly to employment. We anticipate beginning to offer Python in Fall 2021. CIS-1A SLOs are set to align with Microsoft Office User Associate Level Certifications, ensuring industry relevance.

Describe the activities, projects, and opportunities this program offers to support experiential learning and alignment of programs to career and transfer (e.g. capstone projects, portfolios, service-learning opportunities).
The advanced computer programming courses in both C++ and Java, CIS-17B/18B, utilize capstone projects. Project Based Learning is used in all C++ and Java classes.

We recognize this as an area for improvement. For Computer Programming and ADT CS, we can work more closely to develop internships through CSUSB Title V Here to Career grant.

In addition, we are discussing creating a "Tech Hub" based at Norco College for user groups to host meetings which would allow our students to meet with industry professionals.

We will consider adding capstone projects to CIS-1A classes. CIS-1A contains capstone projects, called integrated projects, in the text and online learning materials. We will analyze the viability of adding these to the required coursework.

Without looking at your current PLOs, describe some program outcomes which would best help your students continue on the path towards their workforce and transfer goals (e.g. subject matter expertise, hands on experience, partnerships, etc.).
Help Computer Science majors with Career Guidance. Need event planning support for hosting Guest Speaker series held on campus which would be educational and informative. Create a Technology Hub at Norco College once it's safe to meet face to face on campus.

Review current PLOs. Do the outcomes listed above align with the current program outcomes?
Yes

EMP GOAL 1. Expand college access by increasing both headcount and full-time equivalent students (FTES).

GOALS AND ACTIVITIES

What are you doing now in support of this goal?

In order to improve accessibility and student access and to promote increased headcount, 100% of CIS courses are DE approved and ready for online course offerings.

CIS is working to introduce new programs to appeal to a broader student base. This includes the adoption of the Python programming certificate, which is moving through the Curriculum Approval process and is set to be offered beginning in Fall 2022.

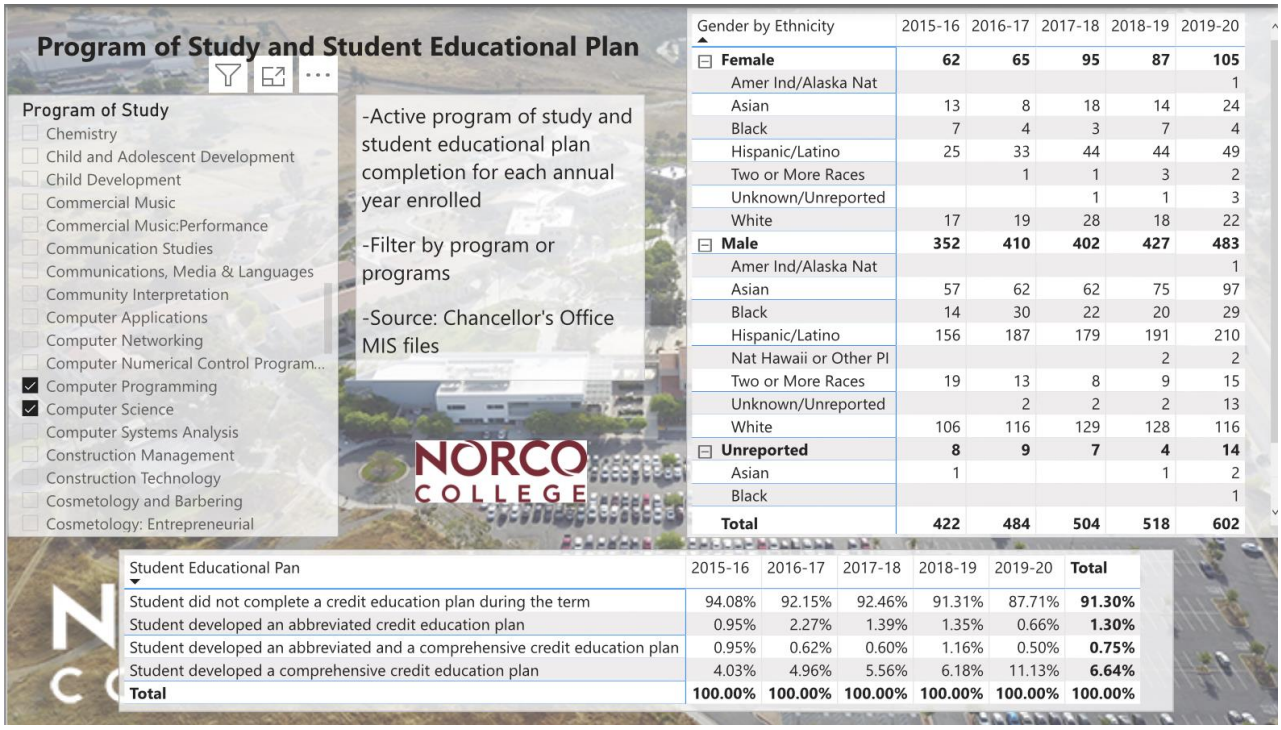
What are your plans/goals (3-year) regarding this goal?

CIS is working to offer more online courses, to offer more options for students. The intent is to make courses more accessible for students, with the aim of expanding the student headcount. CIS is working to introduce new programs to attract a larger student base. These include the adoption of the Python programming certificate, which is currently in progress. The department has identified Data Science and Machine Learning as candidates for new programs or certificates, and is is also investigating the feasibility of adding these programs.

EVIDENCE

Do you have assessment data or other evidence that relates to this goal?

The assessment data for “Program of Study and Student Educational Plan” demonstrates an upward trend of CIS- related programs of study at Norco College over the past 5 years.



Gender by Ethnicity	2015-16	2016-17	2017-18	2018-19	2019-20
Female	**62**	**65**	**95**	**87**	**105**
Amer Ind/Alaska Nat					1
Asian	13	8	18	14	24
Black	7	4	3	7	4
Hispanic/Latino	25	33	44	44	49
Two or More Races		1	1	3	2
Unknown/Unreported			1	1	3
White	17	19	28	18	22
Male	**352**	**410**	**402**	**427**	**483**
Amer Ind/Alaska Nat					1
Asian	57	62	62	75	97
Black	14	30	22	20	29
Hispanic/Latino	156	187	179	191	210
Nat Hawaii or Other PI				2	2
Two or More Races	19	13	8	9	15
Unknown/Unreported		2	2	2	13
White	106	116	129	128	116
Unreported	**8**	**9**	**7**	**4**	**14**
Asian	1			1	2
Black					1
Total	**422**	**484**	**504**	**518**	**602**

Student Educational Pan	2015-16	2016-17	2017-18	2018-19	2019-20	Total
Student did not complete a credit education plan during the term	94.08%	92.15%	92.46%	91.31%	87.71%	**91.30%**
Student developed an abbreviated credit education plan	0.95%	2.27%	1.39%	1.35%	0.66%	**1.30%**
Student developed an abbreviated and a comprehensive credit education plan	0.95%	0.62%	0.60%	1.16%	0.50%	**0.75%**
Student developed a comprehensive credit education plan	4.03%	4.96%	5.56%	6.18%	11.13%	**6.64%**
Total	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**

Table created based on report above

Program Review: Part 1

Academic Year	Students with Educationl plans in Computer Programming and Computer Science	Yearly increase in students with Educationl plans in Computer Programming and Computer Science	Percentage yearly increase in students with Educationl plans in Computer Programming and Computer Science
2015-2016	422		
2016-2017	484	62	12.80991736
2017-2018	504	20	3.968253968
2018-2019	518	14	2.702702703
2019-2020	602	84	13.95348837
	SUM	180	33.4343624
	AVG	45	8.3585906

Based on the above data, there is an average 8.35% increase in the number of students enrolled in the Computer Science and Computer Programming fields of study. This demonstrates measurable progress related to Objective 1.1 and Objective 1.2

RESOURCES

Is there a resource request associated with this EMP Goal? (If yes, please complete a Resource Request, which you can access from the main menu to the left)
Yes

EMP GOAL 2. Implement Guided Pathways framework.

GOALS AND ACTIVITIES

What are you doing now in support of this goal?
CIS offers a completable 2-year plan of study with flexible options for students for degree or transfer. To account for student scheduling, classes are offered on a rotating schedule that offers flexibility to students. Classes are offered onsite and online to provide further options to student learning and success. CIS faculty encourage encourage students to complete their educational plans. CIS faculty incorporates education on pathways in industry for students into their curriculum. CIS faculty educates students on career trajectories based on education as part of their curriculum. CIS is Introducing new certificate for Python programming to keep up to date with industry trends. The python certificate will appeal to a larger number of students and increase enrolment.

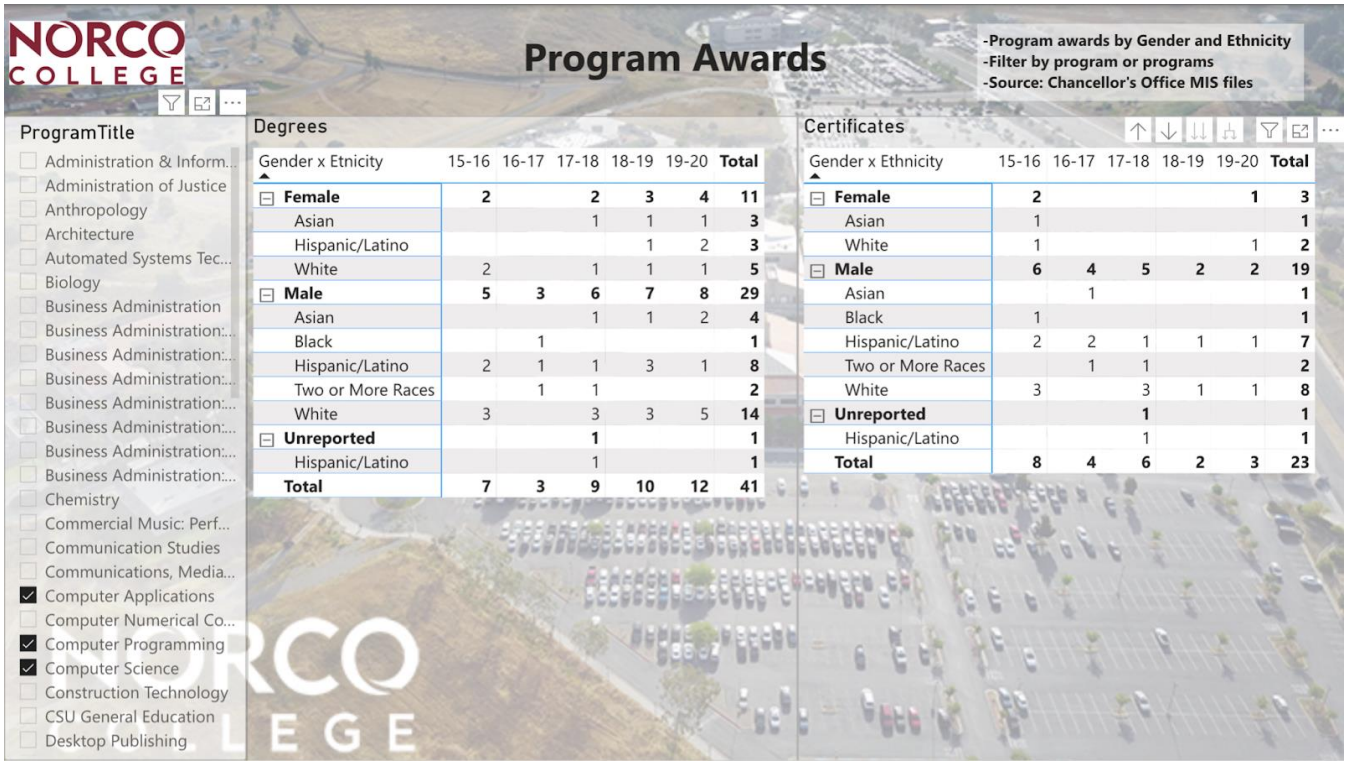
What are your plans/goals (3-year) regarding this goal?
We will continue to support guided pathways through scheduling sequences in a pattern conducive to completing guided pathways.
In addition, in our courses we will be more vocal about guided pathways. We will consistently remind students of the need to complete a SEP of the 2 year sequence of classes and of the next classes to take in the sequence. We will encourage our part-time faculty to do the same.
The data included in the Evidence section demonstrates an increased completion rate of degrees for students in CIS-related fields over the past five years. CIS faculty will work to continue this trend and encourage its growth.
The data included in the Evidence section also demonstrates a decreased completion rate of certificates for students in CIS-related fields over the past five years. CIS faculty will work to correct this trend and encourage students to complete certificate programs. The addition of the new Python certificate and investigation of additional potential certificates is intended to aid in the correction and reversal of this trend.

EVIDENCE

Do you have assessment data or other evidence that relates to this goal?

The graph below demonstrates an increased completion rate of degrees for students in CIS-related fields over the past five years.This is a positive trend, however there is room for improvement. The CIS faculty will develop a coordinated approach to messaging students with announcements and reminders of the importance of completing an educational plan and working toward it each semester.

The graph also demonstrates a decreased completion rate of certificates for students in CIS-related fields over the past five years. CIS faculty will use the same coordinated messaging approach to remind students of certificate programs, next courses, how to apply for a certificate and in general encourage completion. In addition, CIS faculty will request from Institutional Research a survey of those students who selected a program of study with the goal of determining reasons for low completion rates so that a targeted action plan can be devised.



RESOURCES

Is there a resource request associated with this EMP Goal? (If yes, please complete a Resource Request, which you can access from the main menu to the left)

No

EMP GOAL 3. Close all student equity gaps.

GOALS AND ACTIVITIES

What are you doing now in support of this goal?

For CIS-5, the beginning computer programming course, we have identified funding through the Title V Here to Career Grant through CSUSB to support embedded tutors in online sections. The support is provided through online avenues such as Discord and Zoom. Female tutors, who happen to be in DI subgroups, and who are former successful students, have been recruited to provide 1-on-1 tutoring, group tutoring, review sessions, and mentoring. While we don't yet have data to support the impact of this specific intervention, faculty have seen a rise in success rates in all subgroups in CIS-5, and particularly in the female population.

For CIS in general, we are currently identifying students who are disproportionally impacted through our currnt Program Review data analysis and implementing plans to address the gaps.

What are your plans/goals (3-year) regarding this goal?

We are concerned about equity gaps and propose the folowing action plan:

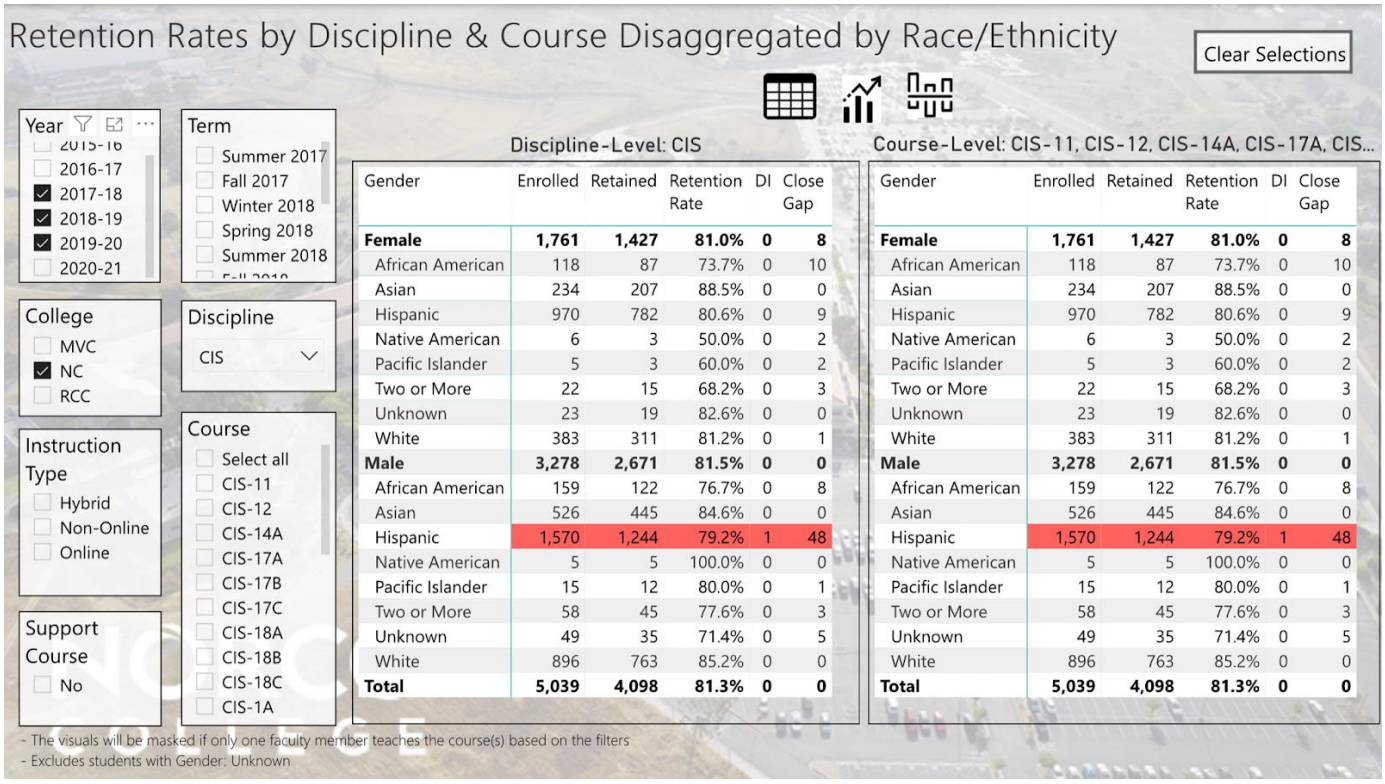
- **Additional Tutorial, Supplemental Instruction, and LRC support** -- In our experience, those who are disproportionally impacted or underprepared for computer courses benefit the most from tutorial support. Embedding tutors in the courses creates a relationship between the class and tutors which we believe makes students more likely to reach out and utilize the services, sometimes for a quick question on Discord, sometimes for a scheduled Zoom session. We recently reached out to the LRC regarding increasing support for CTE courses and had a positive response.
- **Equity Minded Syllabus Training** - all full-time faculty will participate in this training, participate in group discussions related to this training and then modify our syllabi. We will encourage our part-time faculty to complete this training and modify their syllabi as well.
- **CORA trainings on Black MInds Matter, Racial Microagressions and Teaching Men of Color in Community Colleges** -- all full-time faculty will complete these trainings, participate in group discussions related to concrete ways to utilize the training to close the gaps. We will encourage our part-time faculty to complete equity trainings.

EVIDENCE

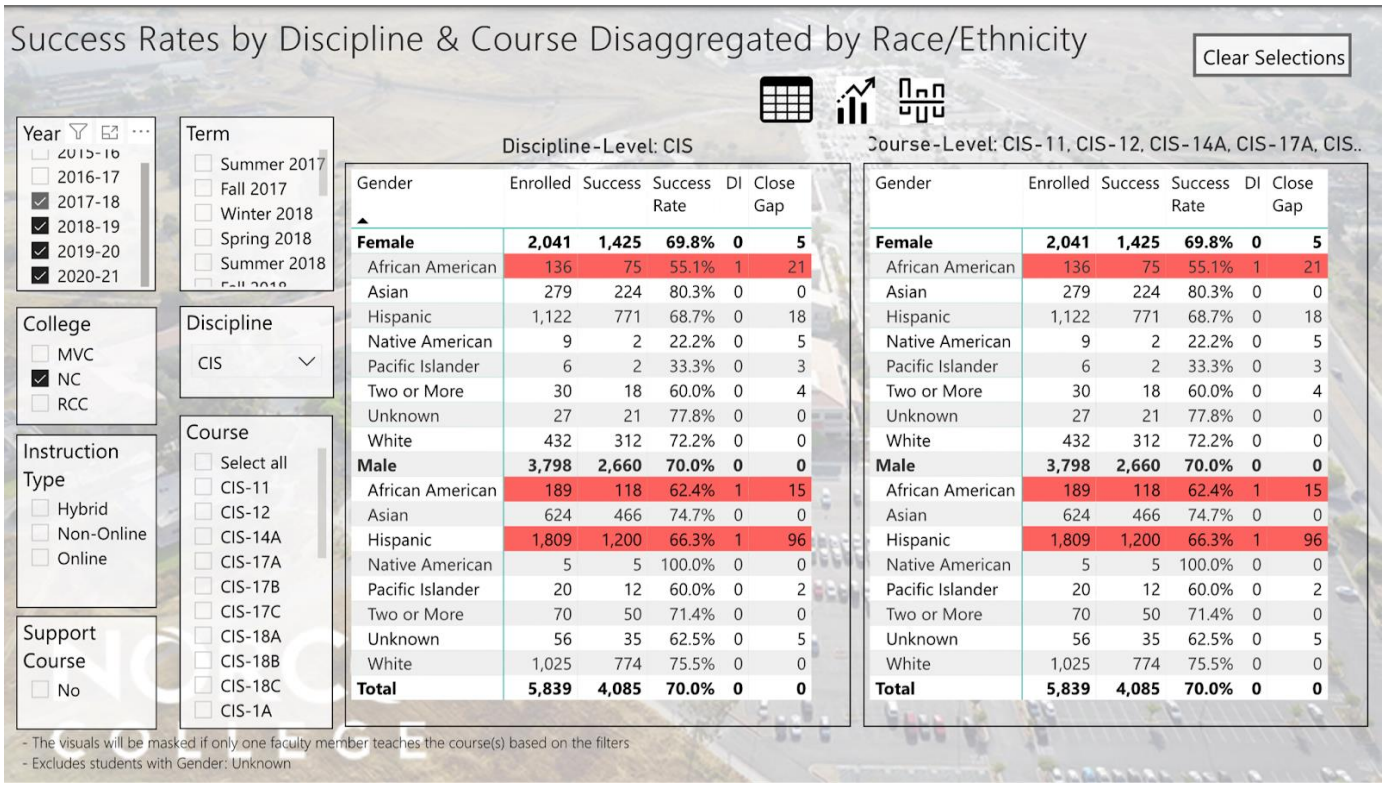
Do you have assessment data or other evidence that relates to this goal?

Based on the data below, we have identified disproportionately impacted areas that we can work to address through the Goals and Activities previously described.

Program Review: Part 1



Gender	Enrolled	Retained	Retention Rate	DI	Close Gap
Female	**1,761**	**1,427**	**81.0%**	**0**	**8**
African American	118	87	73.7%	0	10
Asian	234	207	88.5%	0	0
Hispanic	970	782	80.6%	0	9
Native American	6	3	50.0%	0	2
Pacific Islander	5	3	60.0%	0	2
Two or More	22	15	68.2%	0	3
Unknown	23	19	82.6%	0	0
White	383	311	81.2%	0	1
Male	**3,278**	**2,671**	**81.5%**	**0**	**0**
African American	159	122	76.7%	0	8
Asian	526	445	84.6%	0	0
Hispanic	1,570	1,244	79.2%	1	48
Native American	5	5	100.0%	0	0
Pacific Islander	15	12	80.0%	0	1
Two or More	58	45	77.6%	0	3
Unknown	49	35	71.4%	0	5
White	896	763	85.2%	0	0
Total	**5,039**	**4,098**	**81.3%**	**0**	**0**



Gender	Enrolled	Success	Success Rate	DI	Close Gap
Female	**2,041**	**1,425**	**69.8%**	**0**	**5**
African American	136	75	55.1%	1	21
Asian	279	224	80.3%	0	0
Hispanic	1,122	771	68.7%	0	18
Native American	9	2	22.2%	0	5
Pacific Islander	6	2	33.3%	0	3
Two or More	30	18	60.0%	0	4
Unknown	27	21	77.8%	0	0
White	432	312	72.2%	0	0
Male	**3,798**	**2,660**	**70.0%**	**0**	**0**
African American	189	118	62.4%	1	15
Asian	624	466	74.7%	0	0
Hispanic	1,809	1,200	66.3%	1	96
Native American	5	5	100.0%	0	0
Pacific Islander	20	12	60.0%	0	2
Two or More	70	50	71.4%	0	0
Unknown	56	35	62.5%	0	5
White	1,025	774	75.5%	0	0
Total	**5,839**	**4,085**	**70.0%**	**0**	**0**

RESOURCES

Is there a resource request associated with this EMP Goal? (If yes, please complete a Resource Request, which you can access from the main menu to the left)
No

EMP GOAL 5. Reduce working poverty and the skills gap.

GOALS AND ACTIVITIES

What are you doing now in support of this goal?

CIS faculty is working to increase student success and transfer rates. CIS is offering classes online and in person to support student completion of degree programs, certificates or transfer to other institutions. In order to promote student success, CIS places emphasis on educating students on pathways to industry.

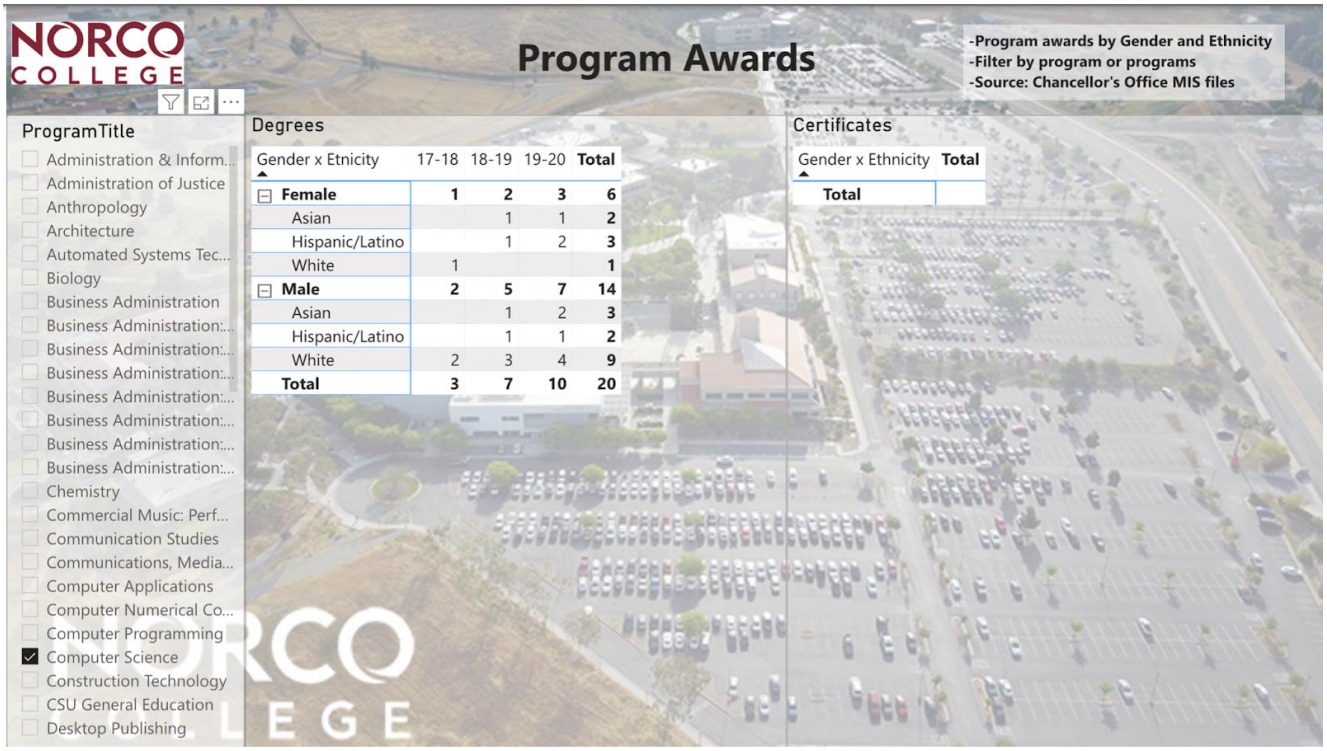
What are your plans/goals (3-year) regarding this goal?

CIS intends to bring in external industry professionals to talk about pathways to industry. CIS plans to investigate the feasability of attracting technology organizations and groups to participate in collaborations with the campus to produce events educating students in relevant industry topics and trends. CIS intends to invite representatives from prospective transfer schools to speak at CIS hosted events to educate students on transfer.

EVIDENCE

Do you have assessment data or other evidence that relates to this goal?

There is an increasing number of students completing degrees in Computer Science. These students are eligible for employment in their field of study.



Program Review: Part 1

RESOURCES

Is there a resource request associated with this EMP Goal? (If yes, please complete a Resource Request, which you can access from the main menu to the left)
No

Program Review Part 2

2021 - 2024

Curriculum

Are all your courses current (within four years)?
No

What percentage of your courses are out of date?
10% or less

If you have courses that are not current, are they in the curriculum process?
Yes

For out of date courses that are not already in progress of updating, what is your plan?
Three courses are out of date:
CIS-66, an oversight, will update this year.
CIS-59, an oversight, will update this year.
CIS-44, course is deleted

Do you have proposals in progress for all the DE courses you intend to file?
Yes

Do you require help to get your courses up to date?
No

Program Review Reflections

What would make program review meaningful and relevant for your unit?
We find the greatest benefit of Program Review is from analyzing the data, trends, and gaps as a group and discussing successes, areas of concern, strategies, actions plans, and goals. The data is often surprising and results in concrete changes. We enjoy the continuous improvement process.
To understand how well our programs serve our students, we would like feedback from our recently graduated students who are currently working industry.
We are concerned about the low number of completers but are at a loss as to why. We'd like help with analyzing why we have so few completers. Is it scheduling roadblocks? Students change their minds? Is there a lack of concern about actually receiving the certificate or AS degree? In other words, do we have completers who have not applied for the certificate or degree? How can we get this data?

What questions do we need to ask to understand your program plans, goals, needs?
Are transferring students well equipped for success in a university Computer Science program?
Are students who earn a certificate in Computer Programming well equipped in the workforce?

What types of data do you need to support your program plans, goals, needs?
Alumni data.
Feedback on why students are not completing certificate or degre.

Program Review Part 2

If there are any supporting documents you would like to attach, please attach them here.
PairedProgrammingHelpsFemaleCS.pdf

Resource Requests

2021 - 2024

What resources do we already have?
CIS Faculty knowledgable in the Python programming language

What resources do you need?
An insufficient number of faculty are prepared to teach Python. CIS Faculty would like to lead a set of faculty-led training seminars. This will facilitate the distribution of knowledge and training needed to bring other CIS faculty up-to-date in their knowledge of Python programming.

Request related to EMP goal or Assessment?
EMP Goal 1

$ Amount Requested
4,000

Resource Type
BUDGET: Request Ongoing Funding (Professional Development, Department or Program Support, Outreach, Marketing)

Potential Funding Source(s)

The evidence to support this request can be found in:
Program Review: Part 1

This request for my area is Priority #:

Submission

2021 - 2024

All parts of my Program Review have been completed and it is ready for review
Yes

Pair-Programming Helps Female Computer Science Students

LINDA L. WERNER, University of California, Santa Cruz
BRIAN HANKS, Fort Lewis College, Durango, Colorado
CHARLIE McDOWELL, University of California, Santa Cruz

Pair-programming has been found to be very beneficial in educational settings. Students who pair in their introductory programming course are more confident, have greater course completion and pass rates, and are more likely to persist in computer-related majors. Although pairing helps all students, we believe that it is particularly beneficial for women because it addresses several significant factors that limit women's participation in computer science. We provide reasons for our belief that pair-programming helps women persist in these majors. We also repeat, with special emphasis on the impact on women, some details published elsewhere regarding our experiments on pair-programming with college and university students. Additionally, we provide new data that supports our original findings.

Categories and Subject Descriptors: K.3.2 [**Computers and Education**]: Computer and Information Science Education

General Terms: Experimentation, Human Factors

Additional Key Words and Phrases: Pair programming, collaboration, gender

1. INTRODUCTION

A 2000 UCLA survey of over 400,000 entering freshman at 717 colleges and universities across the US reported the largest confidence gender gap in computer skills in the 35-year history of the survey. The gender gap in computer use was almost non-existent (79.5% men and 77.8% women reported frequent computer use); however, only 23.2% of the women versus 46.4% of the men rated their computer skills as "above average" or within the "top 10 percent." Also, 9.3% of the men versus 1.8% of the women reported intent to pursue computer programming careers [Sax 2000]. This computer science gender gap has been extensively written about and, unfortunately, has been widening [Camp 1997; 2001In 2004, 65% of the SAT I test takers had completed computer literacy-related course work or experience. The majority (55%) of these students were women, yet when narrowed to course work or experience in computer programming, the percentage of women dropped to 40%. In addition, of the 5% of the 2004 SAT I test takers who intended to major in computer or information science once in college, only 14% were women [College Entrance Examination Board 2004].

As reported by the Computing Research Association (CRA), little change has occurred during the years from 1993/1994 to 2002/2003, when less than 20% of the computer engineering/computer science BS degrees were awarded to women in each of those years.

Authors' addresses: L.L. Werner and C. McDowell, Department of Computer Science, University of California, Santa Cruz; B. Hanks, Department of Computer Science, Fort Lewis College, Durango, CO; email: Linda@cs.ucsc.edu; Charlie@cs.ucsc.edu; hanks_b@fortlewis.edu

During that same period, when gender data is available from the National Science Foundation (NSF), the percentages of science and engineering BS degrees granted to women has steadily increased, with the percentage of women at 50% in the years 2000/2001 [CRA 2005]. Even the most mathematically talented women favor medicine and law over careers in information technology because they perceive those professions as more socially meaningful and interactive [Lightbody et al. 1997]. This is consistent with the AAUW [2000] report that girls are not avoiding high-tech careers because they are failing in them. Rather, the AAUW report identifies the following reasons why fewer women are majoring in computer science (CS):

(1) the widely held perception that a career in computing is not well-rounded or conducive to family life;
(2) the belief that work in the information technology field is conducted in a competitive rather than collaborative environment;
(3) the perception of CS as a solitary occupation that is not well integrated into social discourse or social institutions; and
(4) concerns about safety and security reported by women and their friends and families about working alone at night and on weekends in computer laboratories.

We propose that using pair-programming in college and university CS courses could address three of the reasons why fewer women major in CS; we also have suggestions for removing the last of the four reasons. We present promising results from three studies regarding the use of pair-programming in beginning programming courses. These findings show that students who pair-programmed were more confident in their programming solutions and enjoyed completing the assignments more than students who programmed alone. Paired students were more likely to complete the course, and consequently to pass it. Results have been published regarding a primary study of over 500 mostly residential students in introductory programming courses at the University of California, Santa Cruz (UCSC) [McDowell et al. 2003]. We report here previously unpublished findings regarding a repeat of this study, with over 200 students at two additional institutions of higher education: San Jose State University (SJSU) and Cabrillo College, both commuter campuses. We found that the new findings mirror those at UCSC regarding confidence and pass rates. Due to smaller populations, we do not have statistically significant results in most of the areas for the subset of women at the two commuter campuses. We refer to this second experimental group as the secondary study. We also report on an additional group of UCSC students from the 2003-2004 academic year, which we refer to in this paper as the tertiary study.

Paired students performed as well on final exams taken individually as solo students did. For the primary study, we also looked at whether students continued to register as CS-related majors one year later. We found that paired students were more likely to persist in this major. Significantly more paired women programmers than solo women programmers went on to declare a CS-related major [McDowell et al. 2003]. Hence we claim that pair-programming holds promise for closing the gender gap in CS.

2. WHAT IS PAIR-PROGRAMMING AND HOW CAN IT BE USED IN EDUCATION?

Essentially all non-trivial software projects are created collaboratively. Almost all professional programmers have, on occasion, worked with another colleague on one computer to debug a program that didn't work as expected. This informal process involving two collaborators using a single computer has been formalized as pair-programming, and

become widely known because it is a key practice of the extreme programming (XP) development methodology [Beck 2000].

In XP, all software is designed, developed, and tested using pair-programming. While pairing, one of the programmers, referred to as the "driver," controls the keyboard and mouse and is responsible for entering program code. The second programmer, known as the "navigator," sits next to the driver and watches for errors, discusses alternative design approaches, and offers suggestions. The programmers regularly trade roles while pairing. Two goals of pair-programming are to have all code created collaboratively by the pair and to have the pair collectively "own" the code. Code written by only one member of the pair is reviewed by both partners together before it is officially accepted as part of the program.

Traditional undergraduate introductory programming courses generally require that students work individually on their programming assignments. In these courses, working with another student on a homework programming assignment constitutes cheating and is not tolerated. The only resources available to help students overcome problems that they may be having are the course instructor, the textbook, and the teaching assistant. Students are not allowed to work with their peers, who are also struggling with the same material. A female student interviewed by Berenson et al. [2005] observed that "you have to do all this stuff on your own and there's nobody to talk to and to ask a question to." This pedagogical approach teaches students that software development is an individual activity, thus possibly giving students the mistaken impression that software engineering is an isolating and lonely career.

Collaborative methods are often used in upper-division computer science courses such as compiler design or software engineering in which group projects are encouraged or mandated. A software engineering instructor will sometimes offer assistance to the student groups regarding techniques for collaboration. One example is the research on agile processes, including pair-programming in software engineering courses at NCSU [Berenson et al. 2005]; but the topic of collaboration is rarely discussed in other CS courses.

By deferring collaborative exercises to the upper-division courses, we believe that many CS departments are losing female students who are interested in computer science but became discouraged by its focus on individual, socially isolating work. As reported by Berenson et al. [2005], a female student "said she had been taking computer science courses for three years and did not know anyone in her classes." This changed when she began to pair-program.

We recommend requiring students to pair-program in all introductory programming courses. We introduce our students to pair-programming by having them read "All I Really Need to Know About Pair Programming I Learned In Kindergarten" [Williams and Kessler 2000a]. Additionally, we have published pair-programming implementation guidelines that we derived during our primary study [Bevan et al. 2002]. One of us (Hanks) also uses the "pair-draw" exercise to help students appreciate the benefits of pairing [Kerievsky 2004].

3. HOW DOES PAIR-PROGRAMMING LEAD TO WOMEN PERSISTING IN CS?

In the 2000-2001 academic year, 555 students (141 women, 413 men, and 1 whose gender was not reported) participated in a study on pair-programming at UCSC. We studied four sections of our introductory programming course which were taught by three different instructors. In three of the sections, students pair-programmed; in the fourth they worked individually. The instructor of the solo section also taught one of the paired sections, and is a co-author of this paper (McDowell). The statistics summarized here were collected as

part of that study and reported in McDowell et al. [2003]. There was no significant difference between the pairing and non-pairing students with regard to high school GPA, transfer GPA, or SAT math scores.

We wanted to answer several questions with our study; one was "Are women who pair-program in their introductory programming course more likely to complete and pass the course?" Our definition of course completion is that the student took the final exam; to pass the course, a student had to receive a grade of "C" or better.

A comparison of paired and solo women (101 versus 39) showed that those who paired were more likely than those who worked alone to complete the course (88.1% versus 79.5%, $p = .19$). The 8 percentage point difference in completion rate is practically significant although not statistically significant. For men, a 10 percentage point difference in completion rates between the paired and solo students was significant (91.7% versus 81.5%, $p < .05$). Although the increase in completion rates was similar for women and men, the lack of statistical significance for the women can be explained by the much smaller number of women in our study (140 women compared with 411 men). Among those who completed the course (by taking the final exam), the difference in pass rates between paired and solo programming students was not statistically significant (79.6% versus 78.2%); statistics from our secondary study validate these findings. A comparison of paired and solo women (13 versus 20) shows that those who paired were more likely than those who worked alone to complete the course (92.3% versus 75.0%, $p = .21$). The 17 percentage point difference is practically significant but not statistically significant. For men, a 15 percentage point difference between the paired and solo students was significant (85.1% versus 69.9%, $p < .05$). Among those who completed the course (by taking the final exam), the difference in pass rates between paired and solo programming students was not statistically significant (79.1% versus 87.9%, $p = .15$). However, using our terminology, it can be said that it is practically significant that more of the solo completers passed the class. If we look at all of the students, significantly more of the paired students than solo students passed the course (66.0% versus 52.3%, $p < .05$).

Further evidence that female students who pair-program perform better is provided by data collected in three additional sections of our introductory programming course as part of the tertiary study conducted by a co-author of this paper (Hanks). All students in these courses paired. Of the 24 female students who participated in the study, 23 (95.8%) took the final exam, and 21 passed the course (91.3%). Similar rates were seen for men. Of the 91 men enrolled in the three sections of the course, 85 (93.4%) took the final exam and 78 passed the course (91.8%) These rates are comparable to or better than those reported in our primary study.

Our second question concerns retention in CS-related majors. We wanted to know if pair-programming in the introductory classes led to increased numbers of women persisting in CS. We followed students in our primary study for one full academic year after the introductory programming course. We only followed students who had passed the course with a “C” or better. Our sample size was decreased further by students leaving UCSC. Furthermore, the numbers reported here only include students who stated on the first day of the introductory class that their major (or intended major) was in CS or a CS-related field. Even though our introductory programming course was primarily intended for CS or CS-related majors, the class included students majoring in a wide variety of fields. For this part of our analysis, our sample size was 237 (51 women, 186 men). A significantly higher percentage of the students who paired in the introductory course attempted the subsequent programming course required for CS-related majors (76.7% versus 62.2%, $\div 2(1) = 6.17$, $p < .05$). A separate analysis by gender revealed an

18.2% difference for paired versus solo women (73.8% versus 55.6%). The increase in attempt rates by women who paired over solo women was not statistically significant (÷*2*(1) = 1.19, *p* =.27), even though the same approximate difference (18.6%) in attempt rates was seen for paired men versus solo men, and was statistically significant (88.0% versus 69.4% ÷*2*(1) = 7.60, *p* < .01). Again, the lack of statistical significance for the data on women is probably attributable to their relatively small numbers in this part of the analysis.

Among the students in our study who attempted the second course (which did not use pair-programming), we found no significant difference in pass rates between paired and solo students. Thus, more students who paired passed the introductory course, more of these students attempted the second course, and this larger pool of students passed the second course at similar rates to those who worked alone in the introductory course.

As a second measure of retention, we wanted to know if the paired women students were more likely to declare a CS-related major one year after completing the introductory programming course. We found that 59.5% of the female potential CS-majors who paired declared a CS-related major one year later, compared with only 22.2% of the women who worked alone. This result is both practically and statistically significant (÷2(1) = 4.14, *p* < .05). Men who paired were also more likely to have declared a CS-related major one year later than those who worked individually (74% versus 47.2%, ÷*2* (1) = 9.70, *p* < .005). The same pattern was seen for our students who successfully completed the introductory programming class and were still enrolled at UCSC one year later, *regardless* of what major (or no major) they declared on the first day of the introductory course.

The potential impact of the increased retention rate on the gender gap can be seen by looking at a hypothetical example. Assume that there are 100 potential computer science majors (50 women, 50 men) enrolled in an introductory programming course. If these students worked alone, one year later there would be 35 declared majors, 31% of whom are female (22.2% of 50 women and 47.2% of 50 men). If these students paired, then one year later there would be 67 declared majors, 45% of whom are female (59.5% of 50 women and 74% of 50 men).

Another area of concern was the potential impact of pair-programming on student confidence. We believe that students who are confident of their computing abilities will be more likely to pursue studies in those areas. As part of our study, we asked students to complete a short questionnaire when they turned in each of their programming assignments. To assess student confidence levels, we asked them to respond to the following question: "On a scale from 0 (not at all confident) to 100 (very confident), how confident are you in your solution to this assignment?"

Overall, students who paired reported significantly higher confidence in their program solutions than students who worked independently (89.4 versus 71.2, *p* < .001). This is consistent with the findings from interviews of female students by Berenson et al [2005]. Although as a group all the men were significantly more confident than all the women (87.0 versus 81.1, *p* < .001), there was a significant interaction between pairing and gender with regard to reported confidence. Simple follow-up tests of the interaction indicated that pairing resulted in increased confidence for both women (86.8 versus 63.0, *p* < .001) and men (90.3 versus 74.6, *p* < .001). We also found that the gender of a student's partner was unrelated to the confidence level of that student. Women's confidence increased by 24 points when they paired, compared with a 15 point increase for men. It appears that pairing has a greater effect on confidence levels for women, and therefore may have a visible, positive impact on the gender gap. Unpaired men reported 1.18 times greater confidence

than unpaired women, while paired men reported 1.04 times greater confidence than paired women. Pairing seems to close the confidence gap between women and men.

Similarly, for our secondary study, paired women reported greater confidence levels than unpaired women (83.2 versus 72.6, $p = .31$), but this increase in reported confidence is not statistically significant, probably due to the small sample size ($n = 22$). The average reported confidence level for all paired students in our secondary study was 86.6 versus the average reported confidence level for all unpaired students of 76.0. This difference is significant with $p < .005$.

We asked participants in our tertiary study at UCSC (in which all students were paired), to answer the same question pertaining to confidence. We found that these paired students exhibited similar levels of confidence as the paired students in our original study. In the more recent study, the average confidence level for all students was 88.7; it was 88.8 for men, and 88.3 for women. The results from our secondary and tertiary studies add weight to our earlier finding that students who pair are more confident in their work and that the gender gap in confidence is diminished with pair-programming.

4. WHY DOES PAIR-PROGRAMMING LEAD TO WOMEN PERSISTING IN CS?

Women's belief about the solitary nature of computer science is confirmed when they enroll in an introductory programming course that requires programming assignments to be done individually. Instead, when pair programming is used, it is possible that women view programming as a collaborative exercise. Williams and Kessler suggest that "peer pressure" may be at work as a possible explanation for higher completion rates among paired vs. solo programming students [Williams and Kessler 2000a]. It may be the collaborative aspect of pair programming that is a major reason that the students remain in the class. The increased levels of confidence that can be attributed to pairing are probably also a factor in improved retention.

It is important to us not only that women stay in the class but that they pass at similar rates to men. Given that the exams are taken individually, the paired students are mastering the course material at the same rates as the solo students. Additionally, if a "pair-oriented culture" is encouraged by having short discussion periods during class time, then women might question their belief that work in the information technology is conducted in a competitive rather than collaborative environment. They might also question their perception of CS as a solitary occupation that is not well integrated into social discourse or social institutions. Another serendipitous outcome of pair-programming is that no one works alone late at night or on weekends in a computer laboratory. Partners work together. We hypothesize that for the reasons given above, pair programming contributes to women persisting in CS.

One reason not addressed by pair programming as to why fewer women major in computer science (as stated in the AAUW report) remains. The report states that women believe that a career in computing is not well-rounded or conducive to family life. An effort needs to be made by the authors of introductory programming textbooks to create exercises and examples that "highlight the human, social, and cultural dimensions and applications of computers rather than the technical advances, the speed of the machines or the entrepreneurial culture surrounding them" [AAUW 2000, p. 10]. There seems to be some hope for such an outcome: The recent Java textbook by Cohoon and Davidson [2004] includes programming exercises and examples drawn from fields such as medicine, personal finance, health and fitness, and data visualization. We are encouraged by this, and hope that other authors follow this lead.

5. CONCLUSIONS

Pair-programming is shown to be beneficial to all students. We argue that it is particularly beneficial for women because it addresses factors that potentially limit their participation in CS. The collaborative nature of pair-programming teaches women students that software development is not the competitive, socially isolating activity that they imagined. It encourages women to pursue computer science as a major and as a potential career. Because of this, we strongly advocate the use of pair-programming in all introductory programming courses. We are now using pair-programming in all introductory programming courses we teach. Additionally, we use optional pair- programming in all upper-division programming courses we teach. The teachers who experimented with pair-programming for the secondary study all strongly believe in it and encourage their students to use it. We suggest you try it too!

ACKNOWLEDGMENTS

This work was funded by National Science Foundation grants EIA-0089989 and DUE-0341276. Any opinions, findings, and conclusions or recommendations expressed in this paper are those of the authors and do not necessarily reflect the views of the National Science Foundation.

We also want to thank both Heather Bullock and Julian Fernald at UCSC for their participation as investigators in our NSF study. Thanks also to Michael Burke and Vladimir Drobot at SJSU and Susan Nerton and Ed Parrish at Cabrillo College, who graciously allowed us to experiment with their classes. A final thanks to the anonymous reviewers, one of whom suggested the example regarding the gender gap and a hypothetical class of 100 students.

REFERENCES

American Association of University Women Education Foundation Commission on Technology, Gender, and Teacher Education. 2000. Tech-Savvy: Educating girls in the new computer age. http://www.aauw.org/2000/techsavvy.html.

BECK, K. 2000**.** *Extreme Programming Explained: Embrace Change***.** Addison-Wesley, Reading, MA.

BERENSON, S. B., SLATEN, K. M., WILLIAMS, L., AND HO, C.-W. 2005. Voices of women in a software engineering course: Reflections on collaboration. *Journal on Educational Resources in Computing.* In this issue.

BEVAN, J., WERNER, L., AND MCDOWELL, C. 2002. Guidelines for the use of pair programming in a freshman programming class. In *Proceedings of the Conference on Software Engineering Education and Training*.

CAMP, T. 1997. The incredible shrinking pipeline. *Communications of the ACM 40*, 10 (1997), 103-110.

CAMP, T. 2001. Women in computer science: Reversing the trend. CRA-W, Aug. 2001. Accessed Nov. 19, 2004. .http://www2.cs.cmu.edu/~women/resources/aroundTheWeb/hostedPapers/Syllabus-Camp.pdf.

COHOON, J. AND DAVIDSON, J. 2000. *Java 1.5 Program Design*. McGraw-Hill, Boston.

College Entrance Examination Board. 2004. College-bound seniors A profile of SAT program test takers. Accessed Jan. 23, 2005. http://www.collegeboard.com/prod_downloads/about/news_info/cbsenior/yr2004/2004_CBSNR_total_group.pdf.

CRA. 2005. CRA Taulbee trends: Women students & faculty. Updated May 6, 2004. CRA Taulbee Survey. http://www.cra.org/info/taulbee/women.html.

KERIEVSKY, J. 2004, Pair draw. Accessed Feb. 6, 2005. http://industriallogic.com/games/pairdraw.html.

MCDOWELL, C., WERNER, L., BULLOCK, H., AND FERNALD, J. 2003. The impact of pair programming on student performance, perception, and persistence. In *Proceedings of the 25th International Conference on Software Engineering* (Portland, OR). 602-607.

LIGHTBODY, P., SIANN, G., TAIT, L., AND WALSH, D. 1997. A fulfilling career? Factors which influence women's choice of profession. *Educational Studies 23* (1997), 25-37.

SAX, L. J., ASTIN, A.W., KORN, W. S., AND MAHONEY, K. M. 2000, The American freshman: National norms for fall 2000. For a summary, see http://www.gseis.ucla.edu/heri/norms_pr_oo.html.

WILLIAMS, L. A. AND Kessler, R. R. 2000a, The effects of "pair-pressure" and "pair-learning" on software engineering education. In *Proceedings of the Thirteenth Conference on Software Engineering Education and Training* (Austin, TX). IEEE Computer Society, New York.

WILLIAMS, L. A. AND KESSLER, R. R. 2000b. All I really need to know about pair programming I learned in kindergarten. *Communications of the ACM, 43*, 5 (2000), 108-114.

Received October 2004; revised February 2005; accepted March 2005