CHEM105 Participation and Subsequent Chemistry Success

Institutional data shows a strong negative association between an unsuccessful attempt in CHEM111 and graduation rates, which prompted the Department of Chemistry to create the CHEM105 course. CHEM 105 is a half-semester course that focuses on developing skills needed to be successful in other college level chemistry courses. The purpose of this study is to describe the associations CHEM105 participation has with student success.

Types of CHEM105 and Comparisons

Discussions with students who earned an F or D in CHEM111 revealed that students would lose their full-time status and, possibly, their satisfactory academic progress for financial aid if they W dropped the 5-credit combination of CHEM111 and CHEM112. Additionally, students who did withdraw wanted resources that would help them prepare for a successful repeat of the course. CHEM105 offers students that withdraw from a chemistry course (CHEM107, CHEM111 or CHEM113) the ability to recover credits by providing a condensed course that starts mid-semester. Recognizing that a "preparation" version of the course could benefit students who don't feel ready to start in a general chemistry course, CHEM105 is also offered in the first half of the semester.

Therefore, since the 2015-16 academic year through the current year, CHEM105 has been offered as a 2 credit, 8 week course at two points during the fall and spring semesters. This report assesses CHEM105 independently based on the timing of the course. The primary outcome used to measure effectiveness of CHEM105 is subsequent success in a college-level chemistry course that is includes CHEM107, CHEM111 or CHEM113 since the intent of the course is to improve the skills needed to be successful in a subsequent chemistry course.

CHEM105 First Part of the Semester (CHEM105a)

Students that take CHEM105 in the first part of the semester, referred to as CHEM105a throughout this report, opt into the course with the goal of taking a college-level chemistry course in a subsequent semester. Success in the subsequent college-level course for CHEM105a is compared to the success rate of students that are enrolled in one of the college chemistry courses without any prior chemistry attempts during the same timeframe. This comparison is based on the assumption that if the CHEM105 course had not been offered the CHEM105 students would have gone straight into one of these chemistry courses.

CHEM105 Second Part of the Semester (CHEM105b)

CHEM105 is also offered during the second part of the semester and is referred to as CHEM105b in this report. These students enrolled in college-level chemistry courses, but they are not on track to pass the course by mid-semester. Students can withdraw from their college-level chemistry course and enroll in CHEM105b so they still earn 2 credits and can keep working on their chemistry knowledge. The rate of attempting a college-level chemistry course in a subsequent semester as well as success in these attempts are used as outcomes to assess the effectiveness of CHEM105b. The comparison group for CHEM105b are students who earned an F or withdrew from college-level chemistry during the CHEM105 timeframe. This comparison is based on the

assumptions that if the CHEM105b course had not been offered, these students would have W dropped or earned an F in their initial college-level chemistry course.

Learning to Learn Curriculum

Curriculum changes recently occurred in the CHEM105 course. The course shifted from a traditional curriculum to a learning to learn (L2L) model starting in FA16 for CHEM105a and SP17 for the CHEM105b sections. Research about student learning and performance has revealed that many students experience common risk factors that impede their ability to perform as a collegiate learner. Thus, the L2L curriculum is designed to help learners mitigate their risk factors by focusing on developing the characteristics of a quality collegiate learner. These characteristics include: having a growth mindset, becoming master learners, believing that their past does not define their future, creating a life vision to guide their path to degree completion and after, and shifting from self-judgment to self-improvement by assessing their performance.

The L2L model is assessed by comparing subsequent chemistry success in CHEM105a and CHEM105b for L2L semesters compared to traditional curriculum semesters. Additionally, the second-fall persistence rate of L2L CHEM105a and CHEM105b students is compared to other first-time, full-time students that did not take any version of CHEM105.

Methodology

In order to assess the effectiveness of CHEM105a and CHEM105b, the success rates in subsequent college-level chemistry sections are compared to the success rates of the comparisons groups. Statistical significance of the differences are evaluated by comparing the differences in success with a t-statistic that is calculated based on a reduced comparison group that is statistically matched to the CHEM105 group. The logistic regression results that created the propensity scores for these three matched samples can be found in the appendix (tables A.1-A.3). It is important to note that the fit and significance of these models are not strong. The estimates from the matched sample offer a reference level to assist in determining what we might expect from the CHEM105 group.

In order to assess the impact of the curricular change to a L2L model, success rates in the subsequent attempts of college chemistry are compared across the curriculum types for CHEM105b and CHEM105a. Statistical significance is evaluated using a chi-squared test. Since the L2L model should have a broader impact on persistence at CSU (rather than just future chemistry success), the second-fall persistence rates of first-time, full-time (FTFT) students that successfully complete a CHEM105 course with the L2L model are compared to a statistically matched sample of FTFT students that don't do the CHEM105 L2L course. The results of the propensity score model for this fourth matched sample is in table A.4 of the appendix.

Limitations

The number of CHEM105 students by section timing is barely large enough for the propensity matching methodology and this causes large amounts of uncertainty around the estimates of CHEM105's treatment effect. Across all four outcomes, CHEM105 students have slightly higher observed success rates compared to the comparison groups; however, this cannot be interpreted as a positive impact because these aren't statistically significant. The small sample size creates very large standard errors so it is very difficult to be confident that the observed differences are not just due to chance. As more students complete CHEM105 and can be included in

the analysis, we might gain evidence of the positive impact of CHEM105 on future success in college-level chemistry.

CHEM105 Population

Table 1 displays the enrollment in CHEM105 over all the semesters it has been offered by course timing and curriculum.

Table 1.

CHEM105 Enrollment by Section Timing and Curriculum Type

	FA15	SP16	FA16	SP17	FA17	SP18
CHEM105a	28	11	63	15	65	5
Traditional	28	11	63			
Learning 2 Learn				15	65	5
CHEM105b	35	19	30	29	23	29
Traditional	35	19				
Learning 2 Learn			30	29	23	29

Enrollment is typically larger for CHEM105a during the fall semester and larger for CHEM105b in the spring. It is important to note only 187 students have completed CHEM105a and only 165 students completed CHEM105b. These smaller headcounts limit the ability to infer relationships between the course and future success.

CHEM105 Demographic and Academic Characteristics

This section compares demographic and academic characteristics of CHEM105 and CHEM105b students to their comparison groups as well across the CHEM105 courses.

Table 2 displays the demographic characteristics of CHEM105 students and their comparison group by section timing.

Table 2.

Demographic Characteristics of CHEM105 Population

	CHEM105a	Unmatched Comparison Group	CHEM105b	Unmatched Comparison Group
Headcount	187	8505	165	1031
Race/Ethnicity [1]				
Latinx	16.0%	12.0%	21.2%	16.4%
Native American	1.1%	2.2%	3.6%	2.8%
Asian	3.7%	6.0%	6.7%	6.1%
Black	4.8%	2.8%	9.7%	4.3%
Hawaiian	0.5%	0.8%	0.6%	1.4%
White	87.2%	85.3%	78.2%	83.9%
International	1.6%	4.6%	6.7%	2.2%
Multi-Race	3.7%	3.9%	4.2%	5.6%
Other Demographic Attributes				
First Generation	30.5%	23.2%	34.5%	32.6%
Pell Recipient	20.3%	19.4%	28.5%	26.2%
Female	63.1%	54.3%	54.5%	52.1%
CO Resident	64.2%	66.6%	69.1%	71.8%
CCHE Index Score (AVG)	116.2	118.0	110.3	109.7

[1]Duplicated representation so individuals are represented across all race/ethnicities that they self-selected

First generation, female, Latinx, black, and white students are overrepresented in CHEM105a compared to the students that took have a first attempt at in a college-level chemistry course the same semester but never took CHEM105. Latinx, black, and International students are overrepresented in CHEM105b compared to students that W dropped or earned an F in a college chemistry course during a CHEM105 semester.

Table 3 displays academic attributes of CHEM105 students along with the comparison groups by section timing.

Table 3.

Academic Characteristics of CHEM105 Population

	CHEM105a	Unmatched Comparison Group	CHEM105b	Unmatched Comparison Group
Headcount	187	8505	165	1031
Academic Classifications				
C4E Participant	8%	3%	7%	3%
Key Participant	4%	3%	10%	2%
STEM Major	71%	66%	62%	60%
Good Academic Standing (%)[1]	89%	91%	78%	54%
Student Class Level				
Freshmen	70%	48%	60%	44%
Sophomore	23%	34%	31%	36%
Junior	5%	12%	7%	14%
Senior	1%	4%	2%	5%
College of Major				
Agricultural Sciences	7%	9%	9%	11%
Business	1%	1%	0%	1%
Engineering	4%	20%	8%	9%
Health and Human Sciences	9%	13%	13%	13%
Intra-University	19%	11%	22%	16%
Liberal Arts	1%	1%	1%	1%
Natural Sciences	52%	28%	28%	32%
Veterinary Medicine & Biomedical Sci	1%	7%	12%	7%
Warner College of Natural Resources	5%	9%	7%	10%

[1]Good academic standing (percent of students with a cumulative GPA above 2.0) is measured at the end of the CHEM105 semester

C4E students are overrepresented in both CHEM105 groups, but Key students are only overrepresented among the second part of the semester CHEM105 group. Additionally freshman class levels and undeclared students are overrepresented in both of the CHEM105 timing options. Natural Science majors are overrepresented among the CHEM105 students for the first part of the semester, but not among the CHEM105 group in the second part of the semester.

Overall, there are some important academic and demographic differences between CHEM105 and the comparison groups. First generation, females, black and Latinx students are overrepresented in CHEM105. Additionally, CHEM105 tends to have more first-year students as well as students in co-curricular support programs like Key and C4E. Percent in good academic standing is very similar for the CHEM105a group, but much higher for CHEM105b compared to the comparison group. This is most likely due to the CHEM105b students not earning a D or F in the chemistry course they withdrew from in order to enroll in CHEM105b. One

approach to account for these differences in characteristics in the assessment of CHEM105's association with future chemistry success is to reduce the comparison groups to only statistically similar students.

CHEM105 Associations with Student Success

This section reviews the associations between CHEM105 participation and student success based on statistically matching the comparison group using a variety of academic and demographic characteristics.

Table 4 displays the success rates in subsequent college chemistry courses for CHEM105a students compared to statistically similar students that took college-level chemistry courses in the same semester without completing CHEM105.

Table 4.

Percent of CHEM105a Students that are successful in their Subsequent College Chemistry Course

	N	Rate	PP Difference (SE)[1]	Test Statistic
CHEM105	138	78.3%	4.3 (.061)	0.71
Comparison Group[2]	138	73.9%		

[1]Average treatment effect among the treated with standard error in parenthesis, statistical significance ***would be*** indicated with an asterisk (*)

[2]Success rate in college chemistry among a matched group of students that did not do CHEM105; the unmatched rate was 76.9%

Approximately 78.3% of the students that took CHEM105a are successful in their subsequent college chemistry course. Prior to matching, the comparison group had a success rate of 76.9%. After reducing the comparison group to a random sample of statistically similar students, the success rate is 73.9%. This 4.3 PP difference is not statistically significant so we would conclude that the success rate for CHEM105a participants is similar to the comparison group. Although, we are relatively confident that CHEM105a students do not do worse than their peers whom do not take CHEM105a.

Almost three-quarters (the 138 students included in table 4 among the 187 shown in the demographic tables) of the CHEM105a students attempt college-level chemistry in a subsequent semester. The majority (about 89%) of those that attempted a college-level chemistry course took CHEM111 and the remaining 11% attempted CHEM107. Additionally, the majority (over 90%) of the students that attempted college chemistry did so the semester directly following the CHEM105 semester.

Table 5 displays the success rates in subsequent college chemistry courses for CHEM105b students compared to statistically similar students that withdrew or earned an F in a college-level chemistry courses during the same time period.

Table 5.

Percent of CHEM105b Students that attempted a Subsequent College Chemistry Course

	N	Rate	PP Difference (SE)[1]	Test Statistic
CHEM105	165	47.9%	11.5 (.059)	1.95
Comparison Group[2]	165	36.4%		

[1]Average treatment effect among the treated with standard error in parenthesis, statistical significance ***would be*** indicated with an asterisk (*)
[2]Percent that attempt college chemistry again among a matched group of students that did not do CHEM105; the unmatched rate was 40.2%

About 47.9% of students that take CHEM105b attempt a college chemistry course in a subsequent semester. This is compared to about 36.4% of the matched comparison group (the unmatched rate is 40.2%). Even though this is nearly a 12 PP difference it is not a statistically significant and we cannot conclude that CHEM105b students attempt college chemistry in subsequent semesters at higher rates compared to similar students that do not take CHEM105b. The lower rates of subsequent course attempts might reflect that students change their major to one that does not require chemistry, which could be a result of the L2L curriculum that has students explore their life visions.

It should be noted that students who take CHEM105a do attempt subsequent college chemistry courses at descriptively higher rates (74%) compared to students that take CHEM105b (47.9%). This could be reflective of the psychosocial impact an unsuccessful course attempt has on future attempts.

Table 6 displays the subsequent college-level chemistry course success rates among the students that made a subsequent attempt by CHEM105b participation status.

Table 6.

Percent of CHEM105b Students that are Successful in their Subsequent College Chemistry Course

	N	Rate	PP Difference (SE)[1]	Test Statistic
CHEM105	79	48.1%	5.1 (.085)	0.6
Comparison Group[2]	79	43.0%		

[1]Average treatment effect among the treated with standard error in parenthesis, statistical significance ***would be*** indicated with an asterisk (*)
[2]Success rate in subsequent college chemistry course among a matched group of students that did not do CHEM105; the unmatched rate was 35.6%

Over 48% of CHEM105b students that attempted college-level chemistry in a subsequent semester are successful. This is compared to about 43% of statistically similar students (unmatched rate is lower, 35.6%, for

this analysis). Again, the difference between the CHEM105 group and the matched comparison group is not statistically significant. The small number of students in the CHEM105 group, 79 students, create a lot of uncertainty with huge standard errors (in this instance 8.5 percentage points) reducing statistical power for identifying differences. Therefore, we are limited to saying that rate of success in subsequent college-level chemistry for CHEM105b students are similar to the success rates of students that do not take CHEM105b.

The success rate of CHEM105b students feels very low, e.g. only 38 of the 79 students earned an A, B or C in their subsequent college-level course. For instance, in fall 2017 about 69% of all students in CHEM111 are successful and 79% of the CHEM105a students are success in a future college-level chemistry. However, the CHEM105b students (and their comparison group) have a failed attempt at college chemistry so these lower rates align with other institutional knowledge of the negative associations between failed course attempts and future success (reference).

Among the 79 CHEM105b, the majority (72%) attempted CHEM111 and 16.5% attempted CHEM107 (only 9 students, which is about 11% attempted CHEM113). Success rates in these attempts are highest for CHEM111 (49% successful) and lowest in CHEM113 (44% success). The majority, 62%, of students that took CHEM105 in the second part of the semester made their subsequent attempt in college chemistry the semester directly following CHEM105. About 24% did their subsequent attempt two semesters following CHEM105 and about 13% did their subsequent attempt three or more semesters after CHEM105. Interestingly, success rates in subsequent attempts are lowest, about 43%, for the students that attempted college chemistry the semester directly following CHEM105. This success rate increases to about 57% among students that attempt college chemistry 2 or more semesters after CHEM105.

Table 7 displays the rate of success in a subsequent chemistry course by CHEM105 section timing as well as curriculum.

Table 7.

Percent of CHEM105 Students that are successful in the Subsequent College Chemistry Course by Curriculum Type

	N	Rate	PP Difference	Test Statistic
CHEM105 in First Part of Semester				
Traditional	74	82.4%	-8.99	1.63
Learning 2 Learn	64	73.4%		
CHEM105 in Second Part of Semester				
Traditional	37	51.4%	-6.11	0.29
Learning 2 Learn	42	45.2%		

[1]Chi-squared test statistic, statistical significance ***would be*** indicated with an asterisk (*)

The traditional curriculum has descriptively higher success rates in subsequent college chemistry course attempts compared to the L2L curriculum. However, these differences are not statistically significant. For instance, 51.4% of students that take CHEM105 in the second part of the semester with traditional curriculum are success in their subsequent attempt in college chemistry compared to 45.2% of the students that had the L2L curriculum.

The L2L curriculum should have a broader impact on student success rather than just subsequent chemistry success; therefore, the second-fall persistence rates of FTFT students that took any CHEM105 section with the L2L curriculum are compared to a matched group of FTFT students that did not take CHEM 105. Table 8 displays these persistence rates. Please note that this analysis is not split by the timing of CHEM105 because of the smaller number of FTFT students in a L2L version of CHEM105.

Table 8.

Second Fall Persistence Among FTFT students by L2L CHEM105 course completion

	N	Rate	PP Difference (SE)[1]	Test Statistic
CHEM105	63	84.1%	1.6 (.099)	0.16
Comparison Group[2]	63	82.5%		

[1]Average treatment effect among the treated with standard error in parenthesis, statistical significance ***would be*** indicated with an asterisk (*)

[2]Persistence rate of FTFT students from the FA16 and FA17 cohorts that did not take a L2L CHEM105 course; the unmatched rate was 83.4%

About 84% of the FTFT students that took a L2L course in FA16 or FA17 persisted to their second semester. This is descriptively higher than the overall FTFT persistence rates in FA17 and FA16 (about 83.3%) and the matched comparison group (about 82.5%). However, this is not a statistically significant difference in persistence rates. There is a large amount of uncertainty in the matching process because there are only 63 L2L CHEM105 students. This results in very large standard errors around the estimated treatment effect of the CHEM105. For instance, there is a 1.6 PP difference in the L2L persistence rate compared to the matched group but the standard error around this difference is nearly 10 PP. We can be certain that L2L students persist at rates similar to what we would expect, but cannot say they persist at higher rates.

Conclusions

Descriptively CHEM105 students appear to be doing as well or slightly better than students who are attempting college chemistry courses but who do not take CHEM105. However, once propensity scores are used to match CHEM105 students, the smaller CHEM105 headcounts causes high levels of uncertainty. None of the four matched comparisons completed for this research brief have statistically significant results even though the direction of all the differences in success trend positively for CHEM105. This indicates that CHEM105 students do as well as we would expect, but we cannot be certain they do better than they would have without CHEM105. Statistical power will increase as the cohorts of CHEM105 continue to grow. In short, we need to have more CHEM105 students to be able to complete the types of analyses that are necessary to know the program's impact on student success.

Appendix

Table A.1

Logistic Regression Coefficients for CHEM105a Participation

	Coefficient	Standard Error	P Value
Residency	-0.060	0.074	0.420
Racially Minoritized	-0.011	0.090	0.902
First Generation	0.107	0.084	0.204
Pell Recipient	-0.070	0.095	0.464
Female	0.157	0.072	0.029
STEM Major	-0.038	0.077	0.617
Key or C4E	0.184	0.143	0.199
CSU Completed Credits	-0.018	0.003	0.000
Constant	-1.748	0.119	0.000
N	8617		
Likelihood Ratio Chi-Squared *df*=8	63.96		
Pseudo R^2	0.0452		

Table A.2

Logistic Regression Coefficients for CHEM105b Participation

	Coefficient	Standard Error	P Value
Residency	-0.096	0.103	0.348
Racially Minoritized	0.152	0.106	0.150
First Generation	-0.038	0.108	0.726
Pell Recipient	-0.009	0.114	0.936
Female	0.036	0.093	0.701
STEM Major	-0.017	0.096	0.861
C4E	0.139	0.244	0.568
Key	0.974	0.244	0.000
CSU Completed Credits	-0.003	0.002	0.217
Constant	-1.031	0.133	0.000
N	1196		
Likelihood Ratio Chi-Squared *df*=9	28.71		
Pseudo R^2	0.0299		

Table A.3

Logistic Regression Coefficients for CHEM105b Participation Among Students that have a Subsequent College-Level Chemistry Attempt

	Coefficient	Standard Error	P Value
Residency	-0.254	0.149	0.089
Racially Minoritized	0.153	0.162	0.346
First Generation	-0.161	0.172	0.348
Pell Recipient	-0.031	0.140	0.827
Female	0.121	0.176	0.492
STEM Major	-0.109	0.143	0.446
Key or C4E	0.281	0.298	0.346
CSU Completed Credits	-0.002	0.003	0.431
Constant	-0.705	0.193	0.000
N	492		
Likelihood Ratio Chi-Squared *df*=8	6.62		
Pseudo R^2	0.0153		

Table A.4

Logistic Regression Coefficients for CHEM105b Participation Among First-Time, Full-time Students

	Coefficient	Standard Error	P Value
STEM Major	0.684	0.113	0.000
Index	0.000	0.004	0.992
Constant	-2.898	0.480	0.000
N	9610		
Likelihood Ratio Chi-Squared *df*=2	48.73		
Pseudo R^2	0.0642		