

# Benefits of a Prerequisite Majors' (General) Chemistry Course in STEM Retention and Graduation Rates As Measured through Success in a Biology CURE Course

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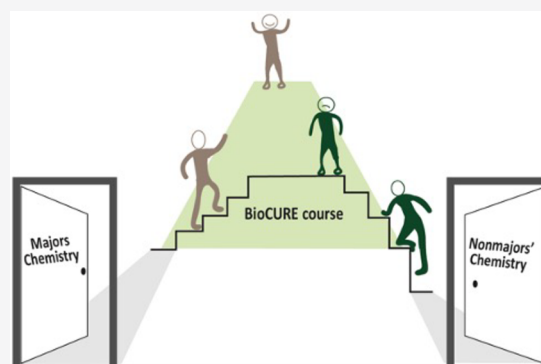
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**ABSTRACT:** A required first-year laboratory course was overhauled into a semester-long biosciences course-based undergraduate research experience (BioCURE) with a goal of enhancing learning and improving retention. Student attributes and outcomes were continually monitored by the University's Institutional Research office over a 5-year period and compared against the pre-BioCURE (traditional Biology lab course). Success in the BioCURE was found to be correlated with a passing grade (ABC) in prerequisite majors' chemistry as opposed to nonmajors' chemistry; concurrent enrollment in either majors' or nonmajors' chemistry was less effective than prerequisite majors' chemistry. This unique metric, of assessing the value of a chemistry course as seen through the success in a subsequent bioscience course, provides the authors with convincing evidence to encourage educators to focus on a rigorous, early academic chemistry foundation as well as emphasize interconnections with other disciplines. Diving deeper, success in a more challenging chemistry course prior to taking a required biology course during biological science students' first two collegiate years correlated with increases in student success in biological sciences degree plans, as evidenced by subsequent increases in retention into the third year and six year graduation rates. Students with ABC grades in any first-year chemistry course had a higher rate of graduating in an initially chosen bioscience discipline, but majors' chemistry benefited at-risk students disproportionately more than high-GPA students showing that early chemistry success is critical for strengthening a diverse STEM workforce.

**KEYWORDS:** First-Year Undergraduate/General, Interdisciplinary/Multidisciplinary/Testing/Assessment, Applications of Chemistry



## INTRODUCTION

The 2012 President's Council of Advisors on Science and Technology (PCAST) report highlighted the need to focus on strategies of persistence to rebuild the Science, Technology, Engineering, and Mathematics (STEM) pipeline in the US.<sup>1</sup> Early access to laboratory research mentoring has been identified as a key indicator to promote both student success and persistence in STEM.<sup>2</sup> With this in mind, the University of Idaho (UI) initiated a Biology Retention and Innovation Network for Students (BRAINS) undergraduate laboratory program in 2015, which focused on improving student retention in sciences by implementing innovative networks of integrated coursework, interdisciplinary course-based undergraduate research experiences (CUREs), and early access to the rigors of basic research. CURE laboratories employ meaningful scientific research, which enables a student to learn and appreciate processes critical for STEM success such as discovery, relevance, scientific practices, collaboration, and iteration. Studies show that CURE laboratories, particularly when taken for more than one semester, increase retention in STEM and enhance learning.<sup>3–5</sup>

The central component of the BRAINS program was the complete overhaul of a required Biology laboratory course serving first-year students ( $\approx 350$ /year seeking degrees in Biology, Microbiology, Biochemistry, Microbiology, Molecular Biology, Animal Veterinarian Sciences, Fisheries, Health Sciences, Biological Engineering, Ag Biotech, etc.) into a semester-long Biology CURE (BioCURE). The BioCURE course focused on skill development, independent student research, and incremental learning objectives (see the Supporting Information (SI) for a description of the BRAINS program). Mathematical and chemical problem-solving were integrated into the daily lab routine as concepts rather than procedures for a combination of technique learning and skill mastery rather than step-by-step instructions. For example, the

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curriculum would describe how and why to calculate and perform a serial dilution instead of giving procedural directions of adding  $X$  mL of one component and diluting to a volumetric mark. Mastery of lab skills was assessed through weekly skills checks. Students were allowed to use notes and equipment manuals during skill checks, mimicking standard procedures in a research lab. Concepts and definitions were updated in the teaching manuals so students could incorporate the language and examples of corresponding disciplines.

It is important to note that, while the majors' chemistry course is required for a degree in Biological Sciences (Biology, Microbiology, Biochemistry) at our university, it is not required for degrees in all departments, and it was not a prerequisite for the BioCURE course. Moreover, students could enroll in majors' or nonmajors' chemistry courses either separately or concurrently. Logistically, this complicated the BioCURE instruction. To offset inequities in students' knowledge of chemistry, a bioscience primer (see SI for primer description and example exercises) was developed and learning assistants were on-hand to help students with material.

Integrating subject matter in introductory courses and measuring persistence has become a valuable part of assessment. Hrycyna et al. suggested a first semester general chemistry curriculum be followed by organic chemistry and biochemistry for life science majors,<sup>6</sup> and this was echoed by Kennerly et al. as they found increases in retention in STEM fields.<sup>7,8</sup> Loughlin and Cresswell integrated biology and chemistry components into first year inquiry-based laboratory exercises for a forensics program and, through student survey, found increased student engagement.<sup>9</sup> Freeman et al. reported that general chemistry success is critical to the STEM pipeline in underrepresented groups advocating for a more active learning approach to the chemistry curriculum.<sup>3,4,10</sup> Wiggins et al. reported through direct interviews that students who participate in multiple CURE laboratories gain the greatest academic benefits<sup>11</sup> and develop a deeper appreciation for interdisciplinary training.

To bridge our courses, the biosciences and chemistry faculty developed BioCURE activities that interconnected with the curriculum of both a first-year majors' level chemistry course and a second-year majors' microbiology course, which also were modified for the BRAINS BioCURE. Strategically, identical instruments were purchased, such as UV-vis spectrophotometers, and labware, such as micropipettes. Faculty agreed to use consistent vernacular when describing techniques used in both disciplines (i.e., technique descriptions and equations for making dilutions) and integrated laboratory exercises and schedules to have samples ready for student analysis.

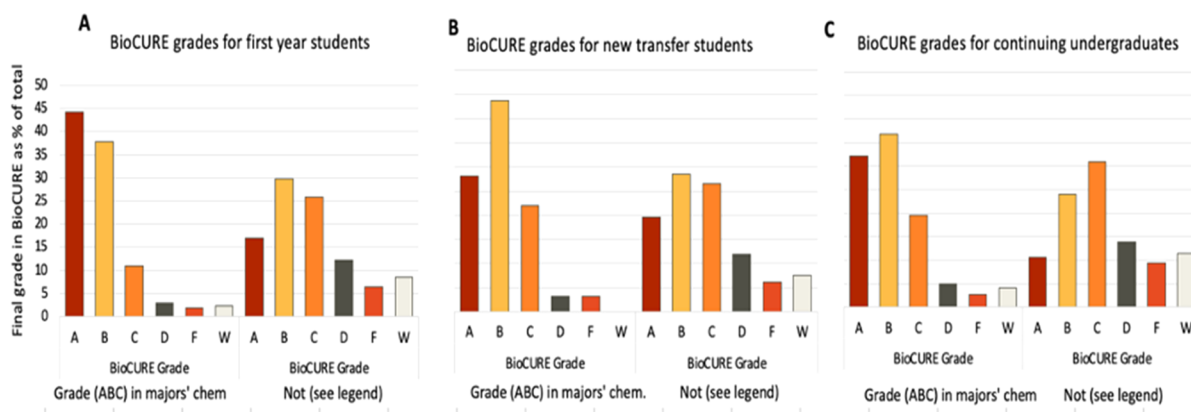
The independent research projects in the BioCURE lab drew on a student's knowledge and understanding of chemistry. Having to make their own solutions from scratch proved to be the antidote to cries of "why do I need to take chemistry?" Multiple biologically integrated exercises were created to strengthen the connection between chemistry and biology. These ranged from the development of an assay for glyphosate (in chemistry laboratories) to quantify low levels in plants (grown in BioCURE laboratories), the analysis of  $\alpha$  and  $\beta$  acids in hop samples, and the formulation of hand sanitizers (in chemistry) with evaluation of efficacy (in microbiology).<sup>12-14</sup> Tissue samples from student teams in the BioCURE studying the accumulation of glyphosate in plants were handed off to chemistry lab students who quantified the glyphosate

concentration using protocols developed.<sup>12</sup> BioCURE students used data from the chemistry students to complete their research projects. In the future, some of the logistical challenges that were encountered could be circumvented by building laboratory exercises that eliminate barriers, both academic and physical, between these disciplines.

To understand what type of academic coursework might best prepare a student for a CURE, we monitored the success of students in the BioCURE lab as a function of their first-year chemistry course. Although chemistry is required for students to take the BioCURE, the timing and rigor are flexible. One can take majors' or nonmajors' chemistry as a prerequisite or corequisite. Students self-select, with advisors, the course that best suits their experience and abilities. The University offers a chemistry placement exam, and the majors' course is recommended (but not required) if a student receives a minimum of 25 on math ACT or 560 on math SAT.

Majors' and nonmajors' chemistry courses differ mainly by rigor and both satisfy a general education lab science requirement. The majors' (general) chemistry is described as "an intensive treatment of the principles of chemistry" while the nonmajors' (introductory) chemistry course is described as "an introduction to a variety of chemical concepts." The material is similar yet taught at varied levels both mathematically and conceptually (see the SI for content material and example exam questions). The content is so similar that the University does not give earned credit hours for both the nonmajors' and the majors' course; once the majors' course is taken and passed, the credit received for the nonmajors' course is removed. Some students with little chemistry experience opt to take nonmajors' chemistry to build their chemistry knowledge. They can take the BioCURE course with this level of preparation. Depending on the requirements for their final degree, they may need to take majors' chemistry.

The central argument of this report is that success in a more rigorous chemistry course early in a student's academic career correlates with higher third year retention and six year graduation rates when measured through the subsequent successes in a BioCURE course and focus on bioscience students. The BioCURE course fits the second term for most first-year biosciences student's degree plans and is, to many students, their first look at authentic research, making this course an excellent indicator for retention in both its content and timing. When comparing student retention in bioscience majors and the BioCURE lab grades, a few trends were found: (1) students significantly performed better in the BioCURE course after taking a semester of majors' chemistry rather than nonmajors' chemistry; (2) students performed better in the BioCURE course with prerequisite rather than corequisite majors' chemistry; and (3) success (defined as a grade of A, B, C) in early chemistry courses resulted in higher retention and graduation rates both in bioscience majors and in other STEM fields. While Shultz et al. and Sveinbjornsson independently investigated the effects of introductory chemistry courses in retention and success in subsequent chemistry courses,<sup>15,16</sup> the study herein examines the effect of chemistry instruction timing and type for a CURE-based biosciences laboratory course and the subsequent retention effects. The data argue that majors' prerequisite chemistry should be encouraged for best academic outcomes. These findings are described in more detail below and highlight the advantage of an early rigorous chemistry curriculum for integrated STEM education.



**Figure 1.** Final grades (as frequency distribution) for BioCURE students who had a passing grade (ABC) in majors' chemistry prior to taking the BioCURE course or not (DFW in majors' chemistry, nonmajors' chemistry, or no recent chemistry). Three student groups were analyzed: (A) New first-year students ( $N = 1462$  total with  $N = 406$  for ABC in majors' chem and  $N = 1056$  for Not); the average biology grade was 3.15 for the ABC majors' chemistry group vs 2.22 for the Not group. (B) Transfer students ( $N = 505$  total;  $N = 64$  for ABC in majors' chem and  $N = 441$  for Not); the average biology grade for transfer students were 2.91 vs 2.33 for students who had passed (ABC grade) majors' chemistry vs Not, respectively. (C) Continuing students ( $N = 1978$  total;  $N = 760$  for ABC in majors' chem and  $N = 1218$  for Not); the average biology grade for continuing students was 2.84 for students who had taken the majors' chemistry vs 1.92 for the Not group.

Difficulties arise when evaluating the competencies of students who have taken courses that have different instructors. However, during the period of this study, a variety of instructors, both male and female with a range of ages (28–62) and rank including tenured Professors, tenure-track Assistant Professors, and instructors, taught both majors' and nonmajors' chemistry courses providing less bias on account of instructor. Over the evaluation period, the instructors used two textbooks, written by the same author differing only in conceptual depth (see the SI for further comparisons of course content including key topics and sample exam questions).

## RESULTS AND DISCUSSION

Retention data, grades in STEM courses, and analysis of student performance were assessed and compared for students who took the BioCURE course from Fall 2015 to Spring 2021 (all data is available via request from University of Idaho Institutional Research, see the SI). A variety of university metrics were surveyed including retention rates of students in biosciences, retention rates in other STEM majors, six year graduation rates in biosciences, in other STEM majors, and University overall retention and six year graduation rates. Additionally, a variety of factors that look at student success on the basis of earned collegiate grade point average (GPA) on a 4-point scale, specifically measuring collegiate GPA vs entering high school GPA. All data were evaluated using the SAS statistical software suite.<sup>17</sup>

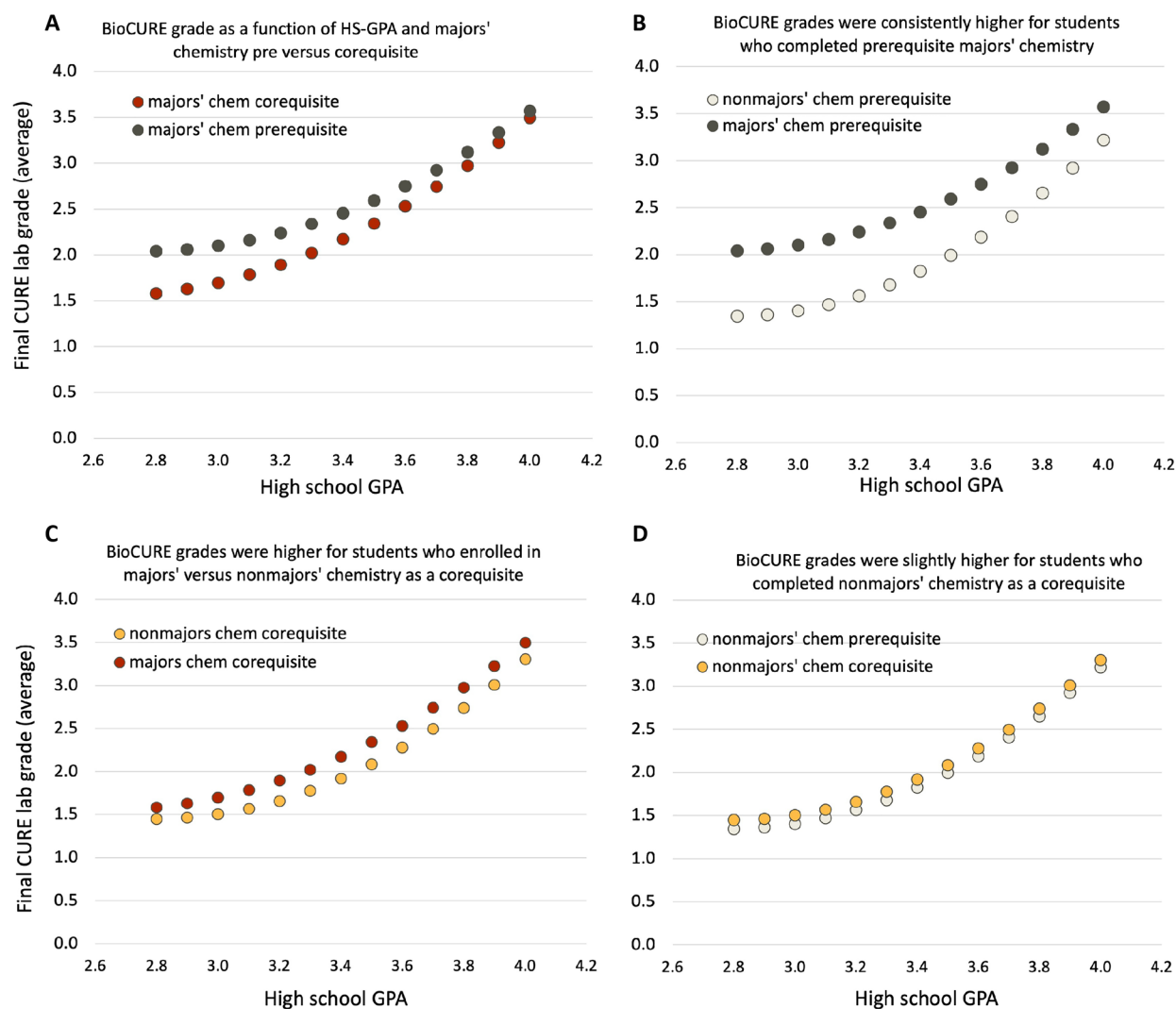
### Evaluation using Student Grades as Covariate

Initially, student success was evaluated through earned grades. Figure 1 shows the frequency distribution of the BioCURE course grades for students who successfully completed a first semester of majors' chemistry (ABC grade;  $N = 406$ ) prior to enrolling in the BioCURE course versus students who did not ( $N = 1056$ ). The category "Not" in Figure 1 refers to all students who took the BioCURE course but received a DFW in majors' chemistry or did not take majors' chemistry (many students in the "not" group took nonmajors' chemistry; only a small subset ( $N = 7$ ) had not taken chemistry in the six years prior to taking BioCURE). New first-year students who completed majors' chemistry with an ABC ( $N = 406$ ) were 2.6

times more likely to achieve an A in the BioCURE course than students who did not (Figure 1A). This trend was conserved for new transfer students (Figure 1B) and continuing students (Figure 1C) as transfer students and continuing undergraduates were 1.4 and 3 times, respectively, more likely to receive an A in the BioCURE course if they took majors' chemistry vs Not.

There are many variables that can complicate the comparison of new first-year, transfer, and continuing students. To "control for" the most likely identifiable source of variation, the student's prior academic achievement, the data was analyzed using covariance (ANCOVA) with high school grade point average (HS-GPA) as the covariate. Additional control variables, such as ACT and SAT math scores and the University's comprehensive math placement system recommendations were also examined, but these indices proved nonsignificant when added as covariates in multiple linear models. Figure 2 indicates that students benefitted more from majors' chemistry taken as a prerequisite (Figure 2A, gray circles) than as a corequisite (red circles). This was particularly significant for students with low HS-GPA, whose scores increased by up to 1.3 times. This trend was more dramatic when comparing BioCURE grades earned after students took majors versus nonmajors chemistry as shown in Figure 2B. BioCURE grades increased up to 1.5 times for students with HS-GPA between 2.8 and 3.5. Figure 2C shows that BioCURE grades were less affected and slightly lower for all students who took any chemistry as a corequisite. Finally, we found no significant grade advantage for students taking nonmajors' chemistry as a prerequisite or corequisite, when analyzed with the high school GPA as a covariate (Figure 2D).

A closer examination of students that took either majors' or nonmajors' chemistry as pre- or corequisite with the BioCURE course revealed that a grade of "A" (90th percentile) in majors' chemistry taken as a prerequisite rather than a corequisite more than doubled the odds of obtaining an "A" in the BioCURE course (Figure 3A versus B). As many students are motivated by grades, these data should be of interest. Students taking nonmajors' chemistry, either as pre- or corequisite, were much less likely to achieve an A grade in the BioCURE course (Figure 3C,D). When earned grades in the BioCURE course



**Figure 2.** Role of chemistry preparation in a BioCURE grade was normalized according to HS-GPA (enrollment minimum is 2.5 required). (A) Students, particularly those at-risk due to low GPA, benefited by taking the majors' chemistry as a prerequisite. (B) Majors' chemistry conferred a significant grade advantage compared with nonmajors' chemistry. (C) BioCURE grades were consistently higher for students that took majors' chemistry as a corequisite compared with nonmajors' chemistry. (D) Students that took nonmajors' chemistry as a corequisite had slightly higher grades in the BioCURE course than students who took nonmajors' chemistry as a prerequisite. Majors' prerequisite  $N = 217$ , majors' corequisite  $N = 102$ , nonmajors' prerequisite  $N = 160$ , nonmajors' corequisite  $N = 38$ .

were investigated as a function of earned grade in majors' vs nonmajors' chemistry, we found that over 60% of students who earned an A or B grade in majors' chemistry also earned an A or B grade in the BioCURE course. Again, it was found that the majors' chemistry prerequisite had a larger effect than the nonmajors' chemistry prerequisite.

#### Evaluation of Retention and Graduation Rates from BioCURE vs Traditional Biology Lab

Retention of students in the bioscience majors and at the University in general was monitored throughout the study. ANCOVA analyses of student performance in the largest, most homogeneous and consequential group (first-year students entering with high school GPAs of 2.50 or above, enrolled in the majors' or nonmajors' chemistry and BioCURE) produced significant results. Since implementation of the BioCURE course, retention of students majoring in biosciences increased by 7% (Table 1). Higher rates of persistence in bioscience degree plans coincided when students had success in majors' chemistry. Students who took the BioCURE course after

taking majors' chemistry as a prerequisite had a 52% higher chance of returning to STEM while those who took nonmajors' chemistry prior to the BioCURE course had a 45% higher chance of returning to STEM over students who took neither chemistry course. Students who took chemistry concurrently were at a 32% (majors') and 34% (nonmajors') higher chance of returning to STEM over students without either course as a prerequisite (data not shown). ANCOVA analysis declared that successful completion of majors' chemistry was a significant indicator over nonmajors' chemistry for both retention in biosciences and the University (see SAS data tables in the SI).

To determine how the choice of chemistry course influenced retention before and after implementation of the BioCURE course, the retention data (as percentage of students still enrolled at the University) was subdivided by majors' and nonmajors' chemistry options and the third year retention and six year graduation rates of cohort 1 (students who took the traditional Biology lab (pre-BioCURE Fall 2010 to Spring



**Figure 3.** Further evidence that majors' chemistry is the preferred pathway for academic success in a STEM course. (A) Forty percent of students ( $N = 219$ ) that received an A in prerequisite majors' chemistry passed BioCURE with a grade of A. (B) Students that took majors' chemistry as corequisite also fared well in BioCURE ( $N = 88$ ). (C and D) Students that took nonmajors' chemistry as a prerequisite (C;  $N = 169$ ) or corequisite (D,  $N = 39$ ), received lower grades in BioCURE than students who took majors' chemistry.

**Table 1. Retention of Students Majoring in Bioscience Degree Plans Increased after the BioCURE was Implemented<sup>a</sup>**

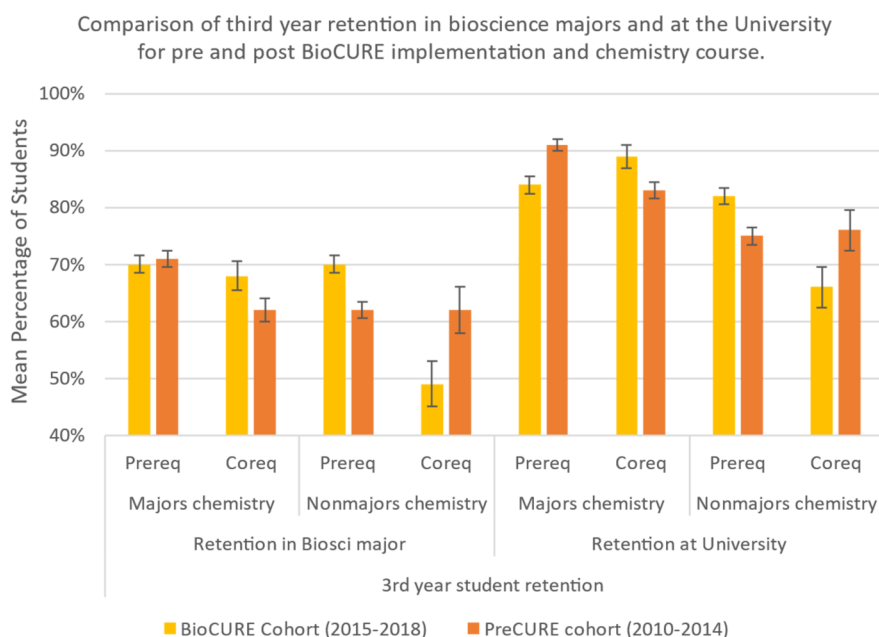
	retention (% remaining in year three)
type of biology course	biological sciences major
traditional biology	59% ( $N = 725$ )
BioCURE	66% ( $N = 617$ )

<sup>a</sup>Legend: Retention was determined for students who took the required freshman biology during their first two years at the University. The two cohorts are the traditional biology course group ( $N = 725$ , Fall 2010 to Spring 2015) and BioCURE ( $N = 617$ , Fall 2015 to Spring 2021). To ensure students in this study took the BioCURE lab on-campus, we excluded students who had Advanced Placement (AP) credit or transfer credit for Biology.

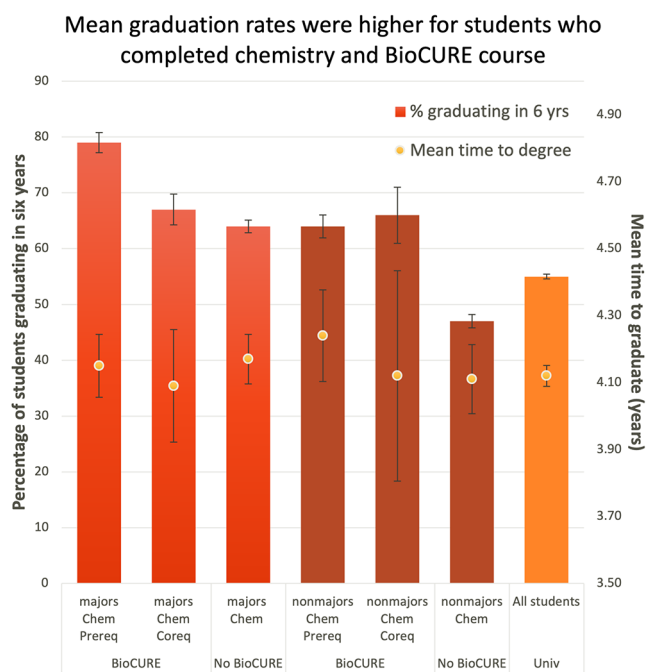
2015)) were compared to cohort 2 (students who took the BioCURE (Fall 2015 to Spring 2019)) and monitored through 2021. A direct comparison of third year retention rates of the two cohorts based on the chemistry course taken is shown in Figure 4. Students included in this comparison were all enrolled in a chemistry course as a first-year student with an entering high school GPA of 2.50 or better and no prior received credit in chemistry (via advanced placement or transfer credit). As shown, majors' chemistry, both pre and post BioCURE implementation, does not indicate an advantage to retention in the bioscience major or at the University based on chemistry course implementation. However, the BioCURE cohort data represents an average mean from a series of student groups over multiple three-year

periods with major drops in retention in years 2020 and 2021, which may be more of an effect of the COVID-19 pandemic, as when success is monitored for student groups who entered in 2017 and 2018, we see year by year retentions of 83% and 85% drop to 73% for the Fall 2017 student group and retentions of 90% and 81% drop to 71% for the Fall 2018 student group (see Figures S1 and S2 and contributing SAS Data tables in the SI). Regardless, majors' chemistry, both before and after the implementation of the BioCURE and independent of prerequisite or corequisite, had a greater overall impact on university retention.

To delimit the relative contributions of chemistry and the BioCURE course to university retention, mean graduation values were examined alongside the percentage of students graduating as a function of the type of chemistry course taken and whether a student took or did not take the BioCURE as to compare six year graduation (6YG) rates of these various student groups vs others at the university. As shown in Figure 5, almost 80% of the cadre of students who successfully completed prerequisite majors' chemistry and passed the BioCURE course graduated within six years. This was over 14% higher than the percentage of students graduating overall from the University (Figure 5, rightmost bar). The mean time to graduate was only slightly higher for the prerequisite majors' chemistry with BioCURE group compared with that of all University students (4.15 versus 4.12 years). Students with prerequisite majors' chemistry who took the BioCURE enjoyed a slightly lower mean time to graduate than students who took majors' chemistry without the BioCURE. Regardless



**Figure 4.** Direct comparison of third-year retentions based on chemistry course for pre and post CURE implementation. There is a significant increase in University retention for students who took majors' chemistry, as either pre- or corequisite with the BioCURE course. *N* values for all categories are (from left to right): BioCURE MC Pre = 171; Trad MC Pre = 286; BioCURE MC Co = 214; Trad MC Co = 234; BioCURE NMC Pre = 79; Trad NMC pre = 156, BioCURE NMC Co = 41, Trad NMC Co = 34; where MC = majors' chemistry and NMC = nonmajors' chemistry.



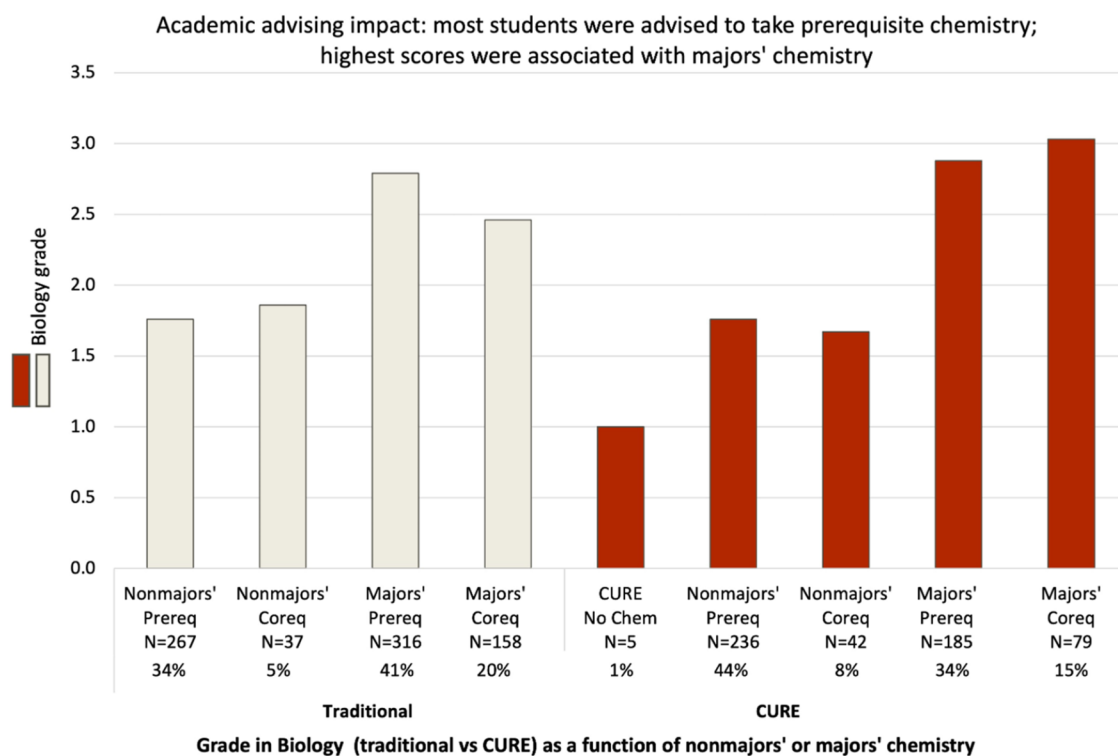
**Figure 5.** Mean graduation rates and mean time to degree for a variety of student groups who either took or did not take the BioCURE course. Those who passed the BioCURE were further dissected for when and which chemistry course was passed ( $N = 1559$  Biosciences students of 7621 total students who entered from 2010 to 2015, tracked through 2020–2021).

of the type of chemistry course taken (nonmajors' vs majors', pre- or coreq), a higher percentage (>60%) of all four cohorts of students who took the BioCURE course graduated within the six year time frame compared to ALL university students (55%). The mean time to graduate was also consistent with the

University average. Control data for students who did not take the BioCURE course but took either nonmajors' or majors' chemistry, essentially nonbiosciences majors, showed that success in majors' chemistry had a higher 6YG rate but also a longer expected time to graduate over those that completed nonmajors' chemistry (Figure 5, No BioCURE bars). Mean entering high school GPAs were also investigated as a function of graduation rate and were consistent with both the students in the majors' chemistry as prerequisite cohort and University-wide students who took majors' chemistry without the BioCURE (data not shown).

When monitoring 6YG rates of students (since 2015) who had success in majors' or nonmajors' chemistry, to determine if a correlation with students opting away from bioscience majors, it was found that those who initially enrolled and graduated as bioscience majors had a similar 6YG rate as those who began as bioscience majors but graduated as non-bioscience majors (62% and 64%, respectively). When broken out to the prerequisite majors' chemistry, the 6YG rate is 84% and 89% while prerequisite nonmajors' chemistry lowers to 72% and 71% for initial biosciences majors who graduated in a different degree plan.

Advising plays a key role in the pathway a student takes during her/his academic period. The advisor, typically, must approve the type and timing of the chemistry course. Given solid data, advisors must be cognizant that rigorous courses may best serve all students, particularly if departments provide support resources (supplemental instruction, tutors, etc.). Figure 6 highlights that majors' chemistry taken prior to biology gives the highest levels of Biology success, especially when normalized to the number of students in each cohort. During the traditional period (cohort 1), biosciences students ( $N = 778$ ) were 1.6 times more likely to take majors' chemistry versus nonmajors' chemistry. Within this group, students taking majors' chemistry ( $N = 542$ ) were twice as likely to take



**Figure 6.** Impact of initial chemistry course chosen on BioCURE GPA. Advisors encourage students to complete chemistry before taking the biology lab, and over 75% of students took prerequisite chemistry ( $N = 1004$ ). However, during the BioCURE period, there was an increasing shift toward nonmajors' prerequisite chemistry over majors' chemistry.

chemistry prior to, as opposed to alongside, their biology course. Students taking nonmajors' chemistry were over seven times more likely to take the course prior to biology. During the BioCURE period, the ratio of students ( $N = 264$ ) in majors versus nonmajors chemistry ( $N = 278$ ) dropped to  $\sim 1.0$ ; hence, 50% of the BioCURE class had not taken majors' chemistry. Prerequisite chemistry was still favored: 5.6 times for nonmajors' chemistry ( $N = 278$ ) and 2.3 times for majors' chemistry ( $N = 264$ ). Despite this shift away from the more rigorous majors' chemistry course, statistically significant differences in BioCURE course grades were found favoring students who passed majors' chemistry versus nonmajors' chemistry with an average grade point lowering of 0.57 points (see ANCOVA and SAS data tables in the SI).

## CONCLUSION

Early success in general STEM disciplines is critical for building student confidence<sup>18</sup> (identifying as a scientist) as well as providing a solid foundation for expected learning in future STEM subject areas. Early STEM courses that combine career applications (i.e., research) have been shown to influence retention and persistence in STEM degrees. Most university science departments encourage upper division students to participate in faculty-mentored research projects, and these opportunities have lubricated the pipeline to graduate school. The development of CUREs has expanded this educational benefit to a greater number of students and CUREs in entry level courses give beginning science students a more realistic experience where careful planning is critical, and outcomes are unknown.

This study found that enrollment in chemistry courses (majors' vs nonmajors') either before or concurrently with a redesigned BioCURE lab course affected a students' BioCURE

grade, their biosciences retention, and the six year graduation rate. The study also discovered when to place chemistry to best aid success in a BioCURE lab course using student performance and retention as the metric. Success (an ABC grade) in majors' chemistry provided the best preparation for students in the BioCURE course. Students benefitted most when they took majors' chemistry at least one semester before taking the BioCURE lab course. There is a simple explanation for this finding: as soon as a student enters a CURE lab, s/he must begin to plan and execute a research project. Some of the instruction needed to proceed with the CURE project is taught toward the end of the first term in a chemistry course (i.e., solution stoichiometry, preparing solutions). That, combined with having already successfully completed a rigorous STEM course, boosts student confidence in their abilities for the CURE course. Students taking chemistry concurrent with a CURE will not have critical knowledge or confidence needed to begin their project. Without the proper foundation, such students will be at risk of failure; discouraged students leave the programs.

Success in any chemistry, either majors' or nonmajors', prior to the BioCURE, increased retention in bioscience degree plans and university 6 year graduation rates in both biosciences and overall STEM. These results are not surprising because large scale studies at other institutions have shown that CURE courses challenge and engage students.<sup>19–21</sup> Moreover, the data indicated that students that entered the university at an academic disadvantage, as measured by a lower ( $<3.0$ ) high school GPA, increased their BioCURE lab GPAs at a higher rate if they had prior success in majors' chemistry over nonmajors chemistry (as seen in Figure 2). This hints that students who currently take nonmajors' chemistry as their segue to first year Biology might be better off in majors'

chemistry. Our data suggest that lower (2.5–3.0) GPA students would benefit from direct placement in majors' chemistry. Resources currently spent on offering a nonmajors' chemistry might be better invested in a single chemistry course with added implements to help students succeed (i.e., small peer-mentoring groups, supplemental instruction, etc.).

The BRAINS program and its integrated student networks provided a platform to connect the importance and connections of topics from a variety of STEM science disciplines. Methods to increase STEM success are valuable to raise the number of successful STEM graduates. From this study, it was found that future STEM grades, retention, and 6 year graduation rates success can be increased with enhanced efforts in promoting early chemistry success.

## ■ ASSOCIATED CONTENT

### SI Supporting Information

The Supporting Information is available at <https://pubs.acs.org/doi/10.1021/acs.jchemed.1c00997>.

BioCURE and primer description, comparison of chemistry course content, student retention data tables and ANCOVA statistics (PDF, DOCX)

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### Notes

The authors declare no competing financial interest.

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