DEPARTMENT OF CHEMISTRY

PROGRAM REVIEW

2015-2020

Programs and Self Study

B.S. Chemistry ACS Certified

B.S. Biochemistry

B.A. Chemistry

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TABLE OF CONTENTS

Program Context and Curriculum

The coherence and quality of the curriculum

The Discipline of Chemistry

Chemistry is a broad area of physical science that is concerned with matter and how it changes. The field of chemistry has traditionally been broken down into 5 sub-disciplines (physical, analytical, biological, organic, inorganic) that have blurred borders, and it is very common for a chemist to be trained as a hybrid between two or more of these sub-disciplines. Cutting edge research in the field does not let a chemist confine him or herself to one area and the discipline now encompasses environmental, materials/nanotechnology, medical/pharmaceutical, and engineering. There are endless applications of chemical research, in addition to the importance of fundamental research and knowledge of the chemical sciences. Since chemistry is a broad discipline it crosses over with other sciences, such as biology and physics. The main defining factor of chemistry is the study of molecules and molecular processes.

A recent trend in chemistry has been to apply knowledge of chemistry to study biological processes, create nano-scale materials, solve equity and achievement gaps in learning chemistry and solve environmental problems. In order to work in such applications a person needs a firm foundation in the basic chemical principles, and that is one area that we strive for as an undergraduate institution.

The Chemistry Department is also part of a larger community of chemists and we follow guidelines of the American Chemical Society for certification of our program. These include specific curriculum coverage, hours of contact between students and faculty and disciplinary expertise in subareas. Also included in the ACS certification of our programs is the dedication of the university to provide tenure and tenure-track faculty in the teaching of laboratory and lecture courses.

The Chemistry Department also has safety responsibilities that are prescribed by the EH&S department on campus.

Context and goals of the program

Mission Statement

The mission of the department of chemistry at Sonoma State University is to create a scholarly learning environment for students, faculty, and staff that leads to the graduation of undergraduate students that are active and life-long learners in the field of chemistry. We encourage and support members of our community to become independent thinkers that are competitive in the field and understand chemistry as a foundation science. We work to achieve these goals and advance the understanding of chemistry through an integrated experience of education and research that fosters collaboration and teamwork. The department's approach to problem solving, critical thinking and the use of analytical and deductive reasoning skills produces students who are creative problem solvers, skilled scientists and productive members of society.

Brief overview of the program and relevant history

The Chemistry Department at SSU was established when Sonoma State College started and the founding members represented most of the sub-disciplines. In the early 70's the department had 3 organic chemists, 2 biochemists, 1 analytical chemist, 1physical chemist and 1 inorganic chemist. In 1984 there was a joint hire with the School of Education for a second physical chemist that would serve the role as an educational chemistry professor. This would comprise the department until 2001 when a Tenure Track faculty member would be hired to replace the retiring inorganic professor. During the next 5 years all of the founding members of the department retired and 4 additional faculty were hired including two different Chairs. Since this time the Chemistry Department has gone through about three Program Revisions, two Program Reviews and has developed a robust inclusive curriculum and policies and procedures. The department currently has 6 TT faculty members, 1 FERPed faculty and 2 long-term adjuncts that are on 3-year contracts.

Since the last program review the chemistry department has experienced significant trauma and large amounts of healing in order to serve students effectively and mentor faculty. This has also created strain on the staff in the department. The Chair of the Department requested help from the Dean of SST and Marty Fankel was assigned to work with the department on mitigating the trauma and resolving conflicts. This work was started, but not comprehensive and never completed. Many of the members of the department do not communicate and/or have trust. The administration had promised the department that all members would participate in facilitated conflict resolutions but this did not happen. This process continued to deteriorate the trust and communication in the department and it is now a dysfunctional work environment and many of the faculty are scared to go to work, express their opinions or participate in department business. Trust and communication are core to the success of any program and allows the faculty to develop curricula, write grant proposals and discuss student needs. Faculty are greatly impacted by these events and this makes it difficult for them to continue to represent students that are struggling with feeling supported by the administration at SSU.

Department Goals:

Goal 1: deliver a modern curriculum in both content and pedagogy that extends beyond the standard classroom experience
Goal 2: provide realistic, cutting-edge, and quality year-round research training
Goal 3: help students prepare for their future in a manner that will allow them to be successful
Goal 4: nurture students and mentor them through individualized and honest guidance for their scholarly development
Goal 5: engage in meaningful conversation about and provide support for professional development of faculty and staff
Goal 6: have a high quality department in terms of students, faculty, staff, available resources, and modern facilities and instrumentation
Goal 7: work collaboratively, work as a team, and maintain close working relationships within our chemical community and the community at large

Program Learning Outcomes for All Three Chemistry Programs (BS Biochemistry, BS Chemistry and BA Chemistry):

1. Read and interpret chemical literature and communicate science effectively in both oral and written formats
2. Understand properties and reactivity of atoms and molecules.
3. Proficient at experimental design with documentation and generation of useful data. Including the proficiency of data manipulation, interpretation and the forming of conclusions based on data.
4. Use chemicals, standard glassware, and instrumentation safely and effectively.
5. Work towards ethical behavior and developing awareness of bias in experimental expectations and social interactions.

Additional Program Learning Outcomes for BS Chemistry

1. Apply a deep mathematical foundation for application to chemical problems.
2. Implement experiments for a novel research problem and demonstrate scientific independence.

Additional Program Learning Outcomes for BS Biochemistry

1. Implement experiments for a novel research problem and demonstrate scientific independence.
2. Describe and apply the relationship between structure and function for biological molecules and how these relationships dictate chemical reactivities in metabolism and life.

As shown above, several of our Program Learning Outcomes align with one or more of the WASC core competencies of written and oral communication, quantitative reasoning, critical thinking, and information literacy. In addition, the WASC core competencies are aligned with the "Golden Four" GE skills outlined by the Chancellor's Office.

In order to ensure that there is alignment between individual courses, the sequence of the courses in our majors and the PLOs the faculty in the chemistry department attempt to engage in meaningful interactions. First, we share courses and curriculum. This is done by team teaching. For example, general chemistry can have 1-6 instructors with varying degrees of responsibility. Also, there might be two general chemistry sections that overlap and instructors will share teaching ideas and curriculum. The department has a shared lab curriculum for all of our classes that have lab. All of the tenured/tenured track faculty have a shared responsibility for the capstone courses and have taught these courses. This helps align faculty expectations, PLOs and curriculum sequences (See Program Learning Outcomes in Classes). The department uses shared drives and shared Canvas course shells to coordinate the curriculum and our Stockroom Technician and AC help with lab manuals and textbook assignments.

Curriculum

Degree offerings:

BS: Chemistry ACS Certificated
BS: Biochemistry ACS Certificated
BA: Chemistry
Minor: Chemistry

The core curriculum of the majors

1. General Chemistry I and II (CHEM 115AB) serve as the foundation of the major and if students are not prepared mathematically for these courses we recommend they complete a semester of Introduction to Chemistry (CHEM 110). These courses cover a very broad range of topics and CHEM 115AB has a lab and discussion component so that all students have activity based learning through hands-on manipulation.

2. Organic Chemistry is a course that expands the basic knowledge learned in general chemistry about molecular structure and expands that to the study of organic molecules. Our department offers two semesters of organic chemistry lecture (CHEM 335AB) and organic chemistry lab (CHEM 336AB) as a separate course.
3. Quantitative Analysis(CHEM 255) is a course which focuses on analytical skills for all chemistry majors and is focused on developing analytical skills in the laboratory.
4. Physical Chemistry is a course that expands the basic knowledge learned in general chemistry about thermodynamics (CHEM 310A) and quantum mechanics (CHEM 310B).
5. Inorganic Chemistry(CHEM 325) course merges many of the concepts and ideas learned from the student's previous chemistry courses. The course looks at the bonding and spectroscopy of both small molecules and transition metal compounds. The course examines the reactions and reaction mechanisms of inorganic, organometallic and bioinorganic molecules. Lastly, the students study the applications of this field by reading the current literature.
6. Biochemistry is a yearlong course. The first semester lecture course examines the structure and function of biological molecules (CHEM 445), and the second semester focuses on metabolism (CHEM 446).
7. CHEM 401 is taken during students' last fall semester. This class provides hands-on experience with experiment planning, chemical synthesis and instrumentation, analysis of chemical samples, data acquisition and analysis and written and oral communication of scientific data. Students will be provided with the opportunity to independently plan and execute experiments. Students are expected to independently research and fill in any knowledge gaps, especially in the areas of physical and biochemistry.
8. Our senior capstone lab classes (CHEM 402 and CHEM 441) are taken during students' last spring semester. In these courses, students complete a semester-long research project involving the synthesis, purification, and characterization of organic or inorganic molecules (CHEM 402 for BS CHEM) or of an enzyme (CHEM 441 for BS BIOCHEM). Students are expected to use scientific literature as a guide to develop their own experimental methods. This provides students with training not only in modern techniques and instrumentation, but also in the analytical skills involved in experimental design and troubleshooting. Students also gain experience in presenting scientific data and conclusions by presenting their projects to the class orally during group meetings throughout the semester, to the department in the form of a poster presentation at the end of the semester, and in a journal-style manuscript. Overall, this course provides students with 'real-world' training, similar to what they will see in industrial and academic research labs outside of a classroom setting.

Core Class for all Degree Paths	Course and Number
General Chemistry I and II	CHEM 115AB
Analytical Chemistry	CHEM 255
Organic Chemistry I and II	CHEM 335AB
Organic Chemistry Lab I	CHEM 336
Physical Chemistry I and II	CHEM 310AB
Inorganic Chemistry I	CHEM 325
Instrumental Analysis	CHEM 475
Advanced Lab I	CHEM 401
Support Courses for all Degree Paths	
Calculus I and II	MATH 161 AND 211
Physics I and II with Lab	PHYS 210AB/209AB OR PHYS 114/116 AND 214/216
Additional Coursework for BS CHEM	
Organic Chemistry Lab II	CHEM 336B
Research methods - one year	CHEM 315/316
Biochemistry - one semester	CHEM 445 OR 446
Advanced Lab II	CHEM 402
Electives in the major - 2 course	CHEM 496 OR APPROVED COURSES
Additional Support for BS CHEM	
Calculus IV - Multivariable	MATH 261
Physics with Calculus	PHYS 114/116 AND 214/216
Additional Courses for BS BioCHEM	
Research methods- one year	CHEM 315/316
Biochemistry I and II	CHEM 445 AND 446
Biochemistry Lab	CHEM 441

LD Cell and Molecular Biology	BIO 130
UD Cell Bio and Lab	BIO 321 AND 325
Elective in either Chemistry or Biology	CHEM 496 OR SELECTED BIO

The Minor

The Chemistry Minor was created to allow students who have taken a substantial amount of chemistry to highlight their effects. The curriculum for a minor in chemistry is shown in **Appendix E**. The vast majority of students that apply for chemistry minor are biology majors, because quantitative analysis is the only additional coursework that is required in their supporting coursework.

Program-Specific Pedagogical Methods

As can be seen from the chemistry's mission statement, department goals, and program learning outcomes, the faculty of the chemistry department work to develop students into life-long learners that critically evaluate information that they encounter through their own research efforts or from social media platforms . Whether that information pertains to science or the latest political issues, the chemistry department works to train students to ask questions, seek data to support conclusions, critically evaluate sources, and disseminate their findings with purpose and intention. This training begins during their first semester with the chemistry department and continues until graduation. For example, as a first year chemistry major, students take CHEM 120A, Thinking Like A Scientist. In this course, students explore issues they may have encountered anecdotally and start to look at the data and practice developing evidence-based conclusions. The semester culminates in a group presentation where they either negate or support a claim using evidence from primary literature. This same type of work is continued in CHEM 120B, culminating in a service learning project where students create an output for a community partner in which they have to disseminate information from primary sources to a broader audience. In this service learning project students are paired with students in the upper division Chemistry Elective course to learn and consult on the more advanced topics. There are also weekly opportunities for more informal discussions to allow students to process content and articulate it in their own words. In both lower and upper division courses we expect students to present their findings and experiences at the campus-wide research symposium. This exposes our students to how scientists disseminate information.

As students move through their chemistry curriculum, the aspects of consulting and evaluating the primary literature, applying foundational chemistry principles, safely working in lab, designing experiments based on a research question, and practicing working ethically while aware of our own biases are woven throughout. Computers and technology play a large role in student success in STEM, therefore our students are exposed to Computational Chemistry every year as well. In a typical curriculum, students only use Computational Chemistry in their third year. Students have reported that this approach has been beneficial to them, as they learn to treat computers as a tool to solve problems in all of their chemistry classes.

Students get hands-on experience in the majority of the Chemistry Department's classes. Some engaging activities we use are gallery walks, think pair shares, fishbowl discussions, and small group work. These active learning techniques are used by a number of our faculty to increase student engagement. In CHEM 255, CHEM 401, CHEM 402 and CHEM 441 students are trained on and work closely with scientific instrumentation, which gives them hands-on experience with the research tools they will use after they graduate. In CHEM 315, our BS students are introduced to the research projects carried out by faculty in the Chemistry Department. They are then matched with a faculty member, who serves as their research mentor. This provides students with the privilege of working on a relevant research project and provides an equitable opportunity to access research. This opportunity highlights our belief that hands-on research can play a pivotal role in the trajectory of a student. This experience continues as students progress towards graduation.

Research

An especially important aspect of any undergraduate chemistry curriculum is the opportunity to engage in a research project under the mentorship of a faculty member. In today's world, students intending to pursue post-baccalaureate training in PhD graduate programs, Medical School, Pharmacy School, etc. are not competitive and require an undergraduate research experience. Moreover, it is evident that research experiences at the undergraduate level (as well as in High School) are an important aspect of encouraging talented students to pursue advanced degrees and careers in chemistry, increase a sense of belonging in STEM and is considered a high impact practice. Research experiences teach students critical thinking and educates them with regards to the "scientific process and method", allowing them the opportunity to see for themselves how science is created and how it evolves and is considered a high impact practice. Evidence for the importance of research in an undergraduate chemistry curriculum and its impact on student outcomes was previously mostly anecdotal. However, a study performed by SRI for the National Science Foundation (NSF) involving over 15,000 survey respondents unambiguously confirms this (1,2). This report found that undergraduate research opportunities (UROs) significantly enhanced understanding, confidence and awareness as well as clarified interests in STEM careers. Indeed, 68% of students in UROs were found to have a significantly increased interest in STEM careers and twice as likely to pursue a PhD. Thus, it is clear that the inclusion of UROs is essential to any chemistry curriculum and the conclusion of this study was that greater attention should be given to UROs at all levels of education. Another article indicates that the demand for talented researchers is outpacing the supply and that there is an ongoing problem of attracting talented students to all areas of science, especially chemistry and physics (3). Indeed, these trends and the expectation that UROs represent part of the solution to this problem prompted the NSF in 2001 to encourage and emphasize undergraduate research in the granting process. This increased emphasis on undergraduate research by the NSF acknowledges the importance of undergraduate research, something other countries are beginning to realize as well (3).

The importance of providing research opportunities for the students is clear. However, it is also worth noting that research has benefits to the research mentors as well. The opportunity for critical thinking, to remain current with the scientific literature and to discuss cutting-edge science is of paramount importance to their development as instructors and scholars. Many things learned and discovered through research endeavors find their way into the curriculum and lectures. Thus, research offers an important avenue for Professors to evolve with their disciplines, increasing their ability to stay current with their teaching and increasing their scholarship.

The advantages of achieving gender, ethnic and cultural diversity in chemistry (and other STEM disciplines) are clear, as yet unrealized (for example, 4) and a core value for SSU. Since the utility of UROs in the recruitment and retention of students in these disciplines is clear (see above), the importance of research in achieving diversity addresses our core values as an institution. Coupled with outreach programs and institutional partnerships, the existence of research opportunities for under-represented populations is fundamental to the goal of achieving diversity as students will undoubtedly be more apt to develop an interest in chemistry and pursue further training, ultimately leading to a career. Thus, there is little doubt that research is an extremely fundamental and important part of a chemistry curriculum, with hugely positive effects on numerous aspects of student training, faculty development and other institutional goals.

1. Russell SH, Hancock MP, McCullough J (2006) *Evaluation of NSF Support for Undergraduate Research Opportunities*. Arlington, VA, USA: National Science Foundation.
2. Russell SH, Hancock MP, McCullough J (2007) THE PIPELINE: benefits of undergraduate research experiences. *Science* **316:** 548–549.
3. Hunter, P. (2007) *EMBO Reports*, 8(8), 717-719.
4. *A Report from the Undergraduate Research Summit,* Bates College, Lewiston, ME, August 2–4, 2003 (http://www.bates.edu/x50817.xml).

Relationship Between Our Program and Other Programs (including GE)

The School of Science and Technology at Sonoma State comprises nine departments. The Chemistry Department teaches service courses for Biology (CHEM 115A/B, 335A/B, 445, 446), Geology (CHEM 115 A/B), Nursing (CHEM 105), Physics (CHEM 115A/B), and Kinesiology (CHEM 105, 115A/B) as well as several pre-health courses for students attempting to meet prerequisites to apply to a pre-health school.

The Chemistry Department's General Education courses include: CHEM 120A/B, CHEM 102, 105, 110, 115A, 125 A/B (during this review, but no longer a part of the GE curriculum), and 401 which is now an upper division area B met-in-major course. The department is also in progress of offering UD electives in area B (Scientific Inquiry and Quantitative Reasoning). All of these courses, except CHEM 120A/B and the UD area B elective courses, are for the general population of students and CHEM 110 meets the CSU's graduation requirement of completing a laboratory course. The recent changes to GE courses required that the Chemistry Department review its GE courses and make appropriate changes to ensure the courses still counted for GE units. There is now an upper division area in scientific inquiry and quantitative reasoning, CHEM 401 satisfies this requirement.

The Chemistry Department also relies on service courses from other departments and many of these are GE classes. Our BS Biochemistry majors must take courses through the Biology Department (BIOL 130, 321, and 325). All of our majors are required to take Physics courses (PHYS 209A/B, 210A/B, or 114, 116, 214, 216). All our majors are also required to take Math courses as well (MATH 161 and 211, our BS Chemistry majors must also take MATH 261 as well.)

Course enrollment

As shown in **Figure 1 & 2** the enrollment in GE courses from Chemistry has remained relatively constant over the last five years. Note that the numbers for 2014 and 2020 are low because they only include one semester, whereas the data for 2015 -2019 are for the academic year.

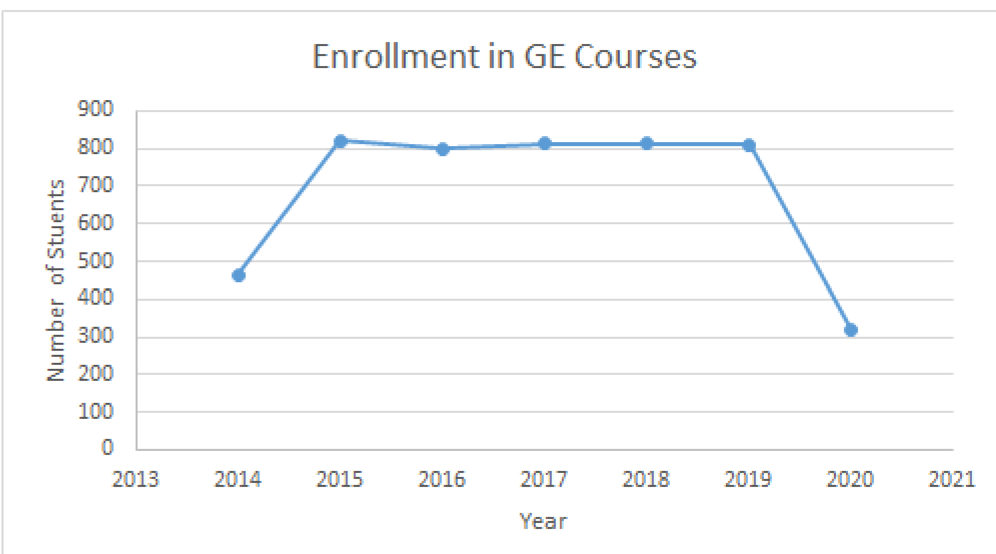

Figure 1: Enrollment in GE Courses by Year. Note: 2014 data only contains Fall semester; 2020 data only contains Spring semester

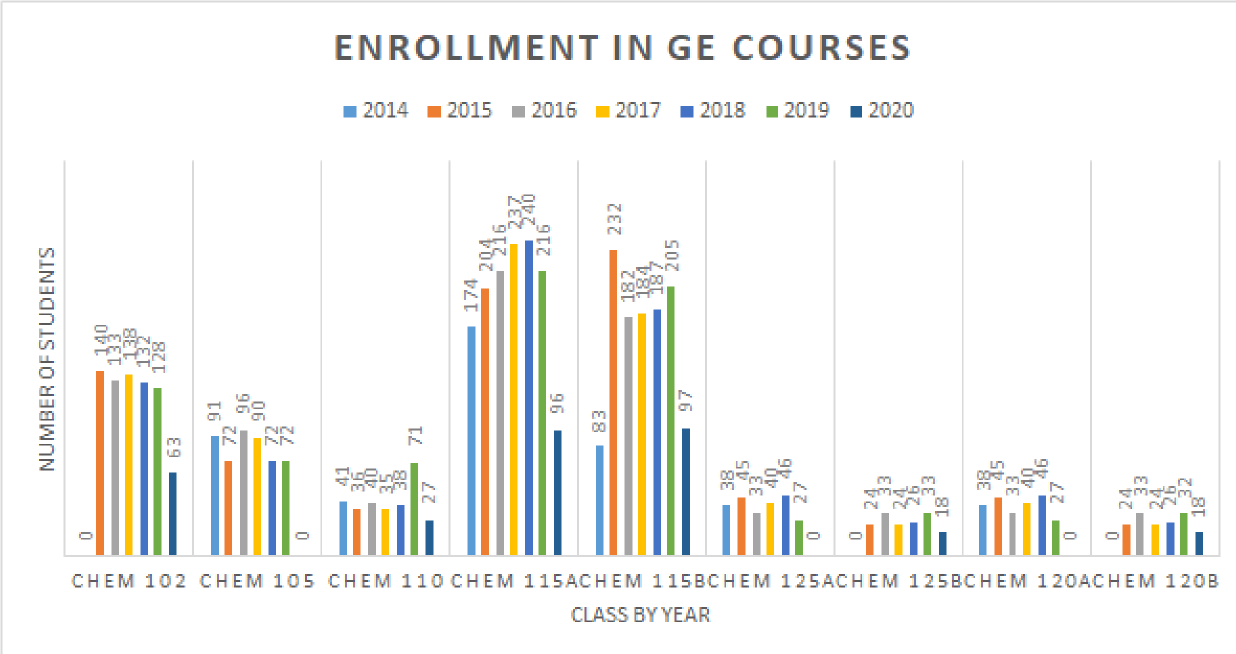

Figure 2: Enrollment in GE Courses Broken Down by Course. Note: 2014 data only contains Fall semester; 2020 data only contains Spring semester

Likewise, the enrollment in lower and upper division majors courses have remained consistent (**Figure 3**).

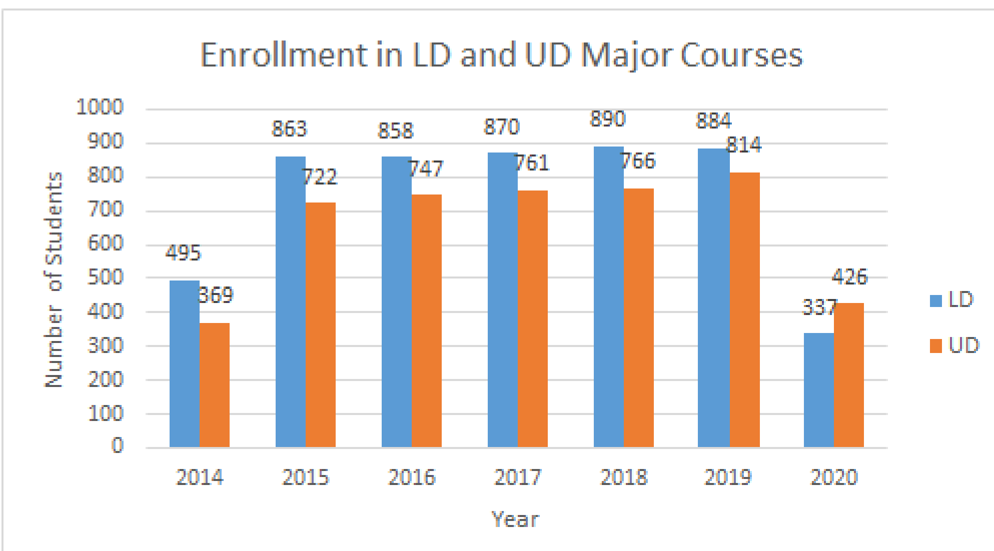

Figure 3: Enrollment in LD and UD Major Courses Note: 2014 data only contains Fall semester; 2020 data only contains Spring semester

A closer inspection of upper division courses showed that organic chemistry lectures (335A & B) have remained fairly constant over the last five years (**Figure 4**).

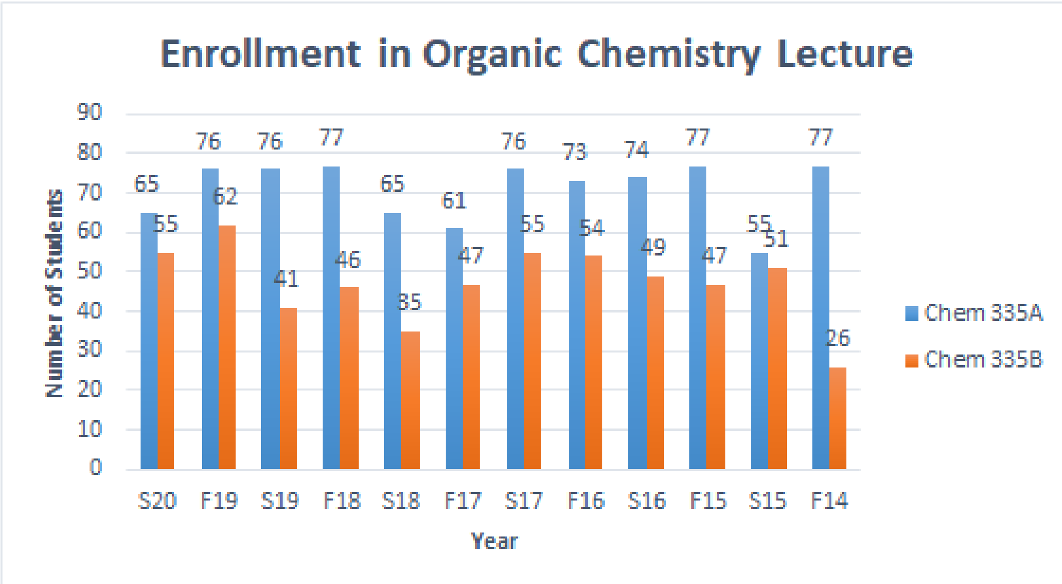

Figure 4: Enrollment in Organic Chemistry Lecture Note:2014 data only contains Fall semester; 2020 data only contains Spring semester

When looking at the corresponding organic chemistry labs Chem 336B shows a fairly steady enrollment over the last five years and about a third of students continue to the second semester of lab (**Figure 5**).

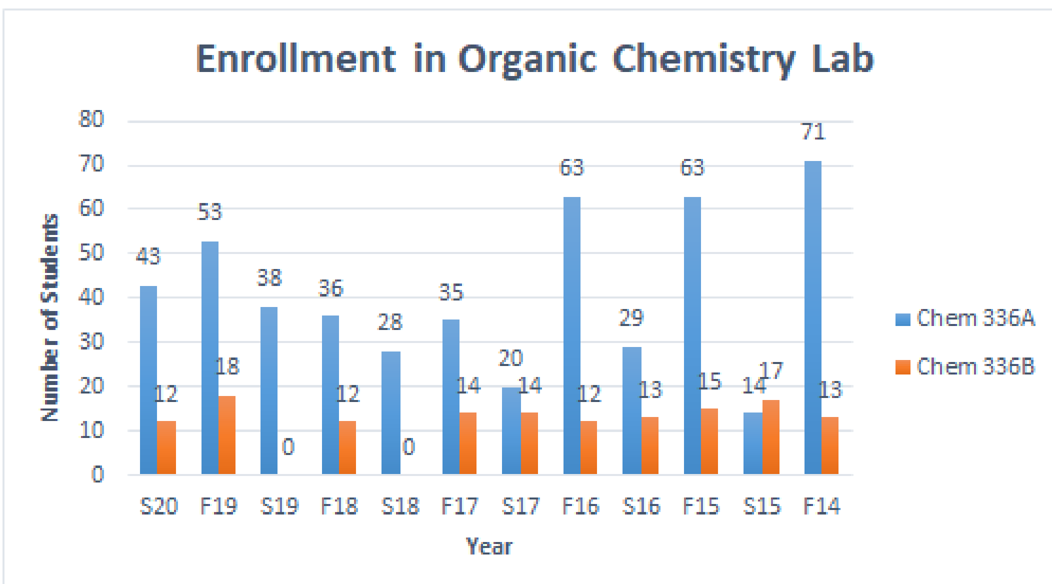

Figure 5: Enrollment in Organic Chemistry Lab; Note: 2014 data only contains Fall semester; 2020 data only contains Spring semester

Figure 6 belows shows the Department's FTES over the last 5 years and there has been little change or growth.

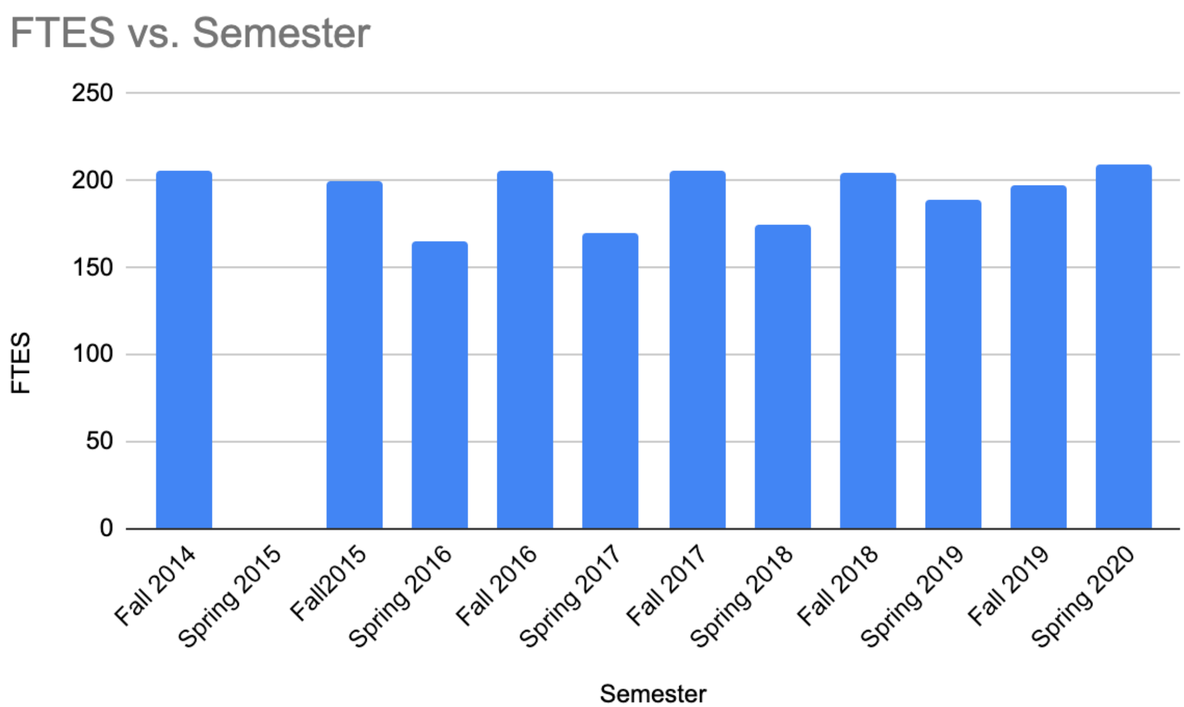

Figure 6. FTES for all Chemistry courses each semester over the last five years. Missing spring 2015 data.

The role of the program in the mission of the university

Sonoma State University has recently updated its mission statement to reach a new vision by 2025. The Chemistry Department contributes to the mission of the university by offering high quality education programs and creating learning (curricular and co-curricular) opportunities that support our core values and priorities.

Mission of SSU for 2025

Sonoma State is a regionally serving public university committed to educational access and excellence. Guided by our core values and driven by a commitment to the liberal arts and sciences, Sonoma State delivers high-quality education through innovative programs that leverage the economic, cultural, and natural resources of the North Bay.

Sonoma State University's Vision

Sonoma State University embraces innovation in our quest to be a national model for public higher education by 2025. Our students graduate prepared to meet the challenges of the 21st century and to make an impact in the community and the world.

Strategic Plan 2025 and How the Chemistry Department Supports this Plan

Our core values are an expression of who we are at Sonoma State. SSU proudly embraces integrity, respect, excellence, and responsibility as part of the Seawolf Commitment. These core values are integrated into each of the priorities of the strategic plan:

1. Diversity and social justice
2. Sustainability and environmental inquiry
3. Connectivity and community engagement
4. Adaptability and responsiveness

Sonoma State's Strategic Plan 2025 has four priorities. Listed in the table below are the Chemistry Department's goals and their alignment with the priorities in the Strategic Plan. The table articulates how we have accomplished those goals over the last five years, framed in terms of our priorities and our core values as an institution.

Priority 1: Student Success	
Goal 1: deliver a modern curriculum in both content and pedagogy that extends beyond the standard classroom experience	● Professional development opportunities to engage in pedagogical reflections ● Service learning opportunities in both the FLC and UD elective. These efforts support our commitment to the core value connectivity and community engagement ● Research opportunities in class and extra curricular ● Upper Division GE- CHEM 300: Chemistry in Sustainability ● CHEM 301- Sexism, Racism, and Bias in Science and Medicine
Goal 3: help students prepare for their future in a manner that will allow them to be successful	● Incorporate advising and developing a four year plan into our first year learning cohort ● Work with SST's advisors to reach out to students who have not registered for classes that keep them on their path towards graduation ● Faculty participate in Seawolf Decision Day ● Chemistry Department sends a welcome email to all students that have been accepted to the program; during the pandemic faculty called all of these students

Goal 2: provide realistic, cutting-edge, and quality year-round research training	● Every faculty member holds office hours ● In the first year cohort, students learn about campus resources ● Faculty use a variety of teaching techniques and approaches ● CHEM 315/316 (Research Methods Classes) ● Faculty participate in the Summer High School Internship Program (SHIP)
Goal 4. nurture students and mentor them through individualized and honest guidance for their scholarly development	● Chemistry Department sends a welcome email to all students that have been accepted to the program; during the pandemic faculty called all of these students

Priority 2: **Academic Excellence and Innovation**	
Department Goals	Contributions by Chemistry Dept
Goal 2: provide realistic, cutting-edge, and quality year-round research training	● Using several courses, the Department has incorporated sustainability and environmental issues into the curriculum: CHEM 102, CHEM 300, CHEM 496 (Atmospheric Chemistry). Embedded in these courses are discussions of sustainability and environmental awareness. ● CHEM 120A and B are courses that , when possible, connect to the community using "Service Learning" projects. For example, past efforts include the development of pamphlets regarding drugs of abuse for the Student Health Center and information for local Health Providers regarding vaccinations and diseases. ● CHEM 315/316 provides hands-on research training for a future career in Chemistry. These courses discuss research ethics, diversity and train students on the flexibility and adaptability required to perform research. ● CHEM 494 provides motivated students the opportunity to continue performing independent research projects. Many of these projects result in publication and/or presentation at regional and national meetings. This experience motivates many students to continue in higher education and allows them to compete at the next level. Numerous projects in the department involve the examination of environmental issues (e.g., air quality, water quality), methods for disseminating scientific information to the community (e.g, development of presentations to pre-college students), and methods to attract younger students to science. Since these activities are periodically presented to the entire department (as

	part of CHEM 315/316), the entire population of faculty and students become exposed to this work and focus. ● CHEM 497 is a departmental seminar program that provides students access to world-renowned chemists/biochemists who present their work to the department and meet with students. This course also allows students to present their work to the Department, allowing them experience in communicating and discussing cutting-edge science. This activity also allows the Department and students to remain up-to-date with respect to the latest methods, ideas and trends in science allowing the department to adapt and respond to current and topical subjects.
Goal 1: deliver a modern curriculum in both content and pedagogy that extends beyond the standard classroom experience	● Faculty have participated in professional development that allows them to explore the current data on how students learn and have incorporated that into their classes ● Faculty have developed active learning exercises to give students a tactile way to interact with the course content. These exercises are shared with the department.

Priority 3: Leadership Cultivation	
Department Goal	Accomplishments by Chemistry Dept
Goal 5: engage in meaningful conversation about and provide support for professional development of faculty and staff	● Faculty and staff are continually informed about and encouraged to attend professional development opportunities. Several faculty members have taught or hosted professional development workshops, such as a faculty learning program titled "Transforming Stem Teaching," support for the transition to virtual, and others.
Goal 7: work collaboratively, work as a team, and maintain close working relationships within our chemical community and the community at large	● Chemistry faculty work as a team with regards to self governance and research. Important decisions are made by vote and departmental policies and documents are developed collaboratively. Chemistry faculty also attend a day-long summer retreat before the start of the academic year. ● Chemistry faculty are also united as a research team. The majority of research space is shared by multiple faculty which encourages interaction between the various research groups. The collaboration between

	department members, however, is much more meaningful. Department research group meeting is held every Friday afternoon, with different groups presenting every week. Furthermore, all faculty participate in instructing CHEM 315/316, the research methods class. Each faculty member advises a student research team for this class. ● Group meetings and co-teaching of courses provide a cemented structure that encourages and makes it easy for chemistry faculty to collaborate. For example, 5 of the 7 tenure track members published a manuscript in 2020. ● The chemistry department also interacts and supports the various communities it belongs to. Team members interact with the scientific community by routinely submitting grant proposals with faculty outside the department. Faculty support the chemical community by attending and hosting conferences. The global community is supported through chemcompute.org, a website that makes theoretical chemistry free, accessible, and intuitive for any user. The department supports the local community by hosting 3rd grade students for a day of demos at SSU and by organizing seminars of interest to the general population.

Priority 4: Transformative Impact	
Department Goals	Contributions by Chemistry Dept
Goal 6: have a high quality department in terms of students, faculty, staff, available resources, and modern facilities and instrumentation	● Maintain our instruments ● Send students to graduate school and local industry which adds to the California workforce and increases the diversity of the workforce ● Grants from NSF, Learning Lab, SSU to support student research
Goal 7: work collaboratively, work as a team, and maintain close working relationships within our chemical community and the community at large	● ACS reports ● ACS meetings especially the Northern California Undergraduate ACS (NCUACS) ● Chemistry Department Charis from across the CSU meet once a year and regularly communicate via email

	• Department discussions with a facilitator to help us understand each other and develop compassion • Department meetings every other week and space is created on alternating weeks to have space for open communication to create • Department retreats to honor the creation of community and connectivity.

Program's progress in addressing recommendations from the previous program review

Recommendations from 2014 Program Review (from Memorandum of Understanding between Department of Chemistry, Dean of School and Science and Technology, and the Provost of Sonoma State University):

1. Inventory, assess, and update the facilities that support the chemistry programs, including space and equipment, and ensure environmental health and safety policies are in place and faculty, staff, and students are trained.
2. Develop a curriculum map and an assessment plan for program goals and learning outcomes, and develop instruments and a timeline for implementing the plan.
3. Use the results of assessment to inform future curricular and programmatic change, continuing to include innovative pedagogies and high impact practices.
4. Continue to build the program through development of a more inclusive chemistry community (alumni, scientists, research labs and institutes, etc.).
5. Working with current resources, identify priorities among the external review recommendations for improving student research opportunities and career/graduate study preparation and implement them.
6. Address the need for additional faculty based on program growth and change.
7. Faculty should submit an annual School of Science and Technology Accomplishments survey to document and communicate research activity.

Plan of Action (from 2014 Program Review)

Rec.	Action	Responsible	Planned completion
1a	Inventory facilities and identify recommended facility updates	Chair, Staff	Fall 2018
1b	Ensure environmental health and safety policies in place	Chair, Faculty	Fall 2018
1c	Implement health and safety training across faculty, students, staff	Chair, Faculty	Ongoing
2a	Develop curriculum map and assessment plan for program goals and PLOs	Faculty	Fall 2018
2b	Implement assessment plan for program goals and PLOs	Faculty	Spring 2019
3	Use results of assessments to inform change	Faculty	Ongoing
4	Develop and implement plan for building a more inclusive chemistry community	Faculty	Report next PR
5a	Identify priorities from external review regarding student research and postgraduate opportunities and develop plan for possible implementation	Faculty, Chair, Dean	Fall 2018
5b	Implement prioritized external review recommendations for student opportunities	Faculty, Chair	Ongoing
6	Monitor program growth and evolving faculty needs	Chair, Dean	Ongoing
7	Faculty will submit annual School of Science and Technology Accomplishments survey to document research activity	Faculty, Chair	Ongoing

Summary of activity since the last PR

1a. The chemistry department has identified two lab spaces in Carson Hall, Carson 1 and Carson 10. The department has recommended that the hoods in those spaces be functional and that DI water be installed. Both of these things were done and this has allowed for an increase in teaching space. In addition, we have identified space in both Carson 1a and in Salazar that Dr. Negru is used for research and we are in repetitive evaluation of these spaces.

1b/c. Some faculty have started to keep specific safety information and protocols either on a website or in a LMS page for students to access when they have questions. Some faculty still have these in binders located in labs.

2a. Faculty had meetings to address assessment plans and developed a rubric to measure learning outcomes in the CHEM 497 class. Faculty revised the PLOs and also created a curriculum map.

2b. After considering assessing the PLO the faculty decided that it would be best to develop new PLOs and assess those.

3. The department used the DUCK assessment test but after looking at the alignment of the questions in the test and our program learning outcomes we decided that this wasn’t the best measure of those outcomes and we are still looking for a better assessment process.

4. Based on data and input from the last PR the department realized that the prior structure of the Chemistry and Biochemistry FLC was not facilitating graduation of majors. The FLC was modified to be more inclusive of both our majors and allow for other majors to participate. Specifically encouraging biology majors and undeclared majors interested in STEM. The revised FLC no longer requires math placement scores to be in M1 or M2.

5a. In 2015 external reviewers commented that the research requirement wasn't serving all of the students because many of them might not want to do research after graduation. However, the department has a BA degree program in which no research courses are required for these majors. We are thinking about turning the BA track into a BS track that is not certified by the ACS.

5b. Faculty in the Chemistry Department continue to encourage students from day 1 to participate in research activities/opportunities and more career opportunities and information is regularly available in the chemistry 497 course.

6. Since the last PR the chemistry department discovered that there was a lot of internal friction and the Dean and Chair worked together to hire a facilitator to help the faculty in the chemistry department communicate more effectively. This continues to be an area of faculty need and should be addressed during the next 5 years.

7. This has been accomplished

Evidence of Program Quality (Assessment)

Collection and Analysis of Student Performance in Program Learning Outcomes

There are several forms of assessment of student performance as they proceed through the curriculum of the Chemistry Department. Traditional methods of assessment are used, such as exams (including a Chemistry Department Exit Exam and standardized American Chemical Society exam) and lab reports. Writing assignments and oral presentations are also used for both formative and summative assessments. Various forms of formative assessment are also used throughout chemistry courses such as group work, quizzes, hands-on activities, quick writes, and clicker questions. These forms of assessment are submitted by students in individual courses by turning in a hard copy or submitting through our learning management system, Canvas.

Starting Fall 2020, all GE courses were required to submit student artifacts from the Signature Assignment for that course. These are to be used to assess the GE learning outcomes but could also be used to assess the PLO for chemistry.

Graduation seniors are required to present an oral seminar in front of the department before graduation. A rubric was developed to use the presentations as a way to assess effective oral communication since the last program review cycle.

All seniors in the BS track take 402 or 441 and in teams they write a proposal for the semester long project and defend this proposal orally. This allows 2-4 of the TT professors in the department to assess the content knowledge, oral communication, written skills and organization of the student's knowledge. It also allows for assessment of critical thinking and teamwork.

In the previous program review, the external reviewers suggested that the Diagnostic of Undergraduate Chemistry Knowledge (DUCK) exam from the ACS be used to assess our program learning outcomes. This exam was used, however, we discovered that this only covered about a third of our Program Learning Outcomes (PLOs). There were too many PLOs and they were too specific, so as a department the PLOs were rewritten. The new PLOs start in lower division classes and develop over the student's educational path. The department discussed the PLOs at faculty retreats. The department has revised experiments and assignments based on these conversations, observations and analysis of the student work, collaboration, lab skills. With the recent update to our program learning outcomes, an assessment plan that aligns with these outcomes needs to be discussed and developed over the next 7-years.

The percentage of these assessments are summarized in Figure 7 below and shows that our students are meeting these outcomes.

Summary of Assessment of Student Learning

Forms of direct assessment that were utilized during this review period include Senior Exit Exam (developed by the SSU Chemistry Department), the American Chemical Society's (ACS) Diagnostic of Undergraduate Chemistry Knowledge (DUCK exam), and assessment of graduate senior seminars. All of these tools assess our graduating Spring senior class, which is usually around 25-27 students.

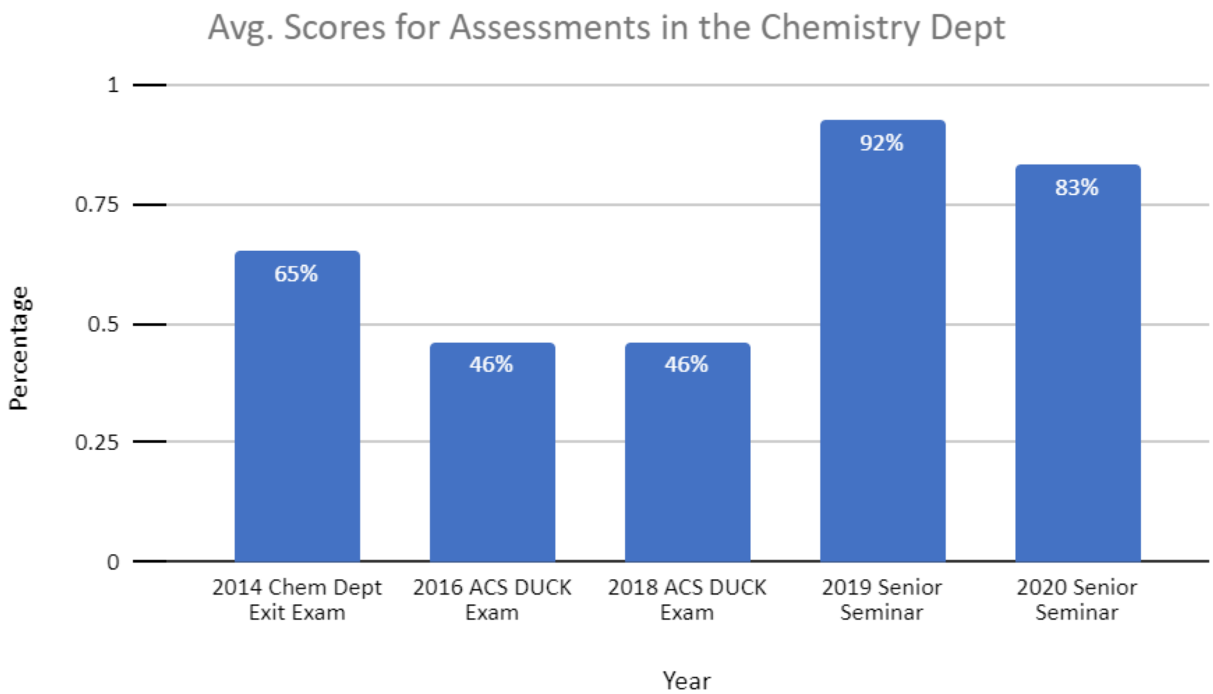

Figure 7: Average scores for assessments carried out in the Chemistry Department during this review period.

Developing an assessment plan is an evolving process for the Chemistry Department. In the department's previous review, there was a thorough assessment plan. However, the program learning outcomes were revamped since then and a proper assessment tool is still needed. As shown above, different tools have been tried, but developing an assessment plan is part of our goals over the next five years. Another challenge with implementing assessment is being consistent each year, no matter the instructor of the course. The department is also thinking about the following questions: How do you measure student success? How does the chemistry department know that they are successful? How do you measure if students are grasping the concepts?

As the department moves forward with further developing our assessment plan, keeping the workload manageable and organized will be important. Therefore, utilizing current assignments will be part of the plan.

Alumni Feedback:

Forms of indirect assessment used during this review period include limited feedback from alumni. The following alumni comments are in response to a request for "feedback about the chemistry department" but were only sent to a small number of Alumni. A more robust data collection plan will be implemented and used over the next 7-years.

Alumni Comments- Feedback on Chemistry Department

Selected Quotes:

"At the end of the day I felt very prepared going into the job world/ being prepared for graduate school after going to Sonoma State. I think going there was the best choice I have made thus far."

"From my perspective, I am very happy with the education I received at SSU. The smaller class sizes let me ask the professor broad scientific questions instead of being referred to a TA."

"My desire to contribute to your research had converted me into an active learner; therefore, I became more vigorous in my learning, especially when it is relevant to our research. It allows me to learn how to be independent in thinking and researching."

"Recommendations are essential for graduate school and possible specific jobs. Ensure the students know what they need to do during their undergrad to obtain an excellent recommendation for these schools/ jobs."

Changes to Curriculum as a Result of Assessment Findings

There were some changes to our curriculum during the review period. Changes that were made as a result of assessment findings were in CHEM 497. Several students commented that more career advising would be useful during their last semester at Sonoma State. It is expected that students take CHEM 497 (Senior Seminar) during their last semester before graduation. Depending on how many students are enrolled in the class, the first few weeks are spent discussing components of an effective presentation. At times, writing a resume is also covered. During this review, alumni were invited back to talk to the graduation seniors about their transition from Sonoma State to their current status. Before the alumni spoke (they were only invited to the second half of class), the students in the class introduced themselves and were asked to talk about where they see themselves in five years. The students found comfort in discovering that not everyone knew what they were doing after graduation. Then in came the alumni and spoke of their own journey. This was a smooth transition and the students expressed their gratitude for that lesson plan. Students were also encouraged to explore the Career Center's Canvas Course, which they all have access to. Also, relevant modules from the Career Center were placed in the Canvas Course for the CHEM 497 class.

Changes were also made to the curriculum of the department's first year learning cohort. However, these changes were not a result of these quantitative assessment findings but based on the attrition of students from the FLC.

Part of the department's five year action plan is to further develop their assessment plan with more intention to our revised program learning outcomes. The department would like to formalize an assessment plan, while allowing the plan to remain dynamic allowing it to evolve as the department does. Part of the assessment plan would include connecting the goals of students when they first arrive at Sonoma State with their actions towards graduation. Guiding them to set expectations that would move them toward achieving these goals. Then during their last semester (perhaps in CHEM 497) an assessment could be used to evaluate progress toward those goals.

Some notable limitations that inhibit effective assessment of learning outcomes are having a way to deliver consistent assessments. Though several tools have been developed and/or tried, a tool or tools to assess our new learning outcomes is still needed. Internal friction within the department impeded the development of a new assessment tool. It would be ideal if the whole department worked together to develop these tools. Also, there is an evolving definition of what it means to be successful. With the previous assessment tools, students showed the chemistry concepts they know through a test. As the department moves forward, questions to be addressed are where are the gaps in the program? The department also wants to identify what causes students to drop out of the program and which students are dropping out. The department wants to create a student centered approach and support the student to enhance student learning. The main focus of the department has been student success, however it is difficult to measure student success if we don't have an agreed upon definition of student success. At this time, there is a loose plan to have these discussions at a department retreat. The department also plans to apply for a Teagle grant to support the use of focus groups to help identify student-centered pedagogical gaps. The department also needs to determine tools that could be used to gauge student success earlier in the program as well.

Progress on departmental goals

Department Goals:

In Progress
On Hold
Added This Cycle

Department Goals	
Goal 1:	deliver a modern curriculum in both content and pedagogy that extends beyond the standard classroom experience
Goal 2:	provide realistic, cutting-edge, and quality year-round research training

Goal 3:	help students prepare for their future in a manner that will allow them to be successful
Goal 4:	nurture students and mentor them through individualized and honest guidance for their scholarly development
Goal 5:	engage in meaningful conversation about and provide support for professional development of faculty and staff
Goal 6:	have a high quality department in terms of students, faculty, staff, available resources, and modern facilities and instrumentation
Goal 7:	work collaboratively, work as a team, and maintain close working relationships within our chemical community and the community at large
Goal 8*:	Develop a **robust** accessible and attainable assessment plan for the PLOs.

Chemistry Department Goals, Measurable Objectives, and Assessment Methods

1. Goal: deliver a modern curriculum in both content and pedagogy that extends beyond the standard classroom experience

Measurable Objectives:

A) Follow ACS guidelines for course offerings, and submit reports to the ACS each year.

B) Students continue to have a high level of interaction with faculty and staff and use all of the instruments in the department.

C) Faculty engage in professional development opportunities and most have developed active learning strategies into their classrooms.

D) The FLC and UD elective engaged in multiple opportunities to produce a service learning experience.

E) All students have an opportunity to engage in research with a faculty mentor

2. Goal: provide realistic, cutting-edge, and quality year-round research training

Measurable Objectives:

A) Faculty are successful in publishing and obtaining funding for their work as evidenced by CVs.

B) Faculty and students attend conferences and present results at conferences and other universities. Virtually all of the Chemistry Department's faculty have been active in presenting at conferences and other universities. Even more so the students have been active in presenting work at conferences.
C) Offer a year-round seminar program. This has been very successful but mostly because of the efforts of Dr. Fukuto and in the coming years the department will need to share these responsibilities.

D) The department receives support from its school and university (monetary, appropriate credit to faculty for supervising undergraduate researchers and writing grant proposals, technician support, matching funds)

F) Students successfully gain entrance into graduate school or industry jobs

G) Hold regularly scheduled group meetings

The chemistry department has been holding year-round department group meetings. Various members of the biology department have also participated in these meetings. In these meetings, students or faculty discuss their research or literature related to their research in an informal manner. Seminar speakers often participate in these group meetings. These group meetings have been less successful over the last review period since not all of the TT faculty attend or/and contribute to the discussions. In addition, these forums were used to pit faculty members against each other saying that the questioning of the students was aggressive.

3. Goal: help students prepare for their future in a manner that will allow them to be successful

Measurable Objectives:

A) Students successfully gain entrance into graduate school or industry jobs

B) Students successfully complete an independent laboratory project

With the inclusion of the chemistry research training courses, Chem 315/316, students taking a BS chemistry or biochemistry degree are required to participate in a research project. In addition, many students who are on the BA chemistry pathway still participate in a research project through the course Chem 494.

C) Students effectively communicate their laboratory work in oral, written, and poster formats.

All chemistry lab courses past general chemistry require detailed, type-written lab reports for each experiment performed. In addition, students in chem 401 are required to give a 50 minute oral presentation on a topic related to the course each week, students in the Chem 315/316 series are required to write a project proposal, a project summary. Students in Chem 497 are required to give a 20 minute seminar to the department. Students in Chem 441 and 402 are required to give a project proposal defense. Also, students in Chem 315, 402, & 441 are generally required to give a poster presentation at the university wide symposium. Lastly, many students give presentations at conferences as mentioned above and some have co-authored peer reviewed publications.

D) supports opportunities for students to hold TA/SI/peer-instructor positions with proper training but these opportunities happen through LARC
E) Students prepare resumes and cover letters in CHEM 497 and are referred to the career center on campus.

Assessment of Goal 3

Student oral presentations were evaluated by all faculty using a shared rubric in Chemistry 497 and were found to be at or above acceptable standards

4. Goal: nurture students and mentor them through individualized and honest guidance for their scholarly development

Measurable Objectives:

A) The TT faculty have regular advising appointments with students and these responsibilities are now shared with professional advisors as part of the GI2025 funds.

B) Lobo connect can now be used to flag students as they progress through the curriculum.

C) Hold regularly scheduled group meetings

See above

D) Provide 4-year (or appropriate) academic planning for entering students

Here the chemistry department has focused on advising first year chemistry and biochemistry students. First of all advising is given to incoming freshmen during the Noma Nation advising sessions but it is unclear who does this advising. Also, during their first year many chemistry students are expected to meet with their advisor and develop a four year plan. This process gets started in the FLC where all advisors are invited to meet the new students and discuss their 4-year plans.

Transfer students are advised regularly and starting with Transfer orientation.

E) Maintain and support a chemistry club

The chemistry department has an active chemistry club with an average of 20 members. The chemistry club has been increasingly active with community outreach events such the National Chemistry Day demonstrations and attending the science fairs of local elementary schools. The advisor is one of the TT faculty members and regularly reports at the department meetings on chemistry club activities. We have discussed the idea of having the president of the chemistry club regularly attend department meetings.

F) Provide information and knowledge for career opportunities

There are two main ways that students are informed about career opportunities. First, the chemistry faculty give at least one seminar per year specifically designed to discuss career opportunities for students. Second, the year-round seminar series provides a wide variety of seminars which educate students about their possible career opportunities including; job placement agencies, speakers from industries, and speakers from various universities.

Assessment of Goal 4

Selected alumni feedback was collected and suggested that the career part of CHEM 497 become a greater focus of the curriculum and threaded in earlier. Also that the seminar series include more speakers from local industry and opportunities for bachelor level jobs.

5. Goal: engage in meaningful conversation about and provide support for professional development of faculty and staff

Measurable Objectives:

A) Hold annual retreats to discuss curriculum and programming

Since this program review the chemistry department has held regular, multi-day retreats every year. During these retreats details for course assessment, departmental goals, course learning objectives, curriculum improvements, and future directions were all laid out. However not all of the faculty attend these retreats and the faculty that do attend are not always comfortable with speaking.

B) Maintain a yearly seminar program

See 1C above.

C) Obtain resources for faculty to attend workshops and conferences in teaching and research

Faculty have been very successful in obtaining PD money for travel and other resources to support them in both research and the classroom.

D) Provide opportunities for staff to attend training workshops in their field. Mostly these efforts have been for the revolving instrument tech position.

E) Hold weekly meetings for all members of the department and keep minutes of these meetings. The department also developed more structure to these meetings over the last five years. This was due in part to the fall out in the department but was really good since prior the department didn't keep minutes of meetings.

Assessment of Goals 5

The department members are not engaging in meaningful dialogue because they don't trust each other. However, in trying to develop this goal the department has increased its efforts to include more structure in the department. Robert's Rules of Order are loosely used to conduct meetings, minutes are taken and distributed and all members of the department are invited to participate. The department needs help from administrators to make progress on this goal.

6. Goal: have a high quality department in terms of students, faculty, staff, available resources, and modern facilities and instrumentation

Progress on this goal can be seen through the measurable objectives in this section. The department is working on maintaining the equipment and instrumentation it currently has with the current resources.

7. Goal: work collaboratively, work as a team, and maintain close working relationships within our chemical community and the community at large

Measurable Objectives:

A) Establish partnerships with local schools and industry.

A partnership with Mendocino Community College was developed in which students from the community College came to use the NMR at SSU.

B) The chair of the SSU chemistry department is part of the community of chairs for all of the chemistry departments of the CSUs and meets regularly with this group. They also exchange ideas and emails.

C) Faculty participate in CSUPERB activities which also forms collaborations with scientists from other CSUs.

D) Faculty members participate in ACS meetings where they collaborate with the chemical community.

E) Work by the faculty members in the chemistry department is peer reviewed which is also a form of collaboration.

8.Goal: Develop a robust accessible and attainable assessment plan for the PLO.

This goal was added this review cycle. The department needs to discuss measurable objectives for this goal.

Faculty

During the last program review cycle the chemistry department had 8 full-time tenured and tenured-track faculty that covered all of the sub-disciplines in chemistry

(2 Biochemists, 2 Analytical, 1 Physical, 1 Inorganic, 2 Organic). During this time 2 of those faculty members retired and entered an early retirement program (FERP) and recently 1 of the 2 has discontinued their FERP. The department also engaged in a search for a tenure track faculty member to cover the lack of synthetic expertise in organic chemistry and in green chemistry. This search failed and this need will continue until the department can find a good fit. In addition, 1 of the 2 biochemistry faculty has taken an interim administrative position in Academic Programs and it is unclear if they will return. This leaves a limited number of experimental chemistry faculty to train students in laboratory chemistry since the other faculty members are either FERP-ed or only engage in non-lab research. Since we have over 180 majors this will become problematic. In addition, in order to continue to keep our ACS certification TT faculty are needed to teach major courses and there is currently not enough faculty to cover those courses and we will need to rely on lecturer faculty to teach both non-major and now major courses.

Figure 8 below shows the change in faculty over the last five years and shows that two faculty members retired and FERP-ed, and one became tenured.

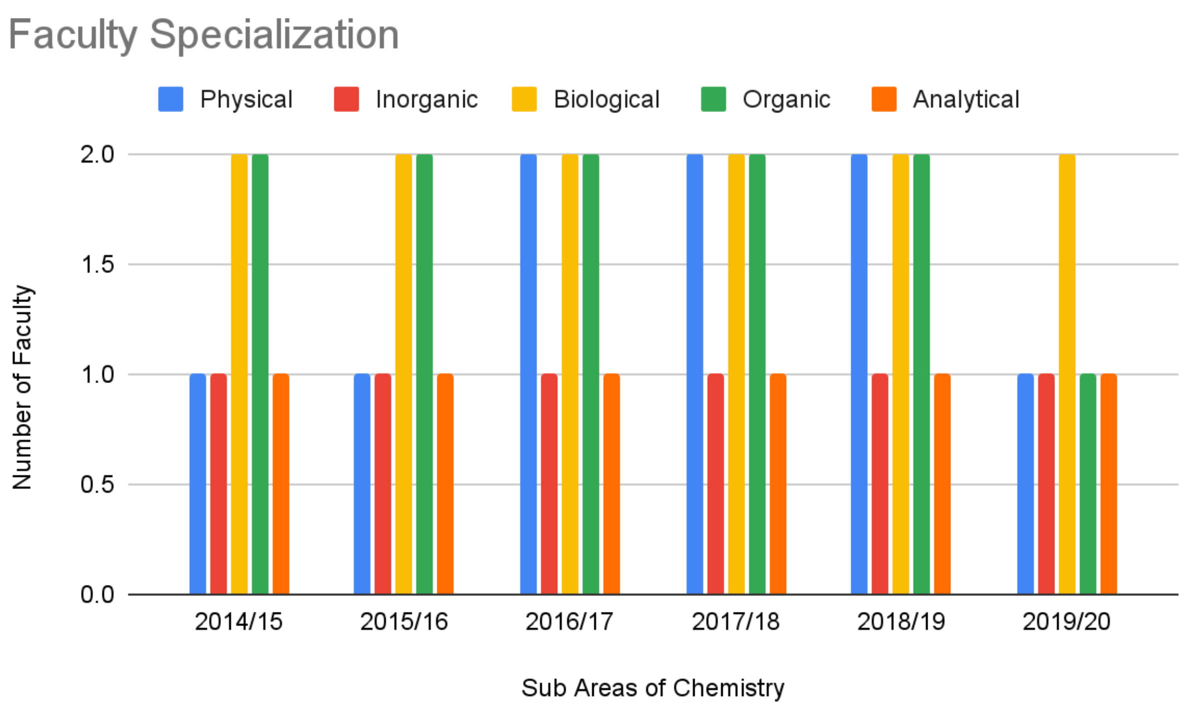

Figure 8. Shows the faculty specialization in the chemistry department over the last five years.

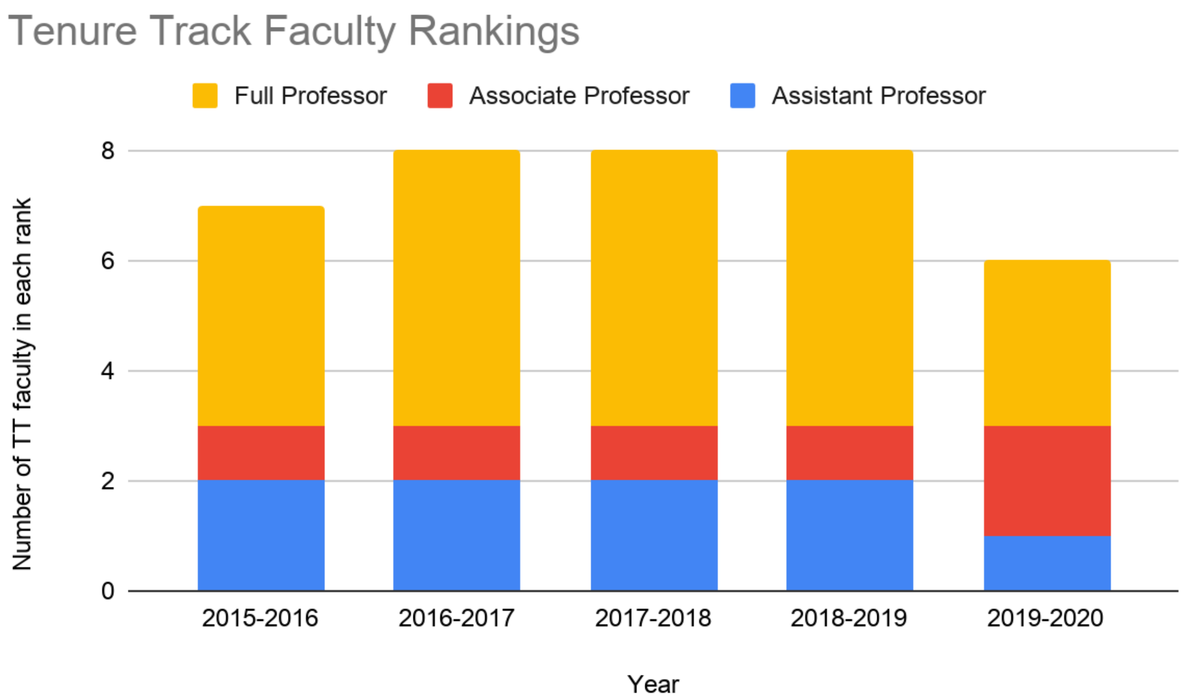

Figure 9. The profile of rank of the tenured and tenured track professors in the Department of Chemistry over the last 5 years

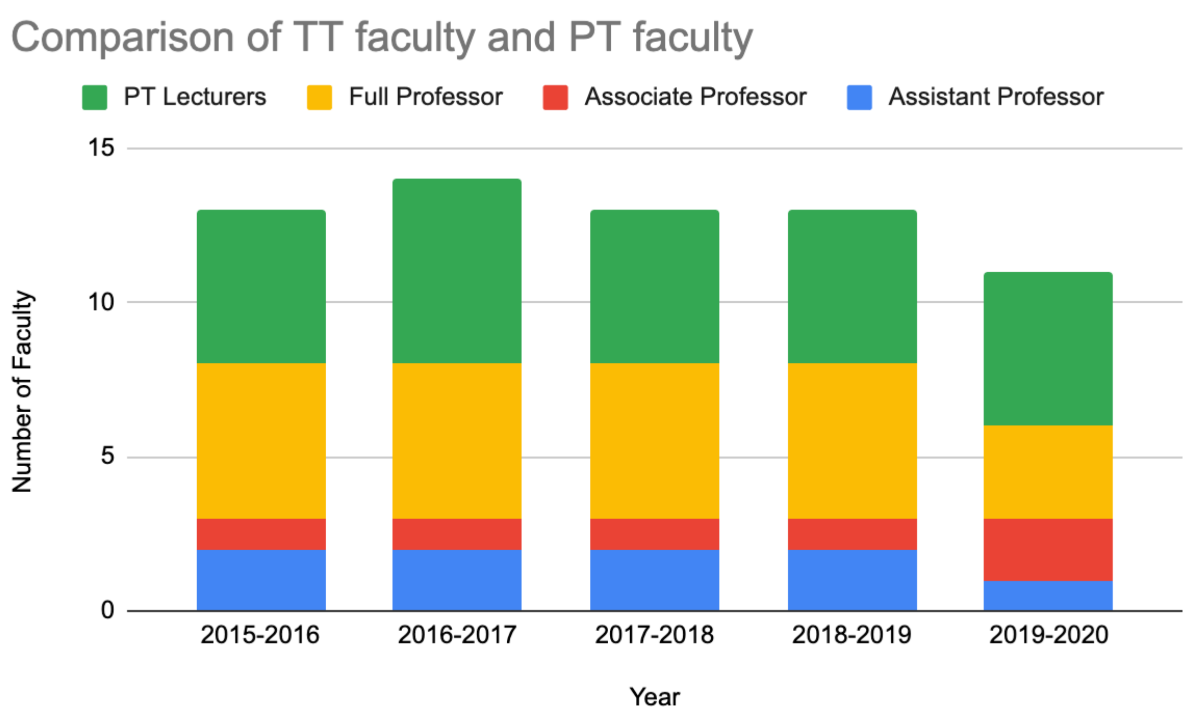

Figure 10. The comparison of part-time to full-time faculty in the Chemistry Department over the last 5 years

Comparison to other CSU chemistry departments of a similar size to SSU

For these comparisons CSUs with a similar number of chemistry majors, which give out a defined chemistry bachelor's degree, and do not give out a masters degree were chosen.

Number of tenure track faculty

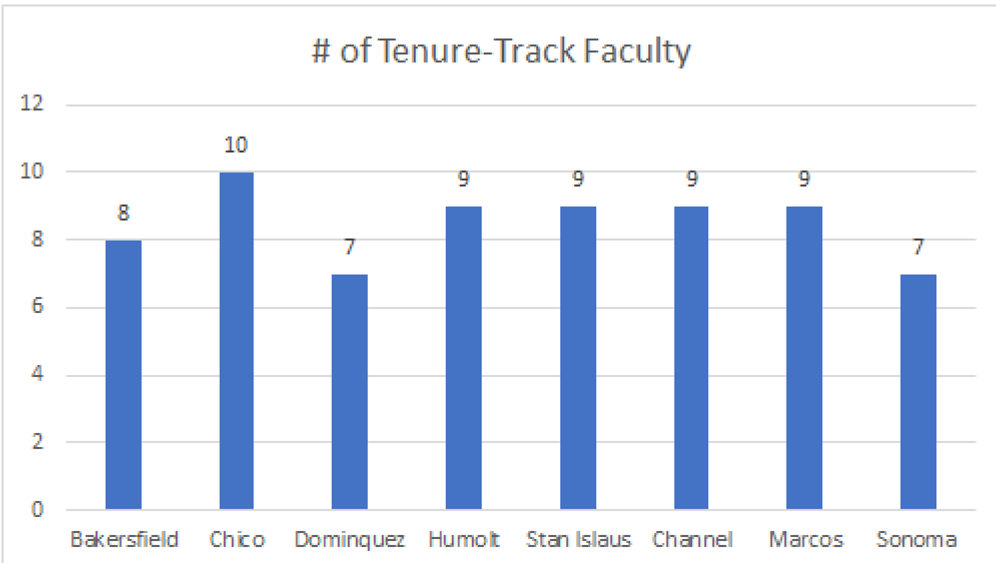

Figure 11. Comparison of TT faculty in similar sized CSUs over the last 5 years

Number of adjunct faculty

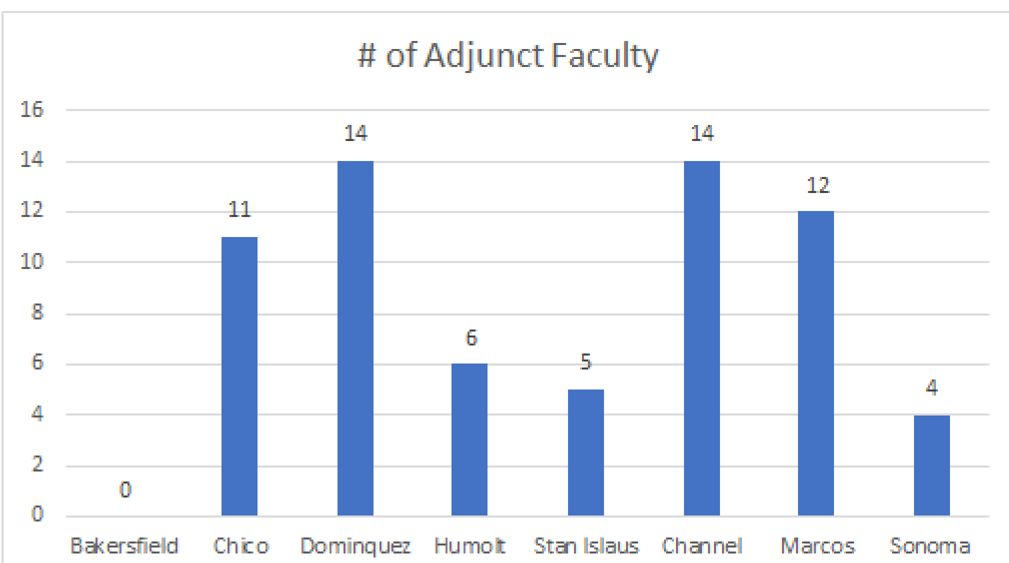

Figure 12. Comparison of adjunct faculty in similar sized CSUs from 2014-now

Start-up packages for new hires- Since the previous program review in 2014, the chemistry department has hired one new, tenure-track faculty, Dr. Bogdan Negru. This new faculty member received a start-up package which was significantly better than previous hires.

Start-up funds in order of hire to SSU.

Dr. Carmen Works (hired 2001): $10000

Dr. Jennifer Lillig (hired 2003): $3000

Dr. Steve Farmer (hired 2006): $10000

Dr . Meng-Chih Su (hired 2006)

Dr. Jon Fukuto (hired 2008): $10000

Dr. Mark Perri (hired 2009): $20000

Dr. Monica Lares (hired 2013): $25000.

Dr . Bogdan Negru (hired 2016?): $50000

Number of New Tenure-track hires- 1

Since the last program review the chemistry department has hired one new TT faculty and had one additional search that failed. It is not clear why the search failed and the top candidate did provide feedback on the process and was very impressed with our department but determined that this was not the move for them.

The chemistry Department continues to hold at 5 TT faculty and the profiles below describe the department over the last five years.

Faculty Members

Full Time Faculty: 6
(See **Appendix D** for Faculty CVs)

Carmen F. Works-joined SSU 2001
(Ph.D. UCSB 2001; Professor)
Bioinorganic Chemistry
Dr. Works' training is in the area of bioinorganic chemistry and focuses on the molecule role of transition metals in biological systems. She received her B.A. in chemistry from San Francisco State University where her undergraduate research was concerned with the synthesis and characterization of organometallic catalysis. Dr. Works completed her Ph.D. at University of California, Santa Barbara and her project concerned the synthesis and photochemical studies of ruthenium Salen nitrosyl compounds as possible chemotherapeutic agents. Dr. Works' training has given her a background in air, light, water sensitive synthesis, biochemistry, spectroscopy and kinetics. Her current research is concerned with determining the mechanisms of; iron-only hydrogenase (an

organicmetallic enzyme that reversibly catalyzes the oxidation of molecular hydrogen), chromium(III) binding proteins and chromate reductase.

Jennifer Lillig- joined SSU 2003

(Ph.D. UCSD 2001; Professor, Interim Associate Dean Academic Programs)
(2020-current)
Biophysical chemistry
Jennifer Whiles Lillig received a B.S. in Chemistry from Harvey Mudd College and a Ph.D. in Chemistry from UC San Diego. She specializes in biochemistry and her research is focused on characterizing structure:function relationships in membrane-active antimicrobial peptides and proteins. She teaches across the department curriculum including general chemistry, general/organic/biological chemistry for pre-nursing students and upper-division and capstone experiences in biochemistry. Her teaching emphasizes chemical problem solving, experimental design and data analysis, writing and reading the chemical literature, and teamwork

Meng-Chih Su-joined SSU 2006

(Ph.D. University of Arkansas 1986; Full Professor, **Retired 2021**)
Physical Analytical Chemistry
Meng-Chih Su received a B.S. in Chemistry from Soochow University, Taipei, Taiwan and a Ph.D. in Chemistry from University of Arkansas. His research focuses on the understanding and characterizing protein adsorption to substrate and its applications in biosensors, biomedical devices and other biotechnologies (protein chip technologies). In particular, the denaturation effect on surface bound proteins is studied in his research group with use of prototype heme protein cytochrome c on fused silica surface.

Steve Farmer-joined SSU 2006

(Ph.D. UCD 2001; Professor)
Organic Chemistry
Dr. Farmer's training is in the area of organic chemistry and his Ph.D. thesis was titled "A Synthesis Route for Ellipticine Via Sulfur Extrusion." This project involved the synthesis of the natural product ellipticine using organic chemistry techniques. In addition, his research group is currently involved in two projects that directly utilize organic chemistry. The first is entitled "Development of a Sulfur Extrusion Route to Carbazole Natural Products" which directly uses organic synthesis techniques for the synthesis of natural products. The second is entitled "Investigation of fluorescent molecules from Naematoloma Fasciculare" which involves the isolation of natural products from local mushrooms.

Jon Fukuto- joined SSU 2008

(Ph.D. UCB 1983; Professor, **FERP-ed**)
Bioorganic, Organometallics
Small molecule signaling species (i.e. NO, CO, H_2S and O_2 and their derived species) are involved in a wide array of physiological function. For example, they are all important in the regulation of the cardiovascular system, cell-cell signaling and

neurotransmission, just to name a few. In spite of their biological importance, the chemistry by which these agents elicit their activity is poorly understood. Thus, research in the Fukuto lab focuses in the chemical biology of these small molecule signaling agents. That is, the Fukuto lab endeavors to determine the relevant physiological chemistry of NO, CO, H_2S and O_2 and their chemical interactions with biological systems as a means of understanding their utility as important physiological mediators and effectors.

Mark Perri- joined SSU 2009

(Ph.D. UCB 2003; Associate Professor)
Environmental, analytical
Dr. Perri's group studies the impact of anthropogenic pollution on our local atmosphere. Projects include measurements of: trace pollutants in our atmosphere by Gas Chromatography - Mass Spectrometery, aerosol optical thickness ("haze"), and ozone. These measurements are used along with computer modeling programs, to understand the types of processes that cause atmospheric pollution and to design control strategies for our unique local region Recently his groups has also been using ion chromatography to quantify pollutants in river water, in order to understand and limit our University's impact on our local watershed.

Monica Lares- joined SSU 2013

(Ph.D. UCSC 2009; Associate Professor)
Biochemistry
The Lares lab is working on identifying key interactions between the B-cell-activating factor receptor (BAFF-R) protein and a RNA aptamer that specifically binds BAFF-R. BAFF-R is expressed on B-cells and overexpressed in non-Hodgkin's lymphoma. When BAFF-R's ligand, B-cell-activating factor (BAFF), binds, proliferation and cell survival increase allowing the cancer to spread faster. Aptamers are capable of binding their targets with high specificity and affinity and have recently been investigated for their therapeutic advantages over antibody-based approaches. An RNA aptamer has been identified that efficiently binds BAFF-R, thus preventing binding of its ligand. The RNA aptamer has also been used to deliver therapeutic reagents that kill the cell. We are working on identifying the specific amino acids of BAFF-R that are responsible for the binding of the aptamer using site-directed mutagenesis. We also want to identify the nucleotides of the RNA aptamer that specifically bind BAFF-R using RNase protection assays. Understanding the specific interactions between BAFF-R and its aptamer would allow us to increase specificity, reducing off-target effects, and facilitate this therapeutic approach through clinical trials.

Bogdan Negru- joined SSU 2016

(Ph.D. UCB 2012; Assistant Professor)
Physical and Analytical Chemistry
The Negru group is interested in developing and understanding surface-enhanced Raman techniques. Raman scattering is a widespread phenomenon in nature, and although it is a weak effect it is very useful. Every chemical species has a unique vibrational fingerprint that can be used to elucidate its structure. Due to the usefulness

and applicability of this technique a very large number of Raman spectroscopies have been developed; so many in fact, that the acronym NR is widely used in literature, and it stands for Normal Raman. Detection of the very few Raman photons that are normally generated is challenging, but nanostructured coinage metal surfaces can provide 6 to 8 orders of magnitude enhancements in the Raman scattering intensity. This means that the nanoparticle substrates we develop in our group can increase the number of Raman photons by as much as 100 million times. There are not many effects in nature that can provide such a substantial increase in signal. We dedicate our time on developing new substrates and characterizing their performance with spectroscopy. Furthermore, we apply the developed substrates to investigate chemistry at the nanoscale.

Emeritus Faculty:

Gene Schaumberg (1965-2003)
Don Marshall (1966-2003)
Marvin Kientz (1967-1998)
Floyd Leslie Brooks (1968-2005)
Doug Rustad (1969-2000)
Vincent Hoagland (1969-2005)
Dale Trowbridge (1969-2008)
Dave Eck (1970-2006)
Doug Martin (1984-2005)

Part-time faculty as of Spring 2021

Monali Joshi
(Ph.D. University of California, Los Angeles 2009; Materials Science and Engineering)

Zachary Sharrett
(Ph.D. University of California, Santa Cruz 2008; Organic Chemistry)

Jared Wiltse
(M.S. Educational Chemistry)

Mary Cornett
(Ph.D.Chemistry)

Anne Nelson
(M.S. Bioinorganic Chemistry, SSU)

Manza Atkinson
(Ph.D. Chemistry)

Program Resources

The Department of Chemistry requires support to meet the certification requirements from the American Chemical Society (ACS), support to meet the requirements from EH&S and support to maintain and acquire instrumentation. The department needs to train faculty in advising both for the main curriculum and in terms of graduation requirements outside the major including GE. The department will also need regular professional development in terms of research support, conference attendance and mentoring of undergraduate students. This would also include workshops on up-to-date pedagogical approaches and current support for students on cultural sensitivity. The department also regularly needs access to computers for students in classes to collect and work up data. Lastly, the department needs access to search engines in the library and literature resources.

Tenured and tenured track faculty have a workload of 12 WTUs per semester and this includes CHEM 494 classes. However, this has become more difficult to support since the department faculty has decreased in numbers and a number of students want to continue to do research in their senior year.

Advising

Currently all 5.5 tenure and tenured track members of the department play a role in our advising process for over 150 majors. Majors are assigned to an advisor by the department AC and are done via the first letter of the last name. This is regularly balanced if one advisor is accumulating too many advises. In addition, Christina Thao is a professional advisor that helps advise all of the majors.

Support staff

Sujan Bhattarai(Chemistry Stockroom Technician 80%)

Marissa McDonald (Administrative Coordinator 50%)

Ryan Grumich (Instrument Technician 50%)

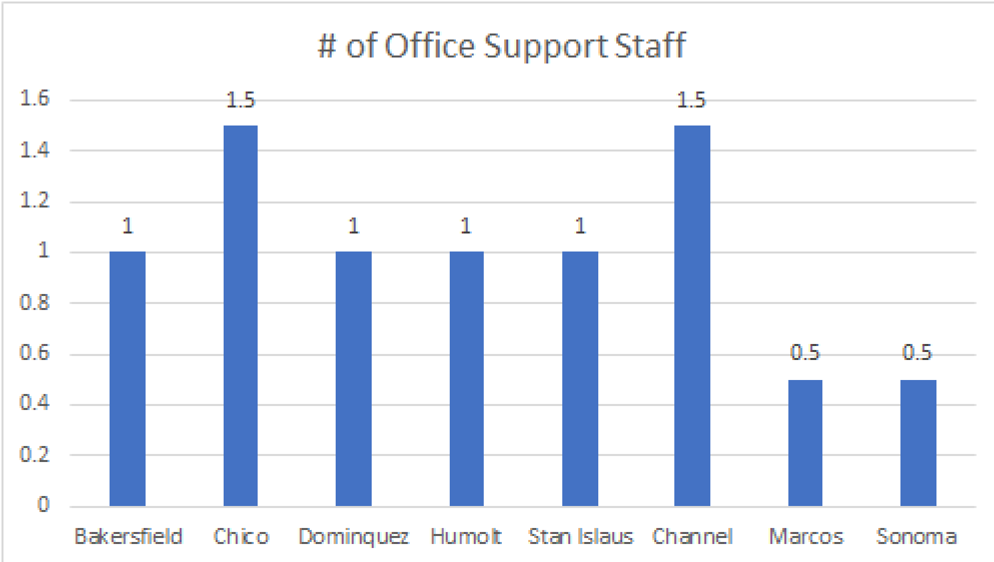

Figure 13. Comparison of office staff for chemistry departments in the CSU of similar size

The typical number of office support staff is between 0.5 and 1.5. Here the SSU chemistry appears to be understaffed compared with other chemistry departments.

A typical number of instrument support staff is between 0 and 3 for chemistry departments of a similar size as SSU's. It appears that SSU appears to be in-line with other CSU's in this regard.

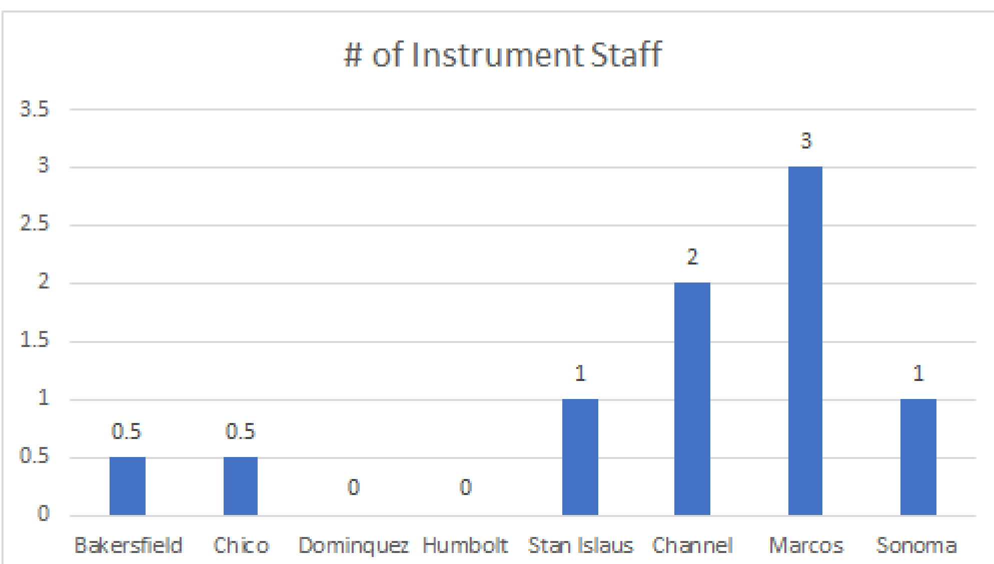

Figure 14. Comparison of instrument tech in chemistry departments in the CSU of similar size

A typical number of stockroom staff is between 0 and 3 for chemistry departments of a similar size as SSU's, with an average of approximately 1 as seen in Figure 15. It appears that SSU is understaffed with other CSU's in this regard. Having additional stockroom support would allow the department to offer evening lab classes to accommodate working students and to simply offer more seats in general chemistry classes.

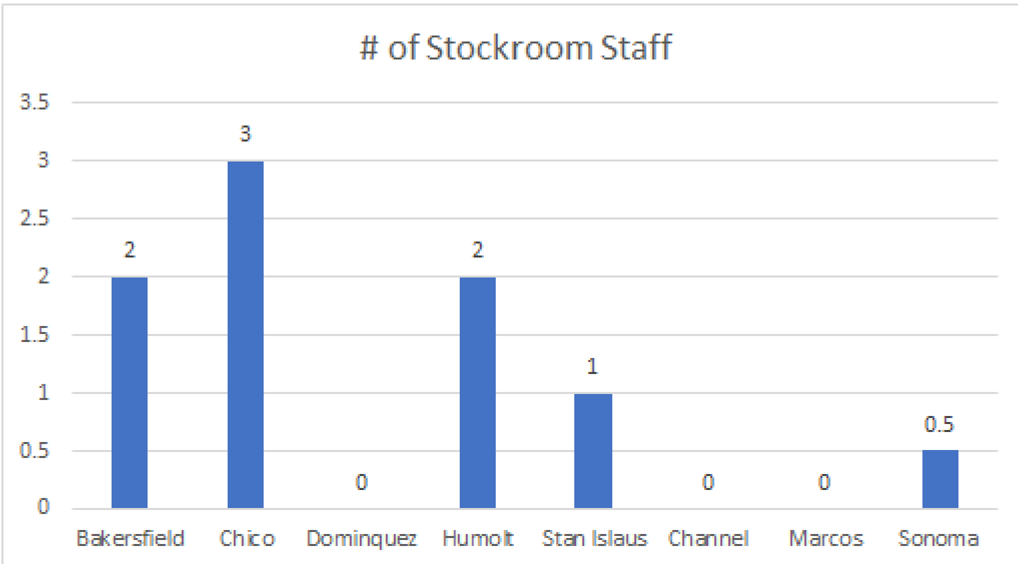

Figure 15. The comparison of support of staff across the similar size CSUs.

Facilities, Equipment and Other Resources

The Department of Chemistry has approximately 7,200 sq. ft. of dedicated laboratory space on the third floor of Darwin Hall, which is a combination of teaching and faculty research space, and additional teaching lab space in Carson.. This space is divided into four general chemistry teaching labs (D326, D328, Carson 1 and 10), an organic chemistry lab (D323), an instrument room (D322), and four labs used for research (D327, D317, D314, D320) to support the teacher scholar model. The teaching labs are accessible for research during regularly scheduled classes (space, instruments, and class format permitting). The department also has chemistry department space, 414 sq. ft., established for spectroscopy in Salazar Hall (room 2000), located next door to Darwin Hall. The chemistry department has an approximately 150 sq. ft. basement room in Darwin Hall (D36) which houses the 400 MHz NMR. Recently, the chemistry department has acquired one third of the radiation capable lab in room D306.

All faculty and senior personnel have desktop/laptop computers that are periodically refreshed. All faculty have direct access to scanners and color laser printers. The computers have internet access and all faculty and senior personnel have dedicated office space of approximately 110 sq. ft., located on the third floor of Darwin Hall. Most of the offices have windows that face into the dedicated research lab spaces and side-doors with lab access.

The chemistry department has a shared conference room (Room 300C) that has general purpose use. The university has a state-of-the-art library with licenses to over 1500 journals including all of the ACS journals and a site license to access Sci-Finder Scholar. The faculty and students have access to all library holdings from any computer on or off campus. The Chemistry Departments also maintains a 458 sq. ft stockroom (D327) which stores lab glassware, chemicals, solvents and safety supplies.

Major equipment

400 MHz NMR spectrometer (Agilent): D36

60 MHz NMR spectrometer (Anansazi): D322

FT-IR spectrometer (Nicolet): D322

Optical Spectrometers (diode array and dual beam, Shimadzu): D320, D322

Atomic Absorption Spectrometer: D320

GC-Mass Spec (Hewlett Packard): D322

GC-FID (Hewlett Packard): D322

GC-MS with auto-sampler (Saturn): D322

Nano-drop spectrophotometer: D320

LS 50B Fluorimeters (Perkin Elmer, including polarizers and plate readers): D320, D322

HPLC with dual wavelength detection, fraction collector, in-line degasser: D320

Additional HPLCs with autosamplers: D322

Equilibrium dialyzer:

Lipid extruder:

Schlenk line for lyophilization: D320 (and research labs)

Electrophoresis and Western Blot equipment: D320

Incubators and shakers: D320

PCR machine: Darwin 320

Chromatography Fridge: Darwin 322

Refrigerated Sorvall RC-6 centrifuge: D314

Cell Culture Set-up (CO_2-Incubators, Laminar flow hood, Microscope): D314

Refrigerators and full-size freezers: Throughout department

Explosion-proof refrigerators: D317, D327

Hoods and Rotovaps: D320 and research labs

The department will need to also decide how it wants to continue to support the high touch activities that it has and student use of the instrumentation.

Department website

The Chemistry Department's website contains the following:

Ads for faculty positions
A Description of the department
A Faculty and Staff Directory and Faculty office hours
4-Year plans and learning outcomes for the department
Advisors and Advising Tips
Descriptions of Faculty Research
A Seminar Schedule
Scholarships page
Safety information but this should be updated and linked to EH&S
Donations link for giving

During the next review period it will be important to have clear direction on who is responsible for maintaining the webpage in the department. Is this a staff or faculty job and the webpage must be updated each semester.

Student Success

The student population of the chemistry department has always reflected the student population of SSU.

Students - Fall 2020

Chemistry BS majors: 43

Biochemistry BS majors: 96

Chemistry BA majors: 30

Total number of chemistry majors: 169

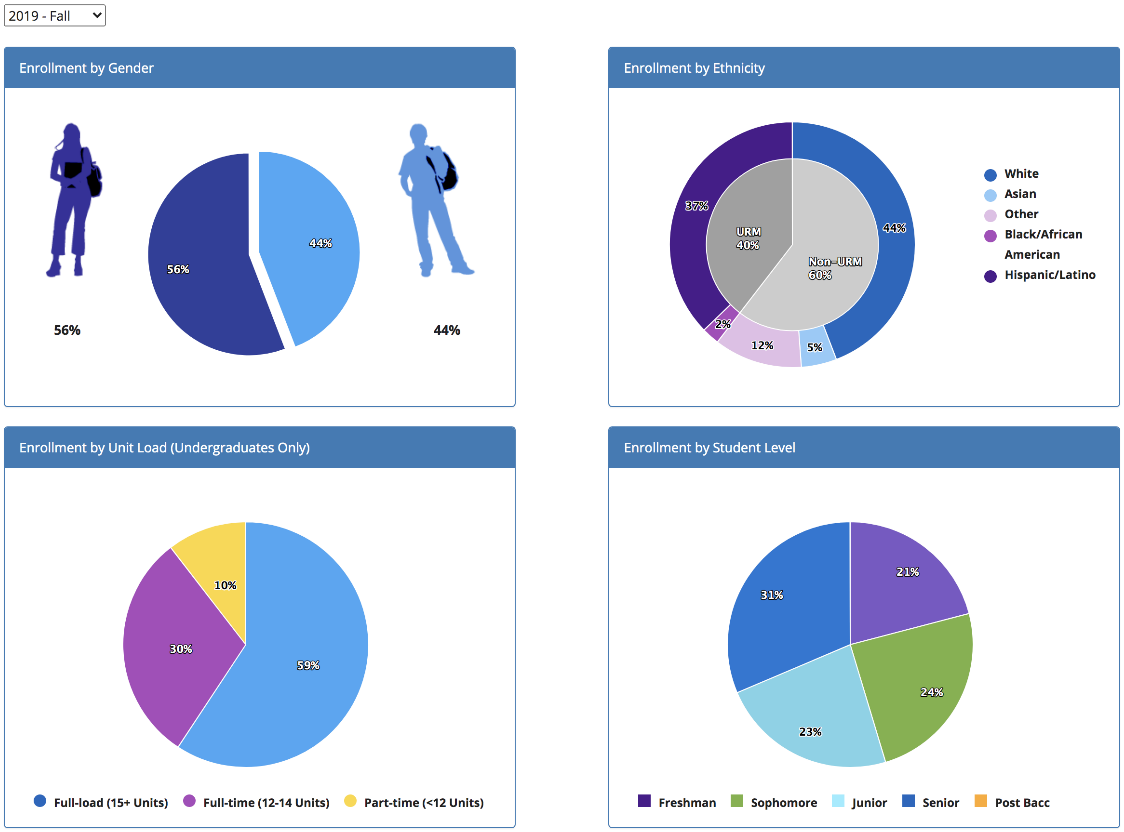

Figure 16. Enrollment profile of students that are majoring in **chemistry** at SSU, data pulled from fall 2019.

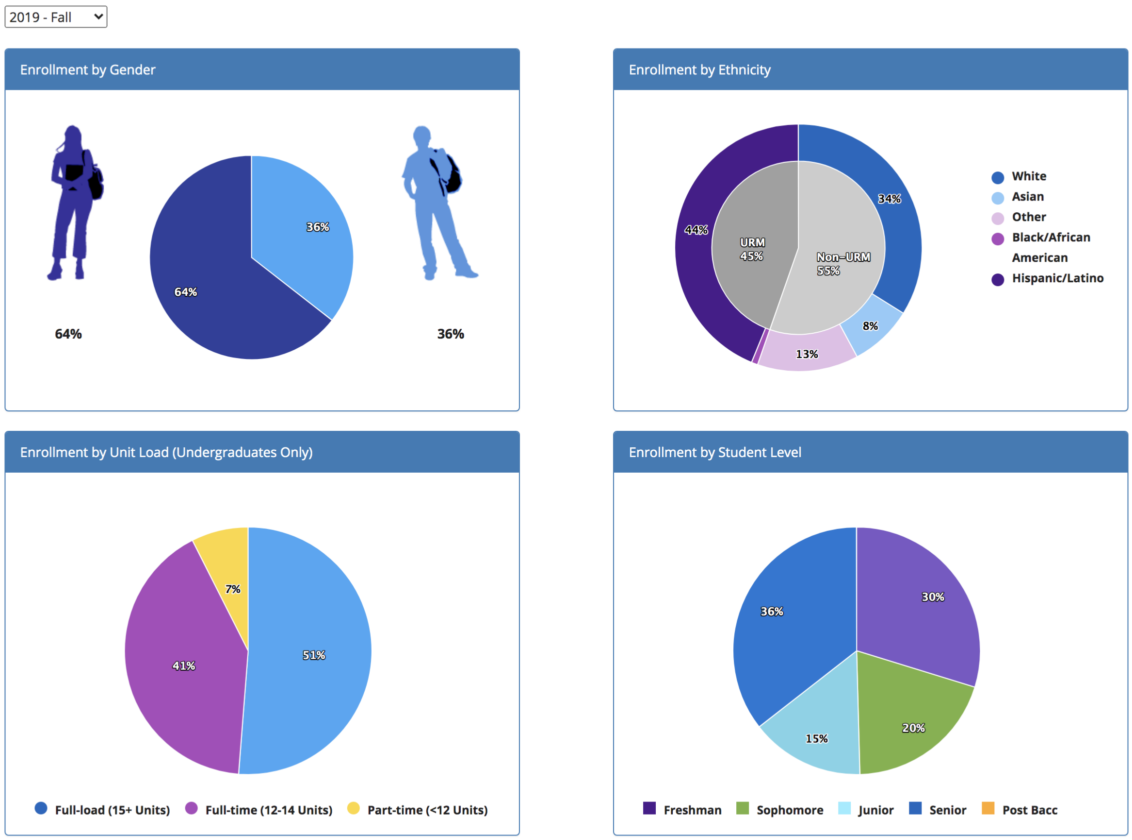

Figure 17. Enrollment profile of students majoring in **biochemistry** at SSU, data pulled from fall 2019.

Graduation by Academic Year

Academic Year	Biochemistry - BS	Chemistry - BA	Chemistry - BS	Grand Total
2015-2016	8(67% of majors)	2	2	12
2016-2017	10(38%)	8	8	26
2017-2018	15 (48%)	6	10	31
2018-2019	18 (44%)	11	12	41
2019-2020	18 (58%)	9	4	31
Distinct Grad Total	**69 (49%)**	**36**	**36**	**141**

Status and trends

Student make-up

As seen in the "Graduation by Academic Year" table above, our total number of graduates has increased since our previous review and roughly half our students major in Biochemistry . As seen in **Figure 16 and 17** above, the majority of our students (both chemistry and biochemistry major) are seniors, which is in-line with the large number of transfer students and the fact that some students end up taking more than 4 years to graduate. The percentage of students who identify as Asian was previously at 11%, and now that number is at 8% for biochemistry and 5% for chemistry majors. Several of our students identify as Hispanic/Latino. The percentages are 37% for chemistry and 44% for biochemistry. This is in line with Sonoma State being recognized as a Hispanic Serving Institution (HSI). We have 2% of chemistry majors and 1% of biochemistry identifying as Black/African American. Previously, the majority of students (48%) racially designated themselves as white. **Figures 16 and 17** show how that number has changed to 44% for chemistry majors and 34% for biochemistry majors. The remaining students identified as other.

Statistics for Biochemistry Majors:

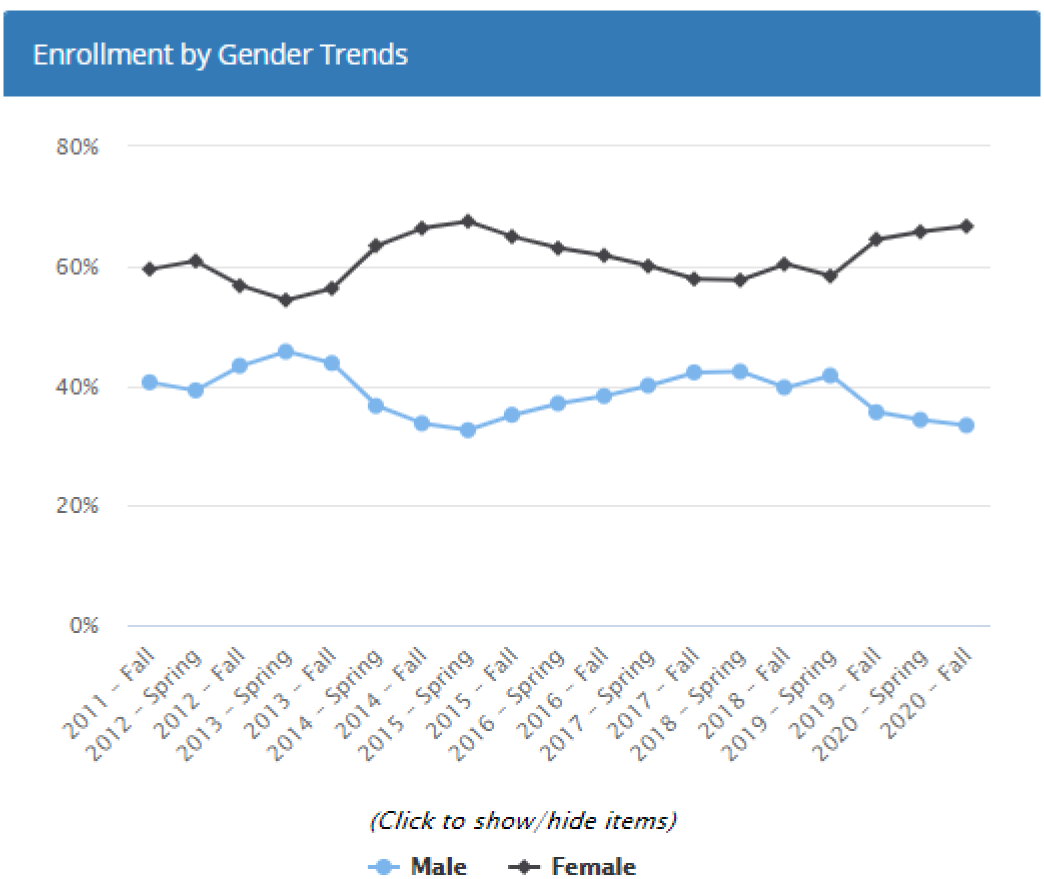

Figure 18. Trends of student's gender in the biochemistry major over the last several years.

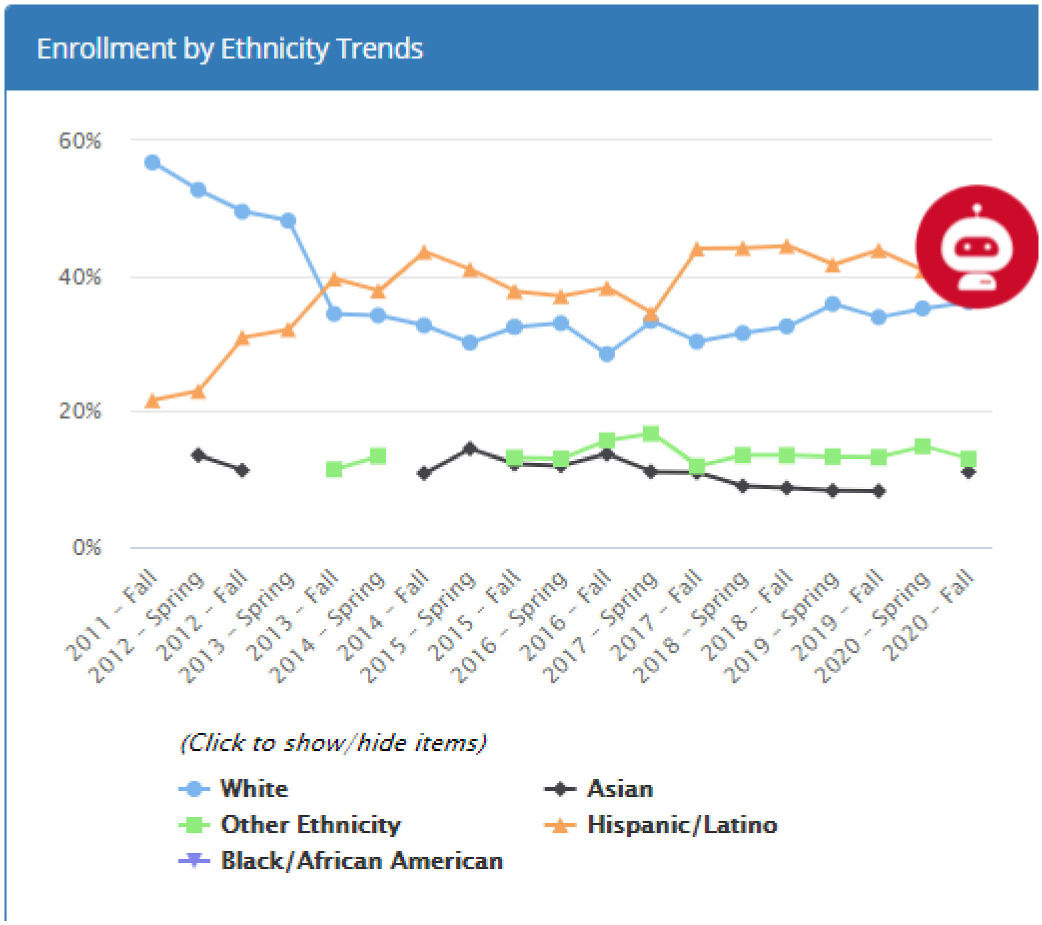

Figure 19. Trends in student ethnicity for biochemistry majors over the last several years.

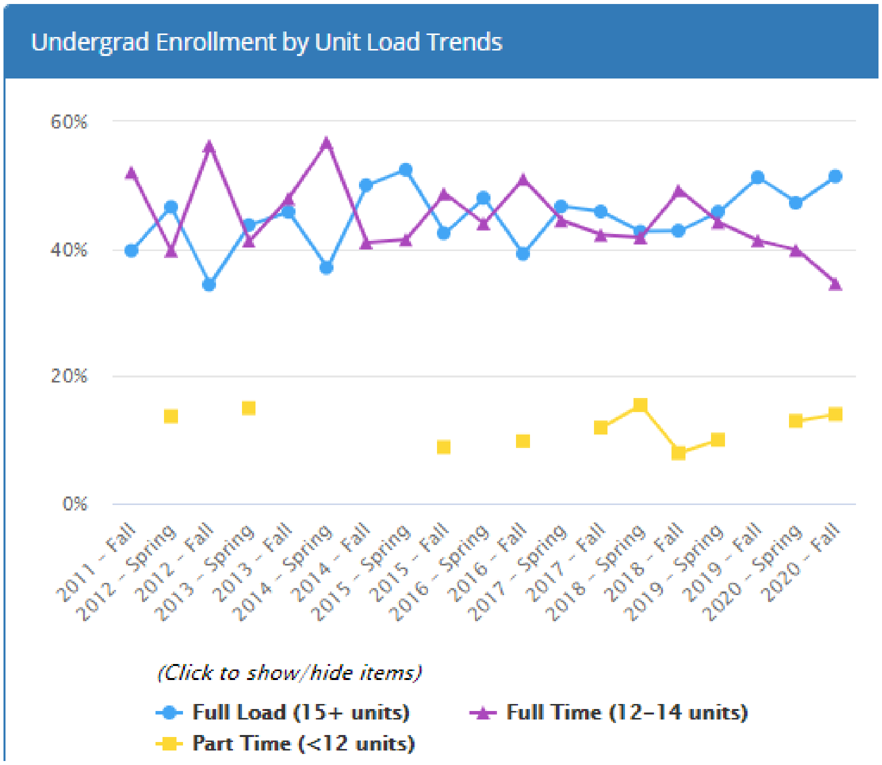

Figure 20. Trends of unit loads for the biochemistry majors over the last several years.

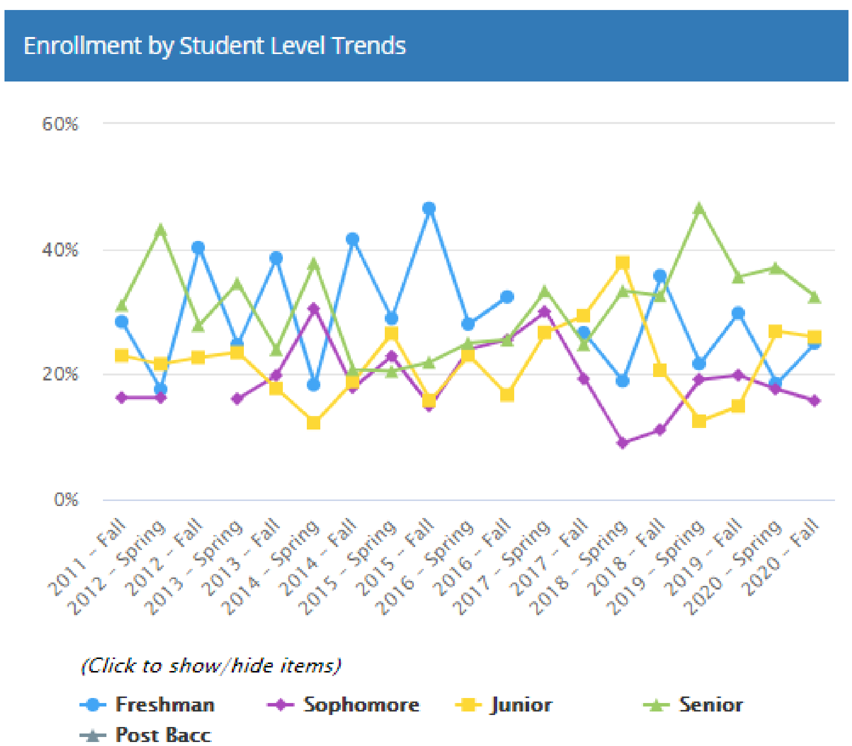

Figure 21. The enrollment of students in the biochemistry major, showing the trends in class (Fr, Sop, Jr. Sr.) level.

Trends for Chemistry Majors:

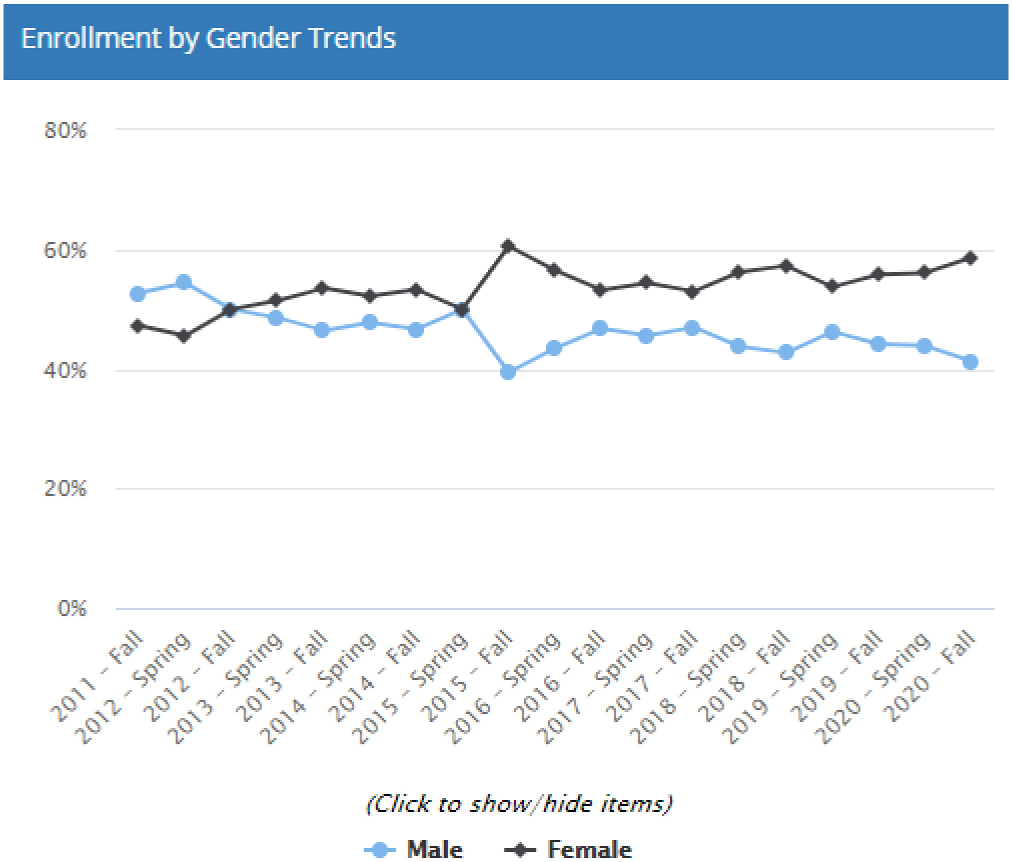

Figure 22. Trends of student's gender in the chemistry majors over the last several years.

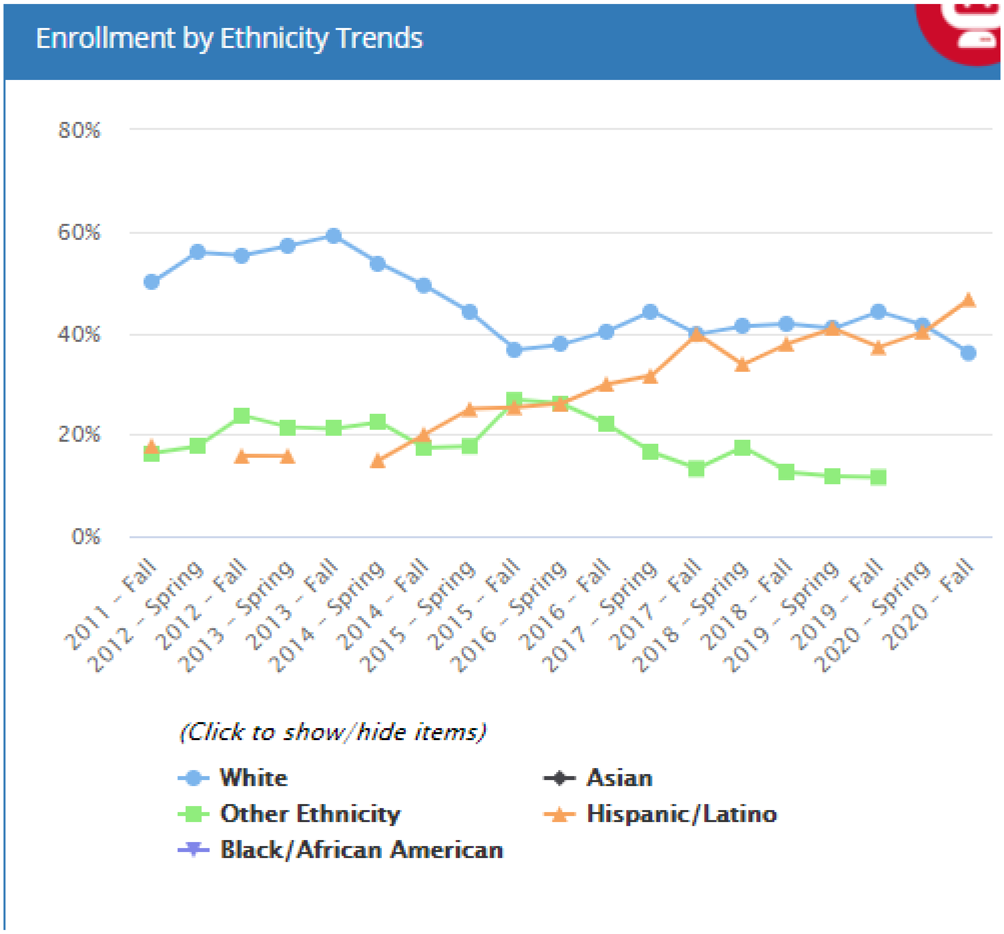

Figure 23. Trends in student ethnicity for chemistry majors over the last several years.

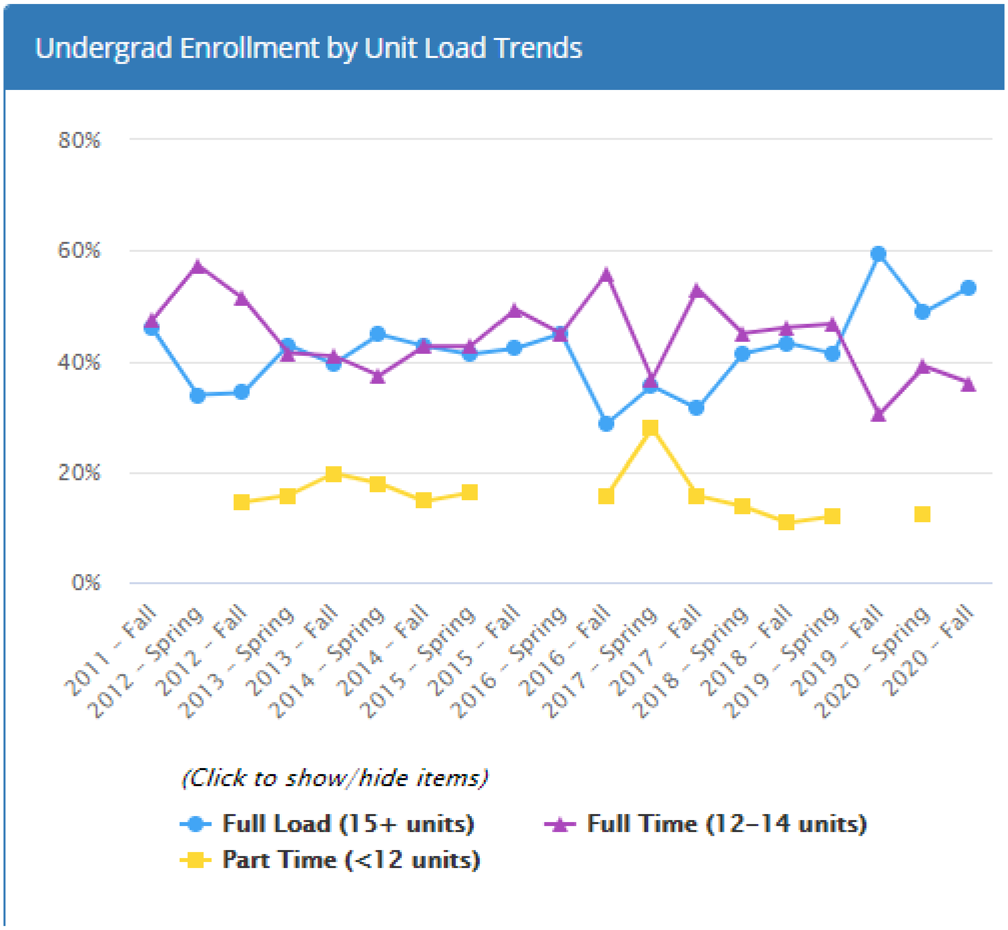

Figure 24. Trends of unit loads for the chemistry majors over the last several years.

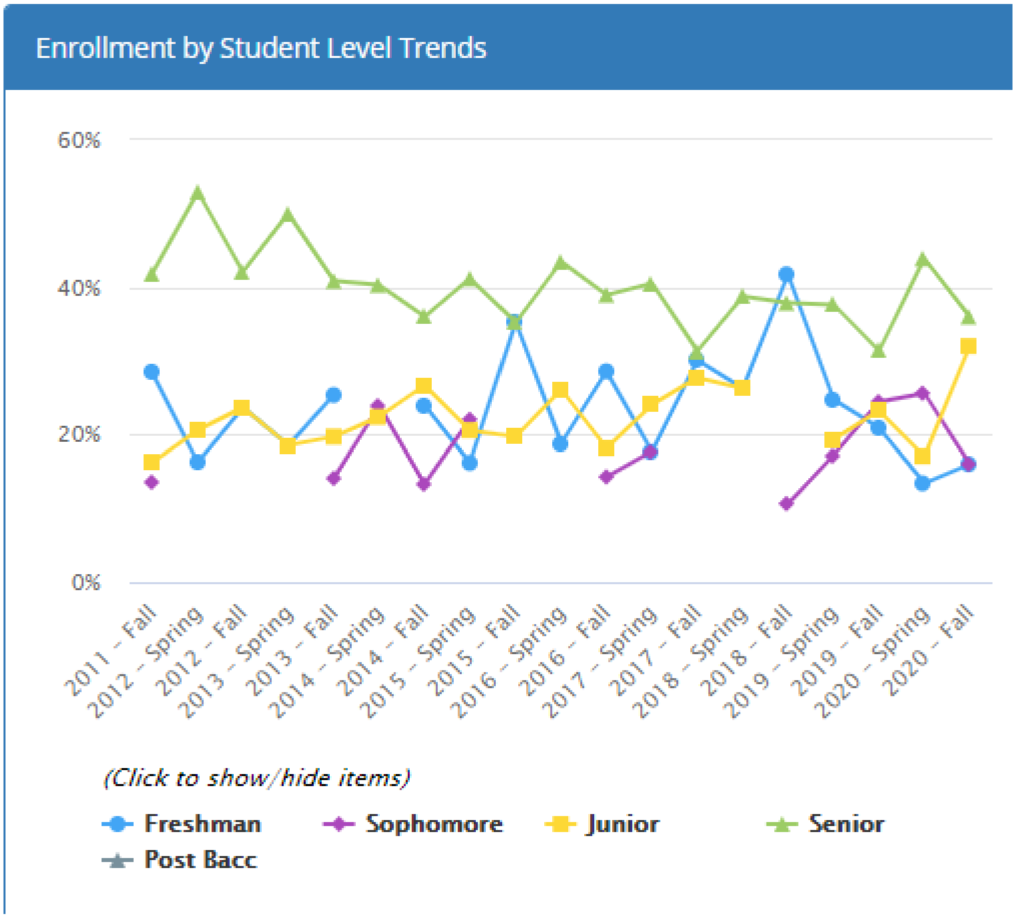

Figure 25. The enrollment of students in the chemistry major, showing the trends in class (Fr, Sop, Jr. Sr.) level.

Student Gender

Over the last five years, the chemistry department has maintained a high percentage of female graduating chemistry majors with an overall average above 50% **(Figure 22)**. This is slightly lower than the female population at Sonoma State overall as seen in Figure 26.

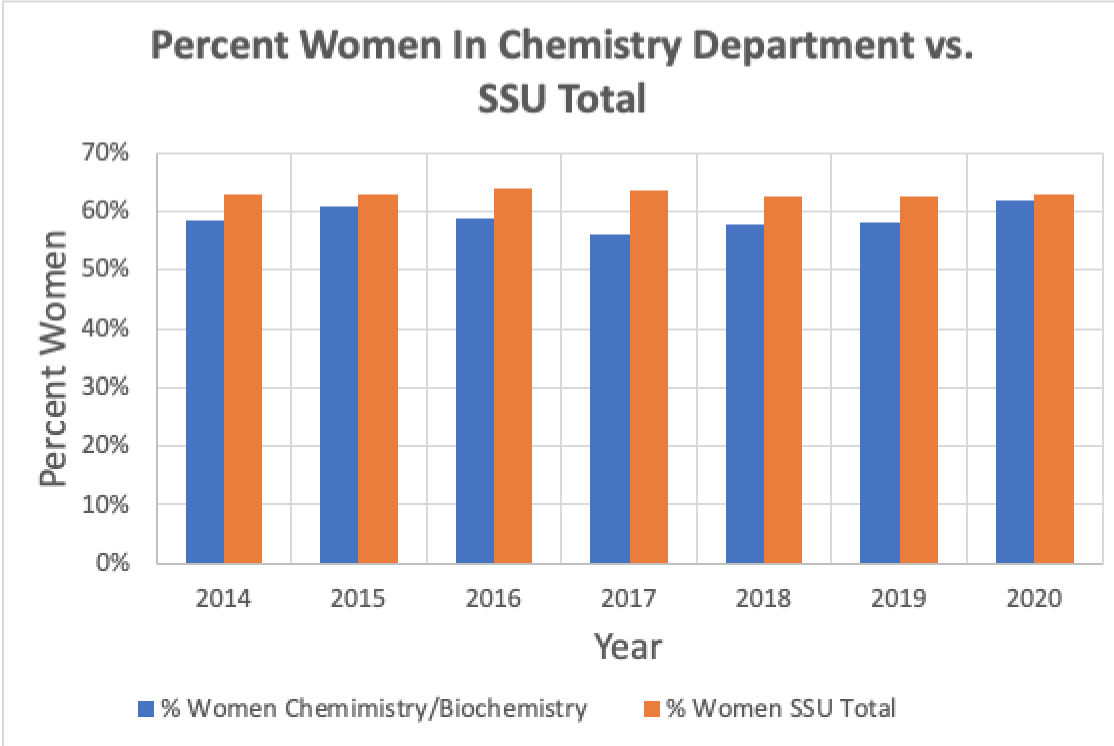

Figure 26. Percentage of women in the Chemistry department compared to Sonoma State total.

Growth of the chemistry department

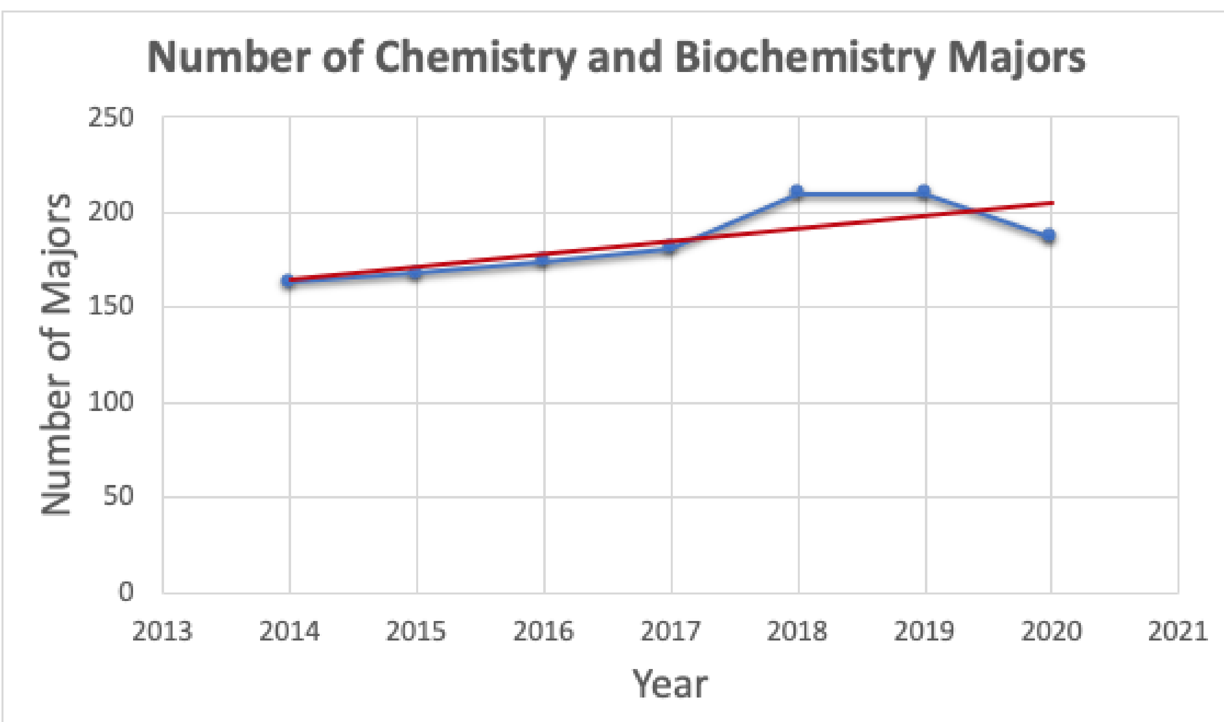

Figure 27. Growth of the Chemistry Department: Number of Chemistry and Biochemistry Majors overall.

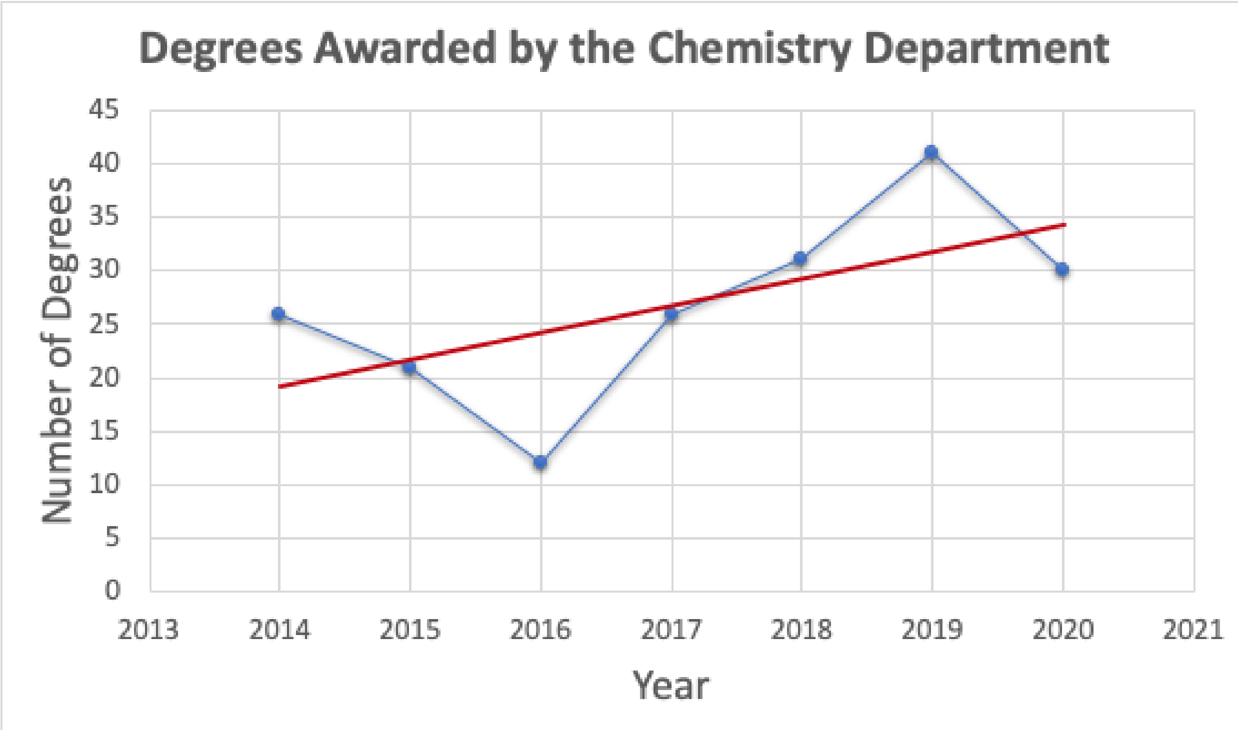

Figure 28. Degrees awarded by the Chemistry Department

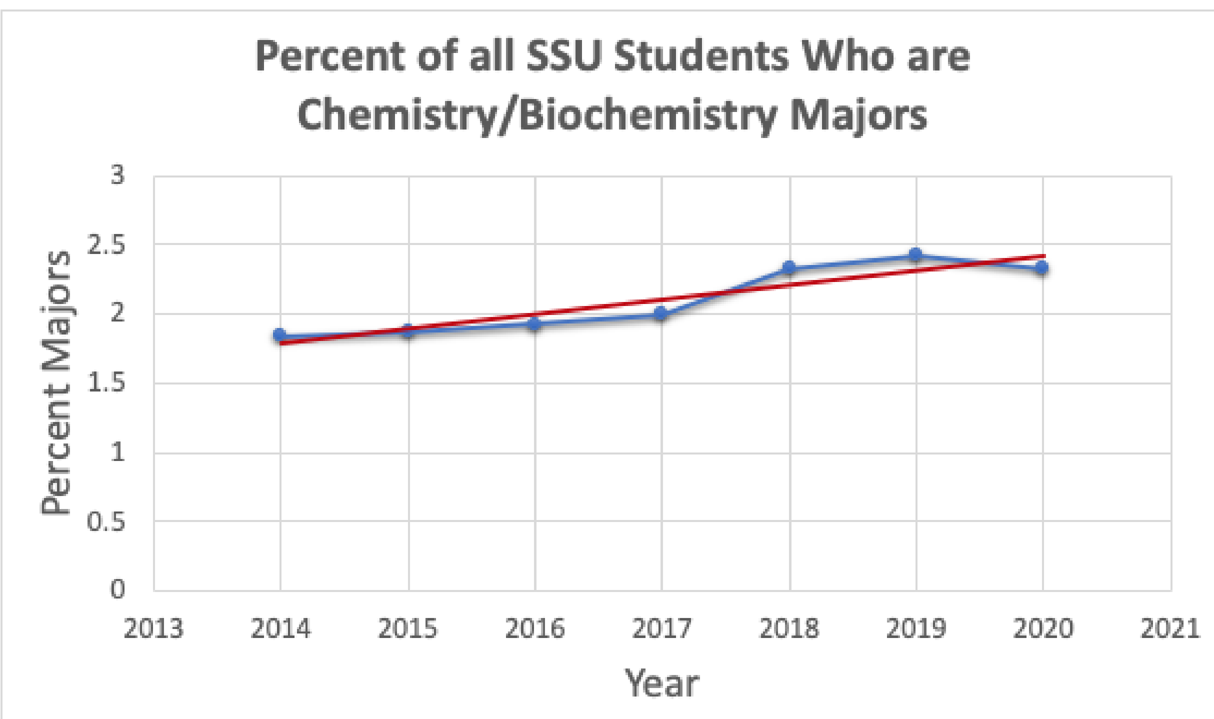

Figure 29. Percent of all SSU students who are chemistry/biochemistry majors.

Chemistry club

The chemistry department has an active chemistry club with an average of 20 members. The chemistry club has been increasingly active with community outreach events such the National Chemistry Day demonstrations and attending the science fairs of local elementary schools. Also, the chemistry club has held social events such as ski trips, hosting invited speakers, trips to local theme parks, and tours of local industries. The chemistry club is supported by the chemistry department through the sales of laboratory manuals.

What are our students doing after graduation?

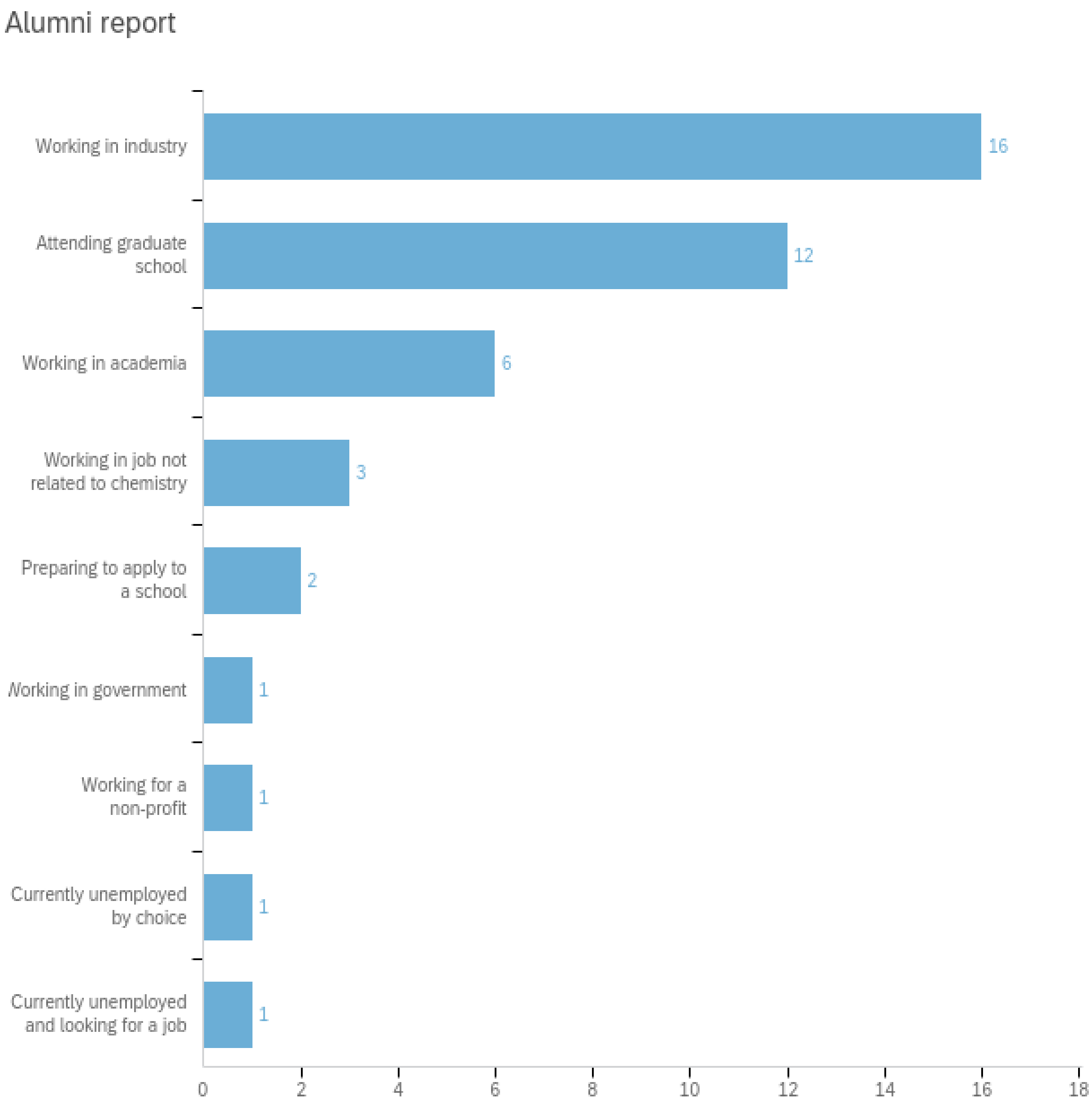

Figure 30 shows the different paths our majors have taken after graduation.

Reflection and Proposed Plan of Action

Challenges Facing the Department

As mentioned in the introduction of this self-study the Chemistry Department experienced major trauma over the last five years that has fractured the faculty. The department participated in conflict resolution that failed because not all faculty members would participate and there was little support from the administration. In addition, the department had a failed search and two faculty members retired and one has continued to FERP. During the time of writing this program review self-study, another member of the faculty took an interim position in academic programs. This review was written in a year in which we taught mostly remote because of Covid-19. These are major challenges facing the department and will make it very difficult for the department to move forward in a productive manner that supports faculty, staff and students.

Leadership and department organization has been another challenge for the department over the last five years. Since the last program review, the University has adopted google as the email and cloud options. This has caused chemistry to move all of the department files from the faculty shared drive to a google drive but not all lecture faculty have access to that drive as they ebb and flow. In addition, to share all files several faculty members have shared folders with content and now we have started sharing Canvas shells to collect course information for things like General Chemistry where everyone teaches these courses.

Curriculum reflection and summary

Over the last five years the department has made several curricular changes. The department has changed the FLC to support more students in the first year and include students that fall into all math categories upon acceptance to SSU. This included eliminating the General Chemistry with Quantitative Analysis course which was hard to justify to the ACS and which we struggled with students feeling successful in that course. The FLC now combines a year long critical thinking course with a oral communication course and we encourage students to also take General Chemistry through pre-enrollment. The department realizes that these mechanisms of cohorting may change but the department is committed to the idea of cohorting these students. For the students that are not prepared for General Chemistry according to their math placement we are cohorting them with the General Chemistry students by placing them all into Chemistry 120ab (thinking and communicating like a scientist).

The department also redesigned the integrated lab course CHEM 401 to become an upper division General Education course in Science. This redesign will allow students to complete this GE requirement in the major. During this revision the faculty was split on also making CHEM 401 a writing intensive course (WIC) and since all of the TT faculty teach in this course the faculty didn’t pursue this option. Since SSU seems dedicated to getting rid of the WEPT option to satisfy the GWAR CSU requirement, the department will revisit this option.

The department also developed two upper division general education courses, CHEM 300 and 301. These courses are; The Sustainability of Chemistry and Sexisum, Racism and Bias in Medicine and Science, respectively. These classes will be taught in the fall 2021 semester for the first time and the department will need to revisit and revise as appropriate.

7-Year Action Plan

1. Request administrative help in supporting the department to build trust so that the TT can support and serve students. Currently the situation doesn't allow for the maximum amount of support for students to be successful.
    a. Support for restorative justice sessions for faculty.
    b. Conflict resolution training for faculty.
    c. Creation of an ombudsperson position.
2. The faculty develop a reasonable and robust assessment plan.
    a. Include a yearly assessment report as had been required by Academic Affairs in the past
3. The department should think about building more connections with local industry and an internship program.
4. Continue to support students in research but think about more applied focus to help students transition into careers.
    a. Work with professional advisors in the Career Center to implement career focused curriculum into CHEM 497.
    b. Invite alumni to speak in CHEM 497 about their transition after graduation from SSU.
    c. Continue to give the Career talk in CHEM 492/497 to help students set long term career goals.
5. Embed more intensional push points with the Career Center in both the FLC and the Senior Seminar course.
6. Continue to support high touch hands-on learning experiences.
7. Formalization of Service Learning and Writing Intensive Courses.
    a. Discuss the possibility of making a more formal Service Learning Project between the First Year Learning Community and the CHEM 496 (CHEM elective).
8. Chair or department committee work on determining if the department's current goals are still relevant. At the beginning of the year, the department can work on setting goals for that year with measurable objectives, develop a timeline to achieve those goals, and assess the status of goals at the end of each year for an annual report. This report could be used to communicate our accomplishments and needs to the dean as well as in the next Program Review.
9. Develop a plan for how we keep, organize, and access information (Google Shared Drive).
10. Discuss if we want to continue to develop events or activities to raise our profile.

11. Hiring plan is to reach 10 tenure track faculty (2 organic, 2 biochem, 2 physical/analytical, 2 inorganic, 1 green/sustainable, 1 educational).
12. Think about classes at night or scheduling in general - for example gen chem (TTh vs MW)

Appendices

A) Curriculum map
B) Syllabi from the previous year
C) Department Policies
D) Faculty CVs
E) Chemistry department 4-year plans

Appendix A-Curriculum Map

	Learning Outcomes for All Three Chemistry Programs, BS Biochemistry, BS Chemistry and BA Chemistry							
Course Number and Names	Read and interpret chemical literature and communicate science effectively in both oral and written formats	Understand properties and reactivity of atoms and molecules.	Proficient at experimental design with documentation and generation of useful data. Including the proficiency of data manipulation, interpretation and the forming of conclusions based on data.	Use chemicals, standard glassware, and instrumentation safely and effectively.	Work towards ethical behavior and developing awareness of bias in experimental expectations and social interactions.	Apply a deep mathematical foundation for application to chemical problems.*	Implement experiments for a novel research problem and demonstrate scientific independence. *#	Describe and apply the relationship between structure and function for biological molecules and how these relationships dictate chemical reactivities in metabolism and life.#
CHEM 115A/B- General Chemistry		Introduced	Introduced	Introduced	Introduced			Introduced
CHEM 120A/B - Thinking Like a Scientist	Introduced	Introduced	Introduced		Introduced			
CHEM 255 - Quantitative Analysis		Developed	Developed	Developed	Developed			
CHEM 335A/B - Organic Chemistry		Developed						Developed
CHEM 336A - Organic Chemistry Lab I	Developed	Developed	Developed	Developed	Developed			
CHEM 336B* - Organic Chemistry Lab II	Developed	Developed	Developed	Developed	Developed			
CHEM 310A/B - Fundamentals of Physical Chemistry		Developed				Developed		
CHEM 315*#- Introduction to Research Methods in Chemistry	Developed	Developed	Developed	Developed	Developed		Developed	
CHEM 316*# - Research Methods in Chemistry	Developed	Developed	Developed	Developed	Developed		Mastered/Demonstrated	
CHEM 325 - Inorganic Chemistry	Mastered/Demonstrated	Mastered/Demonstrated	Mastered/Demonstrated					
CHEM 397$ - Chemistry Practicum	Developed	Developed	Developed	Developed	Developed			
CHEM 401*# - Senior Integrated Lab	Mastered/Demonstrated	Mastered/Demonstrated	Mastered/Demonstrated	Mastered/Demonstrated			Developed	
CHEM 402* - Advanced Synthesis and Instrumental Analysis	Mastered/Demonstrated	Mastered/Demonstrated	Mastered/Demonstrated	Mastered/Demonstrated	Mastered/Demonstrated		Mastered/Demonstrated	
CHEM 441# - Biochemical Methods	Mastered/Demonstrated	Mastered/Demonstrated	Mastered/Demonstrated	Mastered/Demonstrated	Mastered/Demonstrated		Mastered/Demonstrated	
CHEM 445 - Structural Biochemistry	Developed	Developed	Developed					Mastered/Demonstrated
CHEM 446# - Metabolic Biochemistry	Developed	Developed	Developed			Developed		Mastered/Demonstrated
CHEM 475 - Instrumental Analysis		Developed	Developed					
CHEM 494$ - Undergraduate Research	Mastered/Demonstrated	Mastered/Demonstrated	Mastered/Demonstrated	Mastered/Demonstrated	Mastered/Demonstrated		Mastered/Demonstrated	
CHEM 496 - Selected Topics in Chemistry	Mastered/Demonstrated	Mastered/Demonstrated	Mastered/Demonstrated		Mastered/Demonstrated			
CHEM 497 - Research Seminar	Mastered/Demonstrated	Mastered/Demonstrated	Mastered/Demonstrated					
Student Learning Level								
Introduced								
Developed								
Mastered/Demonstrated								
*- Specific to BS Chemistry degree								
#- Specific to BS Biochemistry degree								
$- Optional course								

Appendix B - Course Syllabi

Appendix C - Department of Chemistry Policies

Appendix D - Faculty CVs

Appendix E - Four Year Plans

Bachelor of Arts in Chemistry

<u>Sample Four-year Program for B.A. in Chemistry</u>

Freshman Year:

Fall semester (16 units)	*Spring semester (18 units or 17 units)*
CHEM 115A (5) -GE B1	CHEM 115B (5)
MATH 161 (4) – GE B4	MATH 211 (4)

CHEM FLC: CHEM 120A (3) –GE A1	PHYS 114 (4) or PHYS 210A (3)
GE-A2(3)	PHYS 116 (1) or PHYS 209A (1)
UNIV 102 (1)	CHEM FLC: CHEM 120B (3) –GE A3
	UNIV 102 (1)

Sophomore Year:

Fall semester (13 units or 12 units)	*Spring semester (16 units)*
CHEM 335A (3)	CHEM 335B (3)
CHEM 336A (2)	University Elective (3)
PHYS 214 (4) or PHYS 210B (3)	CHEM 255 (4)
PHYS 216 (1) or PHYS 209B (1)	GE (3) – LD Area C
GE (3)-LD Area E (recommend SCI 220)	GE (3) -LD Area F

Junior Year:

Fall semester (12 units)	*Spring semester (15 units)*
CHEM 310A (3)	CHEM 310B (3)
University Elective (3)	GE (3)- LD C
GE (3) – LD B2 (recommend no lab)	GE (6) – LD D
GE (3) – LD C	University Elective (3)

Senior Year:

Fall Semester (16 units)	*Spring Semester (14 units)*
CHEM 401 (3) – GE UD B	CHEM 325 (3)
CHEM 475 (3)	CHEM 497 (1)
CHEM Elective (Special Topics Major Elective) (4)	University Elective (10)

GE (6) UD C and D	

Bachelor of Science in Chemistry (certified by the American Chemical Society)
<u>Sample Four-year Program for B.S. in Chemistry</u>

Freshman Year:

Fall semester (16 units)	*Spring semester (18 units)*
CHEM 115A (5) – GE B1and Lab	CHEM 115B (5)
MATH 161 (4) – GE B4	MATH 211 (4)
CHEM FLC: CHEM 120A (3) –GE A1	PHYS 114 (4)
GE (3) – A2	PHYS 116 (1)
UNIV 102 (1)	CHEM FLC: CHEM 120B (3) – GE A3
	UNIV 102 (1)

Sophomore Year:

Fall semester (14 units)	*Spring semester (15 units)*
CHEM 335A (3)	CHEM 335B (3)
CHEM 336A (2)	CHEM 336B (2)
PHYS 214 (4)	CHEM 255 (4)
PHYS 216 (1)	GE (3) LD B2 (recommend class without a lab)
MATH 261 (4)	GE (3) E (recommend SCI 220)

Junior Year:

Fall semester (13 units)	*Spring semester (15 units)*
CHEM 445 (3)	CHEM 310B (3)
CHEM 310A (3)	CHEM 316 (2)
CHEM 315 (1)	CHEM Elective (Special topics in chemistry) (4)

GE (6) – LD C	GE (6) – LD D

Senior Year:

Fall Semester (16 units)	*Spring Semester (13 units)*
CHEM 401 Met-in-Major UDGE area B (3)	CHEM 325 (3)
CHEM 475 (3)	CHEM 402 (3)
CHEM Elective (Special Topics in Chemistry) (4)	CHEM 497 (1)
GE (6)- LD C and F	GE (6) – UD C and D

Bachelor of Science in Biochemistry
<u>Sample Four-year Program for B.S. in Biochemistry</u>

Freshman Year:

Fall semester (16 units)	*Spring semester (18 units or 17 units)*
CHEM 115A (5) -GE B1 and Lab	CHEM 115B (5)
MATH 161 (4) – GE B4	MATH 211 (4)
CHEM FLC: CHEM 120A (3) –GE A1	PHYS 114 (4) or PHYS 210A (3)
GE (3) – A2	PHYS 116 (1) or PHYS 209A (1)
UNIV 102 (1)	CHEM FLC: CHEM 120B (3) –GE A3
	UNIV 102 (1)

Sophomore Year:

Fall semester (14 units or 13 units)	*Spring semester (15 units)*
CHEM 335A (3)	CHEM 335B (3)
CHEM 336A (2)	CHEM 255 (4)
PHYS 214 (4) or PHYS 210B (3)	BIO 321 (4)

PHYS 216 (1) or PHYS 209B (1)	BIO 325 (1)
BIO 130 (4) – GE B2	GE (3) – LD E SCI 220

Junior Year:

Fall semester (13 units)	*Spring semester (14 units)*
CHEM 310A (3)	CHEM 310B (3)
CHEM 315 (1)	CHEM 316 (2)
CHEM 445 (3)	CHEM 446 (3)
GE (6) – LD C	GE (6)- LD D

Senior Year:

Fall Semester (16 units)	*Spring Semester (13 units)*
CHEM 401 (3) UD GE B	CHEM 325 (3)
CHEM 475 (3)	CHEM 441 (3)
CHEM or BIO Elective (4)	CHEM 497 (1)
GE (6) – LD F and C	GE (6) – UD C and D

*Note that students will need 1-3 elective units to reach 120 total units to graduate.

Requirements for a Chemistry Minor at Sonoma State University

One year of general chemistry with lab, one semester of organic chemistry with lab, one semester of analytical chemistry taken at any college or university. In addition six upper division units must be taken at Sonoma State University.

Courses	**Units**	**Location**	**Check box**
General Chemistry I and II	8-10	Any	
Organic Chemistry I or II or the one semester equivalent	4-5	Any	
Analytical Chemistry	4	Any	
6 units from the following	**Total 6**	**SSU**	
*Chem 335B Organic II	3	SSU	
*Chem 336B Organic lab II	2	SSU	
Chem 325 Inorganic	3	SSU	

Chem 310A and/or B Physical I and II	3	SSU	
Chem 445 and/or 446 Biochemistry I and II	3	SSU	
Chem 401 Senior Integrated Lab	3	SSU	
Chem 441 Biochemistry lab	3	SSU	
Chem 496 Selected Topics in Chemistry	1-6	SSU	
Chem 497 Research Seminar	1	SSU	
Chem 494 Research	1-3	SSU	

*If these courses are taken at SSU they will count toward the minor but if these courses are transferred in, they do not count.