Department of Chemistry
Program Review Self-Study Report

Based on
Version 1.1
10/21/2015

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Instructions

Please use the data provided and the guiding questions to prepare your program review self-study. Please note that the data provided is not all of the data available to you and a more complete set of program review data will also be provided by the IE office. Also note that there may be a few questions that are not relevant to your academic unit and you can simply write "NA" in those text boxes where this is the case. Finally, the text boxes are intended for the reflective answers to the guiding questions and the summaries of your analyses. If there are related documents that contain data or more detailed information that will help the reviewers better understand your narratives, feel free to add these as appendices at the end. Please do not include anything in the appendices that is not necessary or referenced and discussed in the self-study itself.

Technical Note: For your convenience, fillable text boxes have been inserted after each question. If you have non-text items (e.g. tables, charts, etc.) you would like to insert into the document, feel free to remove and replace the textbox placeholder with your information.

Department Level Analysis

A) Introduction (context for department)

1. Name of Academic Unit, Program(s), and Center(s) that are included in this self-study: Include graduate and undergraduate, undergraduate majors, minors and concentrations, etc.

Academic Unit: Department of Chemistry

Programs: Chemistry B.S., Biology-Chemistry B.S., Environmental Science B.S.

2. This document will be read by both the PLNU Program Review Committee and external reviewers. What do these reviewers need to know about your current programs to understand their context and how they function within the department and across the university? (500 word maximum)

Chemistry is often referred to as the central science because it sits at the intersection of physics and biology, and, thus is essential to a wide range of topics. In fact, chemistry is involved in virtually every aspect of our modern society and is an essential component to address many of our world's current problems. It is also an integral part of a traditional liberal arts program teaching the fundamentals of physical science and thereby providing foundational knowledge to students in numerous other degree programs (including biology, nursing, kinesiology, dietetics, and more). Last year, nearly half of the incoming freshmen took a chemistry course. The Chemistry Department at PLNU is highly regarded, as evidenced by the high quality of our incoming students and the high acceptance rate (>90%) of our graduates into health professions schools and graduate programs. Without a strong chemistry program, students in these other disciplines would not be as successful in gaining entry into postgraduate schools or the work force.

3. If you believe that it will help the reviewers to understand your context, provide a brief history of what has led to your department's current structure and program offerings.

The modern era of science at Pasadena College (PC) started in 1960 with Val Christensen, and a new science building. Val, determined to build an outstanding chemistry program, found the perfect partner in Vic Heasley. Val and Vic knew that by combining high quality teaching with the excitement of original research they could provide a chemistry education few could match.

They established a standard chemistry curriculum but added to it a novel undergraduate research program. By 1968 PC had its first peer-reviewed scientific article published. The summer research program has run every summer since, fueled by over $2M in external grant funding. This small two and three man department has mentored over 260 students. Their work was presented in 137 peer reviewed articles (over one per faculty member per year) and 148 conference presentations.

In 1976, chemistry and biology created the innovative Biology-Chemistry joint major; one ideally designed for students planning careers in medicine, pharmaceuticals or biotech industries. This major has an incredible track record, preparing students for post graduate studies in science and/or medicine.

The American Chemical Society (ACS) has established curricular guidelines for the B.S. in Chemistry and our curriculum has been designed and shaped in order to meet those guidelines to the extent possible in our liberal arts environment.

In the last decade the department has undergone a generational transition. Now there are new talented and inspiring chemists building on this strong tradition.

B) Alignment with Mission

Please answer the following questions for all student populations served by your department: residential, graduate and extended learning:

1. Briefly describe how your department contributes to the intellectual and professional development of PLNU students.

Chemistry is in the mainstream of liberal arts and our program - which provides a quality undergraduate education - is completely consistent with the mission and vision of PLNU: past, present, and future.

The educational experience offered by the Chemistry Department has always focused on the fundamentals of chemical science, thereby preparing students for post graduate studies, teaching, and laboratory work. The experiences offered to students go far beyond technical training. An understanding of our world at the molecular level provides a profound understanding of the foundational aspects of God's creation.

With small classes and extensive student-faculty interaction, graduates have the ability, training, and determination to make a positive impact on their world. For the past fifty years the department has had a deliberate and consistent program of student mentoring. Almost all students work with faculty members as lab TA's: setting up experiments, and teaching their peers. Later, most will work one-on-one with a faculty member on an original research project, learning how chemists acquire new knowledge. We offer educational opportunities to the broadest possible group of students. Everyone who comes to us deserves the chance to discover their capacities. Many have benefited from this "opportunity school" philosophy. Our alumni are doing remarkable work!

2. Review your department's mission, purpose and practice and discuss how your programs contribute to your student's spiritual formation, character development, and discernment of call.

The mission of the Chemistry Department at PLNU coincides with the University mission to Teach, Shape, and Send.

To Teach: Our commitment is to provide students the opportunity to build a broad foundation of knowledge and understanding of the discipline of chemistry, to develop skills in the process of science, and in the practice of critical thinking and quantitative analysis; skills that are required to apply their education to real world situations.

To Shape: In addition to the formal academic interactions, each student will have opportunities to enter into mentoring relationships with our faculty through advising, lab assisting, research activities, and departmental social functions. In this way we intend for our students to grow and mature as professionals and as individuals, coming to understand team work and to value personal integrity. We also expect our students to be in dialogue with us about issues relating to their personal and professional goals, and the interface between science, society, and Christian faith.

To Send: The graduates of this department will be able to apply both their faith and scientific understanding to addressing real world problems in professions such as medicine, allied health fields, education, and industry. They will feel confident that they are well prepared to make positive contributions in their world.

The Chemistry Department has recently developed ideas both inside and outside of the classroom to contribute to our student's spiritual formation, character development, and discernment of call. We received a vocation grant that allowed us to purchase books for a departmental book discussion about vocation and calling and organize career/vocation dinners with our students. Our department met during the summer of 2014 to discuss the book "Living Your Hearts Desire: God's Call and Your Vocation" by Gregory Clapper and dialogue about how to help our students discern their vocation and calling. In the spring of 2015, we organized our first dinner where two faculty members shared their vocational and faith journeys with about 12 students and it was well received. One faculty member joined a Wesleyan discussion group during the summer of 2015 in order to include Christian practices in his classroom. Several other faculty members have tried to incorporate Christian practices into their classes after Dr. David Smith's presentation and workshop about "Teaching as a Christian Practice" at the Faculty Development Day in fall 2015. These practices will hopefully contribute to our student's spiritual formation and character development.

C) Quality, Qualifications and Productivity of Department

Current Full-Time Faculty				
Faculty Name	**Rank**	**Tenure**	**Degree**	**PLNU Service Years**
Beauvais, Laurance	Assistant	Tenure-track	PhD	2
Choung, Sara	Professor	Tenured	PhD	11
Jansma, Ariane	Assistant	Tenure-track	PhD	1.5
Maloney, Katherine	Associate	Tenure-track	PhD	3.5
Martin, Kenneth*	Professor	Tenured	PhD	25
Perry, Marc	Associate	Tenure-track	PhD	5
Rouffet, Matthieu	Associate	Tenure-track	PhD	4
Department percent of full-time faculty with doctorate (terminal) degree				**100%**
PLNU percent of full-time faculty with doctorate (terminal) degree (Fall 2014)				**82%**

*Ken Martin is in the 2nd year of the early retirement program. In 2015-16 his load is scheduled to be 50%.

1. Summarize the most recent scholarly and creative activities of the faculty in this department. If desired, include information about peer reviewed scholarship.

All of the full-time faculty in chemistry (and an emeritus faculty member) are involved in scholarly work. Building on the rich history of undergraduate research that began at Pasadena College in 1965, most of this scholarship takes the form of original research (Scholarship of Discovery) with PLNU students. This paradigm has been adopted by virtually all Chemistry Departments at highly-ranked undergraduate institutions. It is characterized by an intense level of mentorship by the guiding faculty member, who designs the project, directly supervises student researchers, writes grants (to obtain external funding), and writes manuscripts (with students as coauthors) for peer-reviewed publication. One faculty member, Sara Choung, focuses on the Scholarship of Application in her work with pre-health students. 100% of our full-time faculty have published peer-reviewed scholarship (in the form of high-impact scientific journal articles) since completing their PhD. All told, currently active chemistry faculty have published a total of 236 peer-reviewed publications - 35 of these in the last five years. Our focus on involving undergraduates in the research enterprise has yielded 153 peer-reviewed journal articles with student coauthors (26 in the last five years), and at least 190 conference presentations with students (55 in the last five years). This is an extraordinary level of scholarly activity particularly considering the size of the department and the teaching load expectations. One would be hard pressed to find many other evangelical Christian colleges with this level of scholarly production. It is all the more impressive considering the great benefit it provides for our students and their careers.

2. Summarize the grants/awards received by the faculty.

As with peer-reviewed scholarship, the chemistry faculty have a long and impressive history of applying for, and successfully obtaining, grant funding to support undergraduate research at PLNU. Since Val Christensen and Vic Heasley obtained their first NSF grant for $20,000 in 1965, PLNU chemistry faculty have had at least 66 grants funded, bringing in over $2 million of external support to the university. Several years ago this level of success attracted the attention of the grant office of the Howard Hughes Medical Institute (HHMI). This resulted in an invitation to apply for a major HHMI grant. The application, prepared in cooperation with the biology department was successful, as was a follow up grant request filed several years later. Funding from both grants helped support the undergraduate research program, remodel teaching labs, facilitate outreach efforts to underserved minority students, and generally enhance PLNU's reputation in the broader scientific community.

In the last decade, dramatic reductions in federal funding coupled with ever increasing pools of applicants have made securing external funding exceedingly difficult. Nonetheless, PLNU chemistry faculty have persisted in seeking and obtaining funding. In the past five years, six faculty members have applied for a total of 32 grants (6 internal to PLNU, and 26 to external sources). Of these, 16 grants have been funded bringing over $250,000 of external money to PLNU. Specifically, these funds have come from organizations including the National Science Foundation, Research Corporation for Science Advancement, the American Chemical Society's Petroleum Research Fund, the California Department of Food and Agriculture, and more. Most recently the combined science and math departments have written and obtained an impressive S-STEM grant for $576,750 from the National Science Foundation. Katherine Maloney is identified as the principal investigator (PI) on that grant and it promises to bring significant scholarship aid to academically strong, financially needy students doing interdisciplinary work in the natural and computational sciences.

This degree of grant writing activity indicates the determination of Chemistry Department faculty to help fund the research they conduct with their students and the chemistry program in general.

3. Describe how the scholarly and creative activities of the faculty impact the mission and quality of your department.

Since our summer research program began, more than 280 students have participated: most for two consecutive summers. As an early and successful adopter of the undergraduate research model, Point Loma attained national recognition when in 1984 it was identified by the Council on Undergraduate Research (CUR) as one of four "Cinderella" schools where undergraduate research programs were flourishing. Today, the research program is a major factor in attracting top quality students to our program. It is an integral part of a larger culture of mentoring, with a typical student undergoing a natural progression from being just a student, to serving as a teaching assistant, to conducting original research with a faculty mentor. This progression builds attachment to the department, leading to deep and lasting relationships. The undergraduate research experience has launched hundreds into successful careers in science and medicine. These alumni, therefore, have both the means and motivation to give back to PLNU - and they do! Our graduates have facilitated the donation of dozens of state-of-the art instruments to PLNU. Inspired by their research experiences at PLNU, our alumni formed their own support organization, Research Associates, which has given generously to PLNU since its inception in 1977. Started by the Chemistry Department, this group has established a $200,000 scholarship endowment and provides approximately $40,000 annually to support research in chemistry and biology. We are not aware of any other Christian college Chemistry Department that has so effectively engendered this degree of loyalty from their alumni.

4. Comment on the adequacy and availability of institutional support and outside funding for professional development and travel.

As mentioned above, competition for outside funding in support of chemistry is intense. We expect faculty members to write grant proposals, but can't expect those funds to be the sole support of the research program or professional development. The University has contributed support for the summer research as it can within its limited means. Our faculty regularly use all of their available Faculty Development funds to attend professional conferences, most often to present the results of their research, guide student attendees, or participate in other professional activities such as reviewing grant proposals, ACS governance, and helping prepare standardized exams. These meetings also provide wonderful opportunities for gaining understanding of the major trends in chemical education pedagogy. The cost of attending professional meetings is constantly increasing. Current institutional support is inadequate to cover attending even one conference a year. The American Chemical Society (ACS) is the major professional organization for chemistry (all active chemists would be expected to be members). The typical expenses for attending an ACS meeting in recent years include: registration $550+, air travel $400-600, hotel $175/night for 3 nights, food $100-150 or a total of $1,500 to $1,700. Other meetings that faculty would like to attend are even more expensive and as a result have remained out of reach.

Department Faculty Instructional Loads (FT, PT, and Adjuncts)
(excludes release time and independent studies)

	2012/13	2013/14	2014/15	3-yr Average
SCH per IFTE	**441**	**466**	**449**	**452**
PLNU SCH per IFTE	*TBD*	*TBD*	*TBD*	*TBD*
SFTE per IFTE	**13.78**	**14.57**	**14.03**	**14.14**
PLNU SFTE per IFTE	*TBD*	*TBD*	*TBD*	*TBD*
Independent Studies Units Generated	1	0	1	0.7

Individual Faculty Instructional Loads

	2012/13			2013/14			2014/15			3-Yr
Full-Time Faculty	**IU**	**SCH**	**SCH/ IU**	**IU**	**SCH**	**SCH/ IU**	**IU**	**SCH**	**SCH/ IU**	**SCH/IU**
Beauvais, Laurance				22.0	516	23.5	24.5	723	29.5	26.6
Choung, Sara	8.0	69	8.6	16.0	482	30.1	9.0	111	12.3	20.1
Lingner, David	24.5	451.4	18.4							
Jansma, Ariane				9.0	95	10.6	15.4	174.6	11.3	11.0
Koudelka, Kristopher (Bio)							1.1	15.4	13.4	

Maloney, Katherine	22.0	335	15.2	24.5	281	11.5	12.5	201	16.1	13.8
Martin, Kenneth*	16.0	519	32.4	18.0	445	24.7	19.0	593	31.2	29.4
McConnell, Michael (Bio)	2.3	52	22.5	3.1	84	26.7				
Perry, Marc	25.0	499	20.0	23.5	483	20.6	26.0	518	19.9	20.1
Rouffet, Matthieu	26.0	699.6	26.9	23.5	767.6	32.7	26.5	726	27.4	28.9
• Links to complete reports that include part-time and adjunct faculty o 2014-15 o 2013-14 o 2012-13										
Total Full-Time Faculty	123.8	2,625	21.2	139.6	3,153.6	22.6	134.1	3,062	22.8	22.2
Total Part-Time Faculty	--	--	--	16.0	172	10.8	26.5	293.5	11.1	11.0
Total Adjunct Faculty	51.0	587	11.5	31.0	300.4	9.7	32.5	257	7.9	10.0
IU = Instructional Units: Generated faculty workload units excluding release time IFTE = Instructional Full-Time Equivalent: Total Instructional workload units divided by 24 SCH = Student Credit Hours: Generated student credit hours associated with the faculty member SFTE = Student Full-Time Equivalent: Total Student Credit hours divided by 32 for undergraduates/24 for graduate students										

*Ken Martin was not full-time in either 2014-15 or 2015-16. His load was scheduled to be ¾ of a load in 2014-15 and ½ of a load in 2015-16

5. Compare the SCH load of each faculty member against the departmental average. What does this tell you about the distribution of faculty workload within the department? What changes, if any, might be appropriate?

The SCH loads are all quite rationally based on the normal faculty teaching assignments within the department. In typical Chemistry Departments, faculty members are assigned to teach particular courses based on their professional training as well as the department needs. This is true for us as well. All faculty in our department also teach both upper-division and lower-division courses and most are involved in one or more GE or service courses.

There are some anomalies in the 3-year averages reported above. These deserve some comments. It should be noted that Ariane Jansma started in the spring semester of 2013-14 so her load was intentionally light that year with new faculty orientation. Kris Koudelka was involved in the CHE450 course only one year (2014-15) as he and Ariane Jansma were re-designing the companion courses of CHE450 and BIO380. His involvement in the department was a one-time only situation. Katherine Maloney had a maternity leave in 2014-15 so her 3-year average is low. Sara Choung had a sabbatical in 2012-13 so that perturbed her average as well. Finally, Ken Martin was not a full-time faculty member in 2014-15 as he was in the early retirement program and as such was to be assigned ¾ of a full load.

The department faculty members are involved in many other activities that are beneficial to our students but not included in the IU calculations. These include maintaining and repairing department instrumentation, coordinating and overseeing laboratory activities (different from teaching the lab activity), directing student research projects, arranging field trips, connecting students with alumni mentors, giving advice on job searches and resume writing, etc.

One final observation, the 2014-15 Instructional Unit (IU) total of 193.1 is fairly typical, although there might be a slight reduction (2-6 units) with the increased capacity of the nursing and organic laboratory rooms in Sator Hall. In addition to the IU workload there are 16.5 release load units for the department (7 for chair, 4 for pre-health advisor, and 5.5 for lab coordinating and Research Associates work). Together that sums to a total of 209.6 total workload units. Six full time faculty members can be expected to cover 144 of those units if everyone commits to teaching 24 units. The lab manager can be assigned to teach another 12 units for a total of 156. The difference between 209.6 and 156 leaves the department with 53.6 units of unassigned workload. With that many unassigned units there is ample justification for hiring a new physical chemist even without making the case based on the missing curricular expertise a physical chemist will bring. Even after a seventh faculty member is hired to replace Dr. Martin the department will still have the equivalent of a one and a quarter full time equivalent faculty position to be covered by adjuncts.

193.1	typical instructional workload units
16.5	typical release load units (7 chair, 4 pre-health advisor, 4.5 labs coordinators, 1 RA)
209.6	total workload units
-144	6 full time faculty at 24 units/year
-12	teaching units for lab manager
-53.6	uncovered teaching units (2.23 FTE faculty). 28% of curriculum taught by adjuncts!

Based on the analysis of faculty workload, filling Ken Martin's position is appropriate. Hiring a tenure track physical chemist would eventually reduce that total by 24 still leaving 29.6 unit (1.23 FTE) to be taught by adjunct instructors. Even that number of adjunct units is too low considering that adjuncts will also be covering faculty sabbaticals, one of which should be occurring every year with a faculty as committed to scholarship as the Chemistry Department faculty.

6. Does looking at the SCH and SFTE to IFTE ratios compared to PLNU averages provide any insights for your program? Explain.

N/A because the PLNU SFTE and IFTE data is not available yet.

7. Looking at the longitudinal history of independent study units generated in this program, does this provide any insights that might be worth looking into? Explain.

Independent study units are hardly ever used in the Chemistry Department (0 or 1 unit per year for last three years).

8. What role do part time and adjunct faculty play in the quality and success of the department.

In chemistry we have used part-time and adjunct instructors primarily to teach laboratory sections. Secondarily, they were used in the classroom when course demand exceeded full-time staffing. Adjuncts have also been used to cover faculty leaves (maternity, sabbatical, institution-approved reduced workloads, etc.). Over the years we have had both positive and negative experiences with adjunct faculty. The part-time and adjunct faculty we have used in recent years are all mission compatible; some are even our own alumni. They also have the appropriate academic training, most having advanced degrees.

We value the contributions of our part-time and adjunct faculty who have been teaching in our department for several years, and invest their time and energy into the department and our students. A number of our adjuncts bring outside perspective with them since they have experience teaching at various colleges and universities. In addition, one part-time faculty member teaches in both the Biology and Chemistry Departments and has cross-departmental perspective. They are willing to teach evening lab sections, which accommodates the larger number of lab sections that are required for our higher enrollment courses.

Nevertheless, the use of adjunct faculty has sometimes resulted in uneven instructional quality. In chemistry the lab activities are frequently used to reinforce course content as well as teach good laboratory techniques. The lab instructor must be aware of those goals. The difficulty often comes with our large enrollment courses that have multiple lab sections requiring several adjunct instructors. Some of this can be addressed by careful and consistent communication between the lab coordinator and multiple adjuncts, but this can be challenging and it will never be as seamless as if the course instructors taught their own labs. In addition, adjuncts have limited availability relative to what students have come to expect of the full-time faculty in our department. Many of our lab sessions are at night (at least 4-6 per semester) leaving the adjuncts even more isolated from the full-time faculty and less easily supervised.

D) Progress on Recommendations from Previous Program Review

1. List the findings from the previous program review and discuss how each finding has been addressed.

In the mid 1990's the Chemistry Department was the first PLNU department to complete a program review cycle. At that time the outside reviewers noted the deficiency in our inorganic chemistry offerings and they recommended that we find a systematic way of boosting retention in the general chemistry sequence. As a result, it was agreed that we hire an inorganic chemist and add a 2-unit quad class in inorganic chemistry as a beginning step. We also added a 1-unit general chemistry tutorial course as a result of that review. Those are the only increases in our offering in the past 25 years, although there have been many curricular adjustments and alterations in that time.

A follow-up department review was started in 2005 and although not formally completed (the whole process was being revised in those years). The study concluded that our students were being well served by the departmental offerings and that there was ample evidence that our alumni had been well prepared for advanced studies and/or laboratory work in chemistry.

2. What additional significant changes have been made in department programs since the last program review? (e.g. introduction of new major or minor, significant reshaping of a program, etc.)

A number of changes have been made in the last decade to better serve our students and insure consistency with similar programs elsewhere in the United States. The Chemistry major was switched from a BA to a BS in 2005. The BS is a more typical designation for the kind of chemistry degree we offer. In 2011, the two sophomore year organic chemistry courses were changed from a 5-2 to a 4-4 unit course sequence, making a balanced and more transfer-friendly introductory sequence. That same year Analytical Chemistry was expanded from a 2 unit quad course to a 3 unit semester course, allowing coverage of more topics and bringing it more closely in line with programs at similar institutions and with American Chemical Society (ACS) guidelines. Again in 2011, a special topics course was converted into a bioinorganic chemistry course to offer content more closely aligned with the needs of our Biology-Chemistry joint majors. We are currently in the process of re-designing the traditional inorganic chemistry course to better serve the needs of straight Chemistry majors. Our two advanced organic chemistry courses have also been re-conceived to meet the needs of this generation of students. CHE351, a classical Organic Qualitative Analysis course that remained virtually unchanged for over 40 years, was revamped in 2012 as a modern course in Organic Structure Elucidation using state-of-the-art instrumentation and data analysis. Advanced Organic Chemistry (CHE453) has been taught covering the field of transition metal catalysis within organic chemistry. This is such a critical part of modern synthetic chemistry that it needed to be included in the curriculum. The lab (CHE454) has also been taught using a research model where the students are actually carrying out research with unknown results. This helps to ensure that all students, whether they participate in summer research or not, get a research experience as part of their education. Other changes are being considered. Some are even now awaiting APC and faculty approval.

All of these changes are being made to better align our program with the guidelines of the American Chemical Society (ACS). None of these changes increase the size of the Chemistry major or the chemistry portion of the joint majors we share with the Biology Department. They represent a reorganized and optimized version of our already lean curriculum. Given the diversity and expertise of our current staff, attaining ACS approval is a logical next step and it will be an important student recruiting tool moving forward. More of our competitors have ACS approved programs and an increasing number of students and their parents are asking why our program is not ACS approved. For years we have conformed as closely as possible to ACS guidelines. Getting ACS approval for our program is well within reach and it will provide a further endorsement of the quality of our programs.

One final point, the Chemistry Department has worked closely with other departments across campus on the development of interdisciplinary minors involving the natural and computational sciences along with business to provide students with a more specialized skill set if that is their interest. These are new programs that are just now being promoted.

E) General Education and Service Classes

Link(s) to the Department's GE data stored on the GE assessment wheel:
• CHEM_Evidence_2014-2015 Assessment Report_GELO

Reflection on longitudinal assessment of general education student learning data: (If you don't have longitudinal data, use the data that you do have)

1. What have you learned from your general education assessment data?

We are responsible for assessing GELO 1e: Quantitative reasoning. We have assessed all of our GE courses using problems from the cumulative final exam that are quantitative in nature. We have only obtained the data in one academic year and a few of our courses did not meet our criteria for success. It will be difficult to make any recommendations without seeing some longitudinal data.

2. What changes (curricular and others) have you made based on the assessment data?

We will not be able to make meaningful recommendations for change until we have obtained longitudinal data.

3. What additional changes are you recommending based on your review of the assessment data?

N/A

4. How do the pedagogical features of your GE courses compare with the best practices for teaching GE in your discipline?

Within our department, we have two different types of GE courses with distinctly different audiences. First, CHE152 (General Chemistry I) or CHE103 (Introduction to General, Organic, and Biological Chemistry) are required courses for a variety of majors and only rarely has a student signed up for one of these courses for the sole purpose of meeting their physical science GE requirement. Second, we have our traditional GE courses CHE101 (Chemistry in Society) and PSC110 (Physical Science).

The American Chemical Society (ACS) has stated in their Guidelines for Bachelor's Degree Programs the following regarding pedagogy: "Faculty should incorporate pedagogies that have been shown to be effective in undergraduate chemistry education. Examples include problem- or inquiry based learning, peer-led instruction, learning communities, and technology-aided instruction such as the use of personal response systems and flipped or hybrid classes."

The pedagogical features used in our GE courses compare favorably with the best practices from within our discipline. The details of pedagogy used in our GE courses are described in #5.

5. What new pedagogical practices have been tried in GE and service classes by members of your department in the last few years? What has your department learned from these experiments?

Chemistry faculty participate in many activities designed to understand best practices in teaching, and to put them to use on a daily basis. Chemistry faculty have attended a variety of events directed at LEARNING about best practices which include:

- Scientific Faculty Learning Community
- Chemical Education session at national ACS conference
- Project Kaleidoscope (conferences in STEM education)
- Team-Based Learning Workshop
- NSF funded project developing interdisciplinary course modules
- Training opportunities offered by Center for Teaching and Learning

Chemistry faculty have also been invited to give talks related to teaching best practices in the following areas:

- General Chemistry Technology with McGraw-Hill Publishing
- Student engagement techniques at SDSU
- Use of iClickers for assessment at Claremont Colleges

Some of the pedagogical features used in our GE courses includes:

- Team-Based Learning
- Flipping the classroom
- Use of clickers
- Enhancement of student engagement using mini whiteboards and iPads
- Online homework systems

Because these pedagogy changes were incorporated recently and limited data has been collected for our GE courses, it is difficult at this time to say what the impacts the use of different pedagogies has had on our GE courses. As a faculty, we value student engagement and will continue to strive for the best possible student learning experience and make efforts to expand these pedagogies into more of our GE courses.

6. Are there changes that you could make that would make your part of the GE more efficient and effective (e.g. reducing the number of low-enrollment sections, resequencing of classes, reallocation of units, increase interdisciplinary efforts, etc…)?

The Chemistry Department has only a minor involvement in the GE program. We teach only one purely GE course (Chemistry and Society) and we co-teach with Physics one other (Physical Science). Chemistry and Society is only taught in the spring semester and it was divided into two sections some years ago when the total enrollment exceeded 75 students. Physical Science, a lab course, is taught every semester to between 36 and 40 students. This number is limited by the size restrictions of the two accompanying lab sections (20 students each). Due to prioritization this course was recently changed to a 3+1 course in which the lecture counts for 3 units and lab counts as 1 unit. Neither of these courses could be eliminated, nor could the number of sections be reduced barring a major change in the GE program. Physical Science is a common component of a liberal arts core curriculum and these courses make important contributions to the broad educational objectives of PLNU. The GE program at PLNU requires one of the two required science courses be accompanied by a lab. The vast majority of students elect to take their lab experience in the Biology Department. General Chemistry I (CHE152) or Introduction to General, Organic, and Biological Chemistry (CHE103) are required courses for a variety of majors and also meet their physical science GE requirement. Rarely would a student sign up for one of these courses for the sole purpose of meeting their physical science GE requirement.

7. What service courses (non-GE courses that primarily support a program in another department) does your department teach? Are there changes that you could make that would make your service courses more efficient and effective?

Even though students get GE credit for taking Introduction to General, Organic, and Biological Chemistry (CHE103), this functions as a service course. This is a required course for pre-nursing students, and it serves a number of majors within the Kinesiology and Family and Consumer Sciences Departments. A few of these programs have certain competencies that must be achieved to satisfy their external accrediting bodies. This course addresses those competencies. We have offered CHE103 since the beginning of the nursing program. What was a 2 quarter course sequence before 1992, was condensed to a single, 5-unit, one semester course that year. Due to prioritization this course was recently changed from a 5+1 to a 4+1 course in which the lecture counts for 4 units and lab counts as 1 unit. In addition, due to the larger laboratory in the new building, we will be teaching two fewer lab sections next year. A CHE103 type course is common in Chemistry Departments at schools with nursing programs, and it is an essential component in preparing students for certain health related careers. Recently we have had difficulty keeping up with the demand for CHE103. General Chemistry I and II, and Organic Chemistry, could technically be considered service courses since they are required for Biology, Kinesiology, and Dietetics majors, and pre-health students, in addition to Chemistry majors. Because of the larger Organic Chemistry laboratory in the new building, we will be teaching two fewer lab sections (one less in fall and one less in spring).

Aside from the recent changes to the CHE103, and the increased lab capacity, there are no additional significant efficiency gains possible for any of the above mentioned service courses as the lecture sections are regularly over 50 students each and virtually all of the laboratory sections are at or near capacity.

********** Future: find a way to include a GE committee review in this step **********

Program Level Analysis (Chemistry)

Bachelor of Science in Chemistry

Chem-F1) Trend and Financial Analysis

First-Time Freshman Admissions Funnel							
Chemistry	**Fall 2009**	**Fall 2010**	**Fall 2011**	**Fall 2012**	**Fall 2013**	**Fall 2014**	**Fall 2015**
Inquiries	**52**	**82**	**102**	**138**	**122**	**144**	**111**
Share of PLNU inquiries	*0.5%*	*0.5%*	*0.6%*	*0.8%*	*0.7%*	*0.7%*	*0.7%*
Completed Applications	**20**	**13**	**14**	**26**	**15**	**18**	**16**
Share of PLNU Applications	*1.0%*	*0.5%*	*0.5%*	*0.9%*	*0.5%*	*0.7%*	*0.6%*
Applicant Conversion Rate	**38.5%**	**15.9%**	**13.7%**	**18.8%**	**12.3%**	**12.5%**	**14.4%**
PLNU Applicant Conversion Rate	*18.6%*	*17.3%*	*17.0%*	*15.7%*	*16.1%*	*12.1%*	*15.0%*
Admits	**17**	**11**	**10**	**20**	**15**	**16**	**14**
Share of PLNU Admits	*0.9%*	*0.6%*	*0.5%*	*1.0%*	*0.7%*	*0.8%*	*0.7%*
Selection Rate	**85.0%**	**84.6%**	**71.4%**	**76.9%**	**100.0%**	**88.9%**	**87.5%**
PLNU Selection Rate	*87.4%*	*72.9%*	*68.9%*	*69.0%*	*70.5%*	*79.5%*	*79.8%*
New Transfer Admissions Funnel							
Chemistry	**Fall 2009**	**Fall 2010**	**Fall 2011**	**Fall 2012**	**Fall 2013**	**Fall 2014**	**Fall 2015**
Inquiries	**5**	**2**	**3**	**7**	**6**	**10**	**4**
Share of PLNU inquiries	*0.6%*	*0.3%*	*0.3%*	*0.4%*	*0.4%*	*0.5%*	*0.2%*
Completed Applications	**2**	**1**	**3**	**2**	**4**	**4**	**3**
Share of PLNU Applications	*0.5%*	*0.3%*	*0.6%*	*0.4%*	*0.8%*	*0.6%*	*0.7%*
Applicant Conversion Rate	**40.0%**	**sm**	**sm**	**28.6%**	**66.7%**	**40.0%**	**sm**
PLNU Applicant Conversion Rate	*50.2%*	*55.5%*	*56.2%*	*28.4%*	*33.2%*	*36.9%*	*21.7%*
Admits	**2**	**1**	**2**	**1**	**4**	**3**	**3**
Share of PLNU Admits	*0.6%*	*0.4%*	*0.7%*	*0.4%*	*1.2%*	*0.7%*	*0.8%*
Selection Rate	**sm**	**sm**	**sm**	**sm**	**sm**	**sm**	**sm**
PLNU Selection Rate	*79.3%*	*57.9%*	*54.8%*	*60.5%*	*65.4%*	*64.1%*	*79.2%*
sm = cell size too small							

1. What does this data tell you about the external demand for your program? What does this say about the future viability of your program?

Since 2008 we have had a more or less constant increase in the number of inquiries (57 freshmen in 2008 vs. 111 in 2015), which indicates an overall increasing popularity of our program. Our FTF admission rate data clearly shows our program is competitive and it follows the trends of PLNU. Our FTF yield is undoubtedly influenced by both the high quality of our admitted students (who have a lot of opportunities available to them), and the competition from other strong science programs in San Diego and beyond. As mentioned above, the number of strong science programs across San Diego is a key factor that impacts the demand of our program, and many of our competitors are offering more scholarship money to attract these students. While our chemistry program still needs to be advertised more broadly, the trends in the number of inquiries over the past eight years indicate a positive move in that direction. In addition, the joint Biology-Chemistry major offers a great deal in terms of preparing students who plan to enter the health field. Due to the fact that many of our majors are pre-health, it is possible we lose some straight Chemistry majors to the joint Biology-Chemistry major. In terms of future viability, this data suggests that the external demand for this program will most likely continue to increase, especially considering that the number of inquiries are seeing an overall increase.

First-Time Freshman Admissions Yield							
Chemistry	**Fall 2009**	**Fall 2010**	**Fall 2011**	**Fall 2012**	**Fall 2013**	**Fall 2014**	**Fall 2015**
Admits	17	11	10	20	15	16	14
Matriculants	**8**	**2**	**3**	**4**	**7**	**2**	**5**
Share of PLNU Matriculants	*1.5%*	*0.3%*	*0.6%*	*0.7%*	*1.1%*	*0.3%*	*0.8%*
Yield Rate	**47.1%**	**18.2%**	**30.0%**	**20.0%**	**46.7%**	**12.5%**	**35.7%**
PLNU Yield Rate	*29.3%*	*30.5%*	*27.7%*	*30.3%*	*31.0%*	*27.9%*	*29.9%*
New Transfer Admissions Yield							
Chemistry	**Fall 2009**	**Fall 2010**	**Fall 2011**	**Fall 2012**	**Fall 2013**	**Fall 2014**	**Fall 2015**
Admits	2	1	2	1	4	3	3
Matriculants	**1**	**1**	**2**	**0**	**1**	**2**	**2**
Share of PLNU Matriculants	*0.6%*	*0.7%*	*1.3%*	*0.0%*	*0.7%*	*1.0%*	*1.2%*
Yield Rate	**sm**	**sm**	**sm**	**sm**	**sm**	**sm**	**sm**
PLNU Yield Rate	*51.1%*	*60.2%*	*54.7%*	*47.3%*	*44.6%*	*46.0%*	*48.0%*
sm = cell size too small							

2. How does your yield rate (percentage of students who enroll at PLNU after being admitted) compare to the PLNU average? If your rate is more than 8 percentage points above the PLNU average, what factors do you believe are contributing to this positive outcome? If your rate is more than 8 percentage points below the PLNU average for more than one year, what factors do you believe are contributing to this difference?

The percentage of students who matriculate versus apply to the program appears to fluctuate from year to year. For example, in 2009 we had 47.1% of applicants matriculate (almost 18% higher than the PLNU rate), whereas in 2014, the chemistry program had 12.5% matriculants, which was ~15% lower than the PLNU rate. Looking at this data combined with the above table outlining external interest in this program suggests that we are receiving applications from a highly talented pool of students, which ultimately results in very highly qualified students admitted to the Chemistry major. However, because of this, in any given year, these students will most likely receive offers from multiple universities. Therefore, depending on where else students apply and are accepted, there will be years when this program has fewer matriculants. This will also be contingent on the scholarship opportunities, both from PLNU and the other schools. Finally, with the addition of the new science building, we will most likely be able to attract even more students from this very competitive pool, based on the very positive response we are already receiving from current and prospective students who have had an opportunity to see the facilities. Overall, we believe as programs such as Science Honors Weekend continue to attract the top performing students, these numbers will most likely continue to fluctuate year to year depending on our competitor programs.

Enrollment							
Majors	**Fall 2009**	**Fall 2010**	**Fall 2011**	**Fall 2012**	**Fall 2013**	**Fall 2014**	**Fall 2015**
Chemistry	**25**	**25**	**25**	**18**	**15**	**17**	**18**
Share of PLNU Undergraduates	*1.0%*	*1.0%*	*1.1%*	*0.7%*	*0.6%*	*0.7%*	*0.7%*
Minors	**Fall 2009**	**Fall 2010**	**Fall 2011**	**Fall 2012**	**Fall 2013**	**Fall 2014**	**Fall 2015**
No minors in this program							
Major Migration of Completers*							
Top Importing Programs:	**2009/10**	**2010/11**	**2011/12**	**2012/13**	**2013/14**	**2014/15**	**6-yr Total**
Pre-Nursing					1	1	2
Biology (BS)				1			1
Biology-Chemistry		1					1
Engineering Physics	1						1

Mathematics		1					1
Undeclared		1					1
Top Export Destinations:	**2009/10**	**2010/11**	**2011/12**	**2012/13**	**2013/14**	**2014/15**	**6-yr Total**
Environmental Science				1	1		2
Exercise Science	1		1				2
* Based on degree completions of students who either started or finished within the program and who originally matriculated as first-time freshmen							

3. What does this data tell you about the internal demand for your program? Does this raise any questions about the viability and/or sustainability of your program as it is currently configured? Explain why or why not. Are there any actionable strategies that you can do that might make a difference if your trends are in the wrong direction?

Over the years our Chemistry majors account for about 1% of PLNU undergraduate students. The 6-yr totals show that we import more majors than we export so internal demand for this program is good and this does not raise questions about viability and sustainability. Furthermore, it is very difficult to transition into a Chemistry major from a different program, outside of Biology, Biology-Chemistry or Environmental Science, after one year. There are a number of sequenced classes and prerequisites that a student from a different program (e.g. Psychology or Nursing) would not have taken. As such, internal shifting is rare and it is therefore necessary to recruit students as they enter the university. (Note that the two students who transferred in from Pre-Nursing did so *despite* having to take the freshman and sophomore chemistry curriculum concurrently – a strong testament to their level of interest!) Our program is fairly small, yet we demonstrate a strong stability over the years. The Chemistry Department provides important service courses for a number of other majors including Biology, Kinesiology, Physics, Nursing, Applied Health Sciences, and Dietetics. According to this data, we have maintained a consistent number of undergraduates in our courses and as the other programs grow, so does the need for the service courses that we offer.

General Education and Service Credit Hour Production **Department of Chemistry** (duplicated in other program-level sections)				
	2011/12	**2012/13**	**2013/14**	**2014/15**
Total Dept UG student credit hours	3,247	3,071	3,479	3,445
Number of GE sections taught	7	7	9	9
% of SCH that are GE	47.7%	48.9%	54.3%	51.8%
Share of PLNU GE SCH	*4.5%*	*4.2%*	*5.2%*	*5.0%*
Number of service course sections taught	No service courses in this program			
% of SCH that are service				
Share of PLNU service SCH				

4. What does this data tell you about how your program is impacted by the needs of GE and other academic disciplines? Does this raise any questions about the viability and/or sustainability of your program if these non-programmatic trends continue? Explain why or why not.

About half of our department's SCH are in GE courses. Our GE courses are CHE101, CHE103, CHE152, and PSC110. This high percentage is a little misleading because most of the students who take CHE103 and CHE152 are required to take these courses for their major and are not solely taking them to fulfill their physical science (with a lab) GE requirement. Although none of our courses meet the definition being used for service courses, we serve a large number of students from other departments and schools, such as Biology, Physics and Engineering, Kinesiology, and Nursing. We also serve pre-health students, who are required to take chemistry courses such as CHE103, CHE152, CHE153, CHE294, and CHE304. In addition, chemistry students do not take CHE103 and the majority of students in CHE152, CHE153, CHE294, and CHE304 are not chemistry students. We do not anticipate a decrease in these SCH and therefore do not think it raises questions about viability or sustainability.

Delaware Study Data **Department of Chemistry** (duplicated in other program-level sections)												
	2010/11			**2011/12**			**2012/13**			**2013/14**		
Program Cost per SCH	**$268**			**$284**			**$279**			**$258**		
Benchmark Percentiles	$194	$240	$271	$177	$242	$293	$183	$233	$292	$191	$247	$306
Ranking	Medium			Medium			Medium			Medium		

5. We know that the following factors influence the Delaware cost per credit hour:
   - Large amount of GE and service classes taught by the program
   - The career stage of the program faculty (early career faculty are less expensive)
   - The number of elective courses in the program
   - The amount of unfunded load (faculty receiving more credit for a course than the number of units received by a student – e.g. 4 units of faculty load for teaching a 3 unit class)
   - The amount of release time associated with the program
   - Faculty members on sabbatical
   - The size of the department budget and the cost of specialized equipment

   Please reflect on your program's Delaware data in light of this information. In particular, what factors contribute to your program having a high (above 75th percentile), medium (50th-75th percentile), or low (below 50th percentile) ranking?

Our cost per SCH falls consistently in the medium range compared to the Delaware Data benchmarks. The 2013-2014 academic year had the lowest cost of the 4 years reported above. Chemistry education may be more expensive than other PLNU programs, but compared to similar programs elsewhere we are delivering good value at a comparable cost to other schools.

6. Recognizing that not all factors above are under departmental control, what kinds of adjustments might be made to reduce the cost per student credit hour?

Because of prioritization, we changed the unit structure of CHE103 from a 5 unit lecture and 0 unit lab to 4 unit lecture and 1 unit lab. We made a similar change to PSC110 from a 4 unit lecture and 0 unit lab to 3 unit lecture and 1 unit lab. With the larger labs in the new science building, we will be offering two fewer lab sections of CHE103 and one fewer lab section of CHE294 in the fall compared to last fall and we already offered one fewer lab section of CHE304 this spring. These changes decrease the cost per SCH.

***** Future *****
Financial Data: (possibly delayed to the future)
Extra Revenue Generated by Program (lab fees, studio fees, etc.)
Extra Revenue per student credit hour

Extra Costs for the program (equipment not purchased outside of department budget, etc.)
Extra costs per student credit hour
Modified Delaware values: Delaware – extra revenue per SCH + extra costs per SCH

7. Do these modified Delaware values tell you anything new about the future viability and/or sustainability of your program as it is currently configured? Please explain.

N/A because no modified Delaware values.

Chem-F2) Findings from Assessment

Links to the department's assessment wheel
• Student Learning Outcomes • Curriculum Maps • Assessment Plan • Evidence of Student Learning • Use of the Evidence of Student Learning

Reflection on longitudinal assessment of student learning data:

1. What have you learned from this program's student learning assessment data?

All current faculty were involved in revising the Program Learning Outcomes for the Chemistry major last year. Therefore, this is the first year that we are collecting assessment data for all our PLOs and we lack longitudinal data. Prior to this, we have longitudinal data for PLOs 1 and 4 through our ETS exam and alumni survey. Based on the overall assessment data, we conclude that our students are meeting the standards set by the department for each PLO. Moreover, from the MFT-ETS data that has been collected in the last several years, we can conclude that in the five subcategories of Chemistry (Biochemistry, Analytical, Organic, Inorganic and Physical Chemistry), our students meet and/or exceed the criteria for success. It is important to point out that we have a limited number of straight Chemistry majors (average n = 4.75 per year over the last 4 years); therefore, trends will be more relevant in the next couple years once we have gathered more data. We have received informal feedback from students who have gone on to graduate school that indicates a lack of preparation in inorganic chemistry.

2. What changes (curricular and others) have you made based on the student learning assessment data?

Because we recently changed our PLOs, we have only begun collecting data on all our PLOs this year. This makes it difficult to rely on this data to make substantial changes in our program. As mentioned in #2 on page 11, a number of changes were made to our organic, analytical, bioinorganic, and advanced organic courses.

3. What additional changes are you recommending based on your review of the student learning assessment data?

We are currently seeking, pending faculty approval, to increase the number of units for Inorganic Chemistry in order to expand the knowledge of our Chemistry majors in this area of chemistry. In addition, we are currently working to align our course offerings with the guild (ACS) standards.

DQP Outcomes with Scores
***** TBD *****
DQP Definitions
Intellectual Skills Intellectual Skills define proficiencies that transcend the boundaries of particular fields of study: analytic inquiry, use of information resources, engaging diverse perspectives, ethical reasoning, quantitative fluency, and communicative fluency.
Specialized Knowledge What students in any specialization should demonstrate with respect to the specialization, often called the major field. All fields call more or less explicitly for proficiencies involving terminology, theory, methods, tools, literature, complex problems or applications and cognizance of limits.
Applied and Collaborative Learning Applied learning suggests what graduates can do with what they know. This area focuses on the interaction of academic and non-academic settings and the corresponding integration of theory and practice, along with the ideal of learning with others in the course of application projects.
Broad and Integrative Knowledge Students integrate their broad learning by exploring, connecting and applying concepts and methods across multiple fields of study to complex questions—in the student's areas of specialization, in work or other field-based settings and in the wider society.
Civic and Global Learning Civic and Global Learning proficiencies rely principally on the types of cognitive activities (describing, examining, elucidating, justifying) that are within the direct purview of the university, but they also include evidence of civic activities and learning beyond collegiate settings. These proficiencies reflect the need for analytic inquiry and engagement with diverse perspectives.

Reflection on DQP related data:

Understanding that the DQP framework provides one particular lens on the meaning, quality and integrity of your curriculum, reflect on the DQP data and framework provided for your program.

4. What have you learned from this program's DQP comparison?

The Chemistry Department mapped our PLOs to the DQP using the curriculum map found on our assessment wheel.

In order to assess intellectual skills, we have used the 5 core competencies, which were assessed during our senior seminar capstone course in 2015. Students were assessed using part of the AAC&U rubrics. The criteria for success were met for written communication, information literacy, oral communication and quantitative reasoning but were not met for critical thinking skills. This was the first year the core competencies were assessed in this course using these assignments. It is difficult to make conclusions without longitudinal data over a few years.

Specialized knowledge was assessed using a direct measure (MFT-ETS scores) and an indirect measure (senior exit survey). While the ETS exam has been administered for the last several years (except in 2014), the senior exit survey data was only conducted in 2015. The data showed that our students met the standards in specialized knowledge. Even though this data is recent, it is still encouraging to know that our Chemistry majors demonstrate proficiencies in chemical terminology, theories, methods, tools, literature and complex problems. It is noteworthy that over the years our students do well above the national average in the ETS exam in chemistry thus showing the efficacy of our instruction and course content.

Applied learning was assessed using senior and alumni surveys. We just began assessing the use of instrumentation in the 2015-2016 academic year. One way to measure success in applied learning is to measure whether alums and seniors felt prepared for a career in science or post-graduate studies. Based on the data collected, we can conclude that our students met the set standards. The success rate for alumni who apply to graduate or professional schools has been well over 90% for at least 20 years. For dental, medical, optometry, pharmacy, and veterinary schools, there have been 166 acceptances out of 181 applicants (91.7%) between 2004 – 2014. An alumni survey conducted by the Biology and Chemistry Departments in January 2015 that included graduates from 2004 – 2014 showed that of the 16 Chemistry majors who responded (44% response), 81% are employed or attending school in a chemistry or STEM-related field. This data shows that our students can apply what they have learned and thus be successful after graduating with a Chemistry BS from PLNU.

Broad integrative knowledge and civic and global learning were not assessed in our program because they did not apply.

5. What changes (curricular and others) have you made based on the DQP comparison?

We have had the DQP data for one year and therefore are unable to use this comparison to make any changes at this point.

6. What additional changes are you recommending based on your review of the DQP comparison?

N/A

Links to stakeholder assessment data (if present this will be department housed data)
• Surveys • Focus Groups • Market Analysis • Etc…

Reflection on stakeholder feedback data:

7. What have you learned from this program's stakeholder assessment data? If you do not have stakeholder data, please provide a plan for how you will regularly collect this in the future.

An alumni survey was conducted by the Biology and Chemistry Departments in January 2015 that included graduates from 2004 – 2014. 408 alumni were emailed and 115 responded (28% response rate). The lowest response rate was from the class of 2007 (7%). All other classes had a response rate of 21 – 42%, which is fairly typical of alumni surveys. 16 Chemistry majors responded (44% response) and 81% of these alumni are employed or attending school in a chemistry or STEM-related field. The success rate for alumni who apply to graduate or professional schools has been well over 90% for at least 20 years. For dental, medical, optometry, pharmacy, and veterinary schools, there have been 166 acceptances out of 181 applicants (91.7%) between 2004 – 2014. A senior exit survey also revealed that 100% of our 2015 chemistry graduates felt prepared for post-graduate studies or science related careers.

8. What changes (curricular and others) have you made based on the stakeholder assessment data?

No changes have been made based on stakeholder assessment data and we plan to maintain the quality of our program and keep preparing students for post graduate studies or any science related careers.

9. What additional changes are you recommending based on your review of the stakeholder assessment data?

No additional changes are being recommended based on stakeholder assessment data.

Chem-F3) Curriculum Analysis

In looking at your curriculum, the program review process is asking you to analyze it through three different lenses. The first lens is looking at your content and structure from the perspective of guild standards or standards gleaned from looking at programs at comparator institutions. The second lens that of employability and is asking you to look at your curriculum and educational experiences from the perspective of skills and professional qualities that you are developing in your students that will serve them will in their future work and vocational callings. The third lens is that of pedagogy and is asking you to look at the delivery of your curriculum to ensure a high quality student learning experience.

Menu and Elective Unit Analysis Chemistry	
Number of menu and elective units required by the program	0
Number of menu and elective units offered by the program	0
Menu/Elective Ratio	0.00
Longitudinal Class Section Enrollment Data	
• Link to Class Section Enrollment Report	

Comparison of current curriculum to guild standards and/or comparator institutions.

If your guild standards are associated with a specialized accreditation that your program has, these should be the basis of your analysis. If your guild standards are associated with specialized accreditation that we do not have, then you should primarily use comparator institutions as the basis for your analysis.

If your guild has standards that are not associated with specialized accreditation, then you may choose to use those standards and/or comparator institutions.

After consultation with your Dean, provide the set of guild standards or a list of the comparator institutions that you are using in your analysis.

If using guild standards:

1. Please provide a list of the guild standards that you are using to evaluate your curriculum.

The American Chemical Society (ACS) has developed a set of standards that allow a chemistry degree to come with ACS approval. http://www.acs.org/content/dam/acsorg/about/governance/committees/training/2015-acs-guidelines-for-bachelors-degree-programs.pdf Most universities have ACS approved degrees or desire to make their degrees ACS approved. There are 680 ACS approved undergraduate chemistry programs in the U.S. A few of PLNU's comparator institutions have ACS approved programs while all but one of PLNU's aspirant institutions have ACS approved programs. SDSU, USD, and UCSD all have ACS approved programs. For years we have conformed as closely as possible to ACS guidelines. We would like to obtain ACS approval for our B.S. in Chemistry. Given the diversity and expertise of our current staff, attaining ACS approval is a logical next step, and it will be an important student recruiting tool moving forward. More of our competitors have ACS approved programs and an increasing number of students and their parents are asking why our program is not ACS approved. Getting ACS approval for our program is well within reach and it will provide a further endorsement of the quality of our programs. Below are the requirements for an ACS approved degree in chemistry:

1) **General Chemistry:** Must have a 1-2 semester general chemistry course.
2) **Foundation Course Work:** Students must take the equivalent of a 3-unit or larger semester-long course in each of the traditional sub-disciplines of chemistry: analytical, biochemistry, inorganic, organic, and physical.
3) **In-Depth Course Work:** Students must take at least 4 semester long in-depth courses for a minimum of 12 units. An in-depth course is one that would build upon foundational course work and would, therefore, have a foundational course as a prerequisite.
4) **Laboratory Experience:** Students must have a total of 400 hours of laboratory experience beyond general chemistry in at least 4 of the traditional sub-disciplines.
5) **Frequency of Course Offerings:** At least 4 foundational courses must be taught annually. Also, 4 semester long in-depth courses (a minimum of 12 units) must be taught annually.
6) **Capstone Experience:** Students should be involved in an integrative experience that synthesizes the knowledge and skills they obtained across the curriculum.
7) **Additional Requirements:** At least two of the following types of systems must be covered: synthetic polymers, biological macromolecules, supramolecular aggregates, meso- or nanoscale materials. Coverage of these materials should occur in approximately the amount of time equal to one quarter of a standard semester course.
8) **Non-Chemistry Requirements**: Must have a minimum of two semesters each of calculus and physics. (It is strongly recommended that additional math such as multivariable calculus and differential equations be taken.)

2. Indicate if and how your curriculum satisfies the standards (this can be done in a table or narrative form). If applicable, indicate areas where your curriculum falls short of the standards.

#1 is met by CHE152 and CHE153.
#2 is met by CHE213 (analytical), CHE450 (biochemistry), CHE294 (organic), CHE325 (physical), and possibly CHE153 (inorganic).
#3 is met for analytical with both CHE351 and CHE370 and organic with CHE304. It would also be met for physical with CHE326 and inorganic with CHE468 if our proposals to change these courses from 2-unit quad courses to 3-unit semester courses that were passed by APC are approved by the faculty.
#4 is now met with the changes to CHE327 and CHE467 that were recently approved by APC.
#5 is not met since we offer 6 out of 12 units of in-depth courses annually and the other in-depth courses are offered every other year.
#6 is met by Chemistry Seminar (CHE495).
#7 is met by CHE304, CHE450, and CHE466.
#8 is met by MTH164, MTH174, PHY241, and PHY242.
Our curriculum satisfies most, but not all, of the standards. With minor changes, we should be able to attain the standards set by the ACS.

Based on the analysis of standard and reflection on the menu and elective ratio above, consider and discuss the following questions:

3. Are there courses in your program that should be modified? Why or why not.

Yes, we do not have enough semester long 3 unit in-depth courses. Therefore, Physical Chemistry II (CHE326) and Advanced Inorganic II (CHE468) will be converted from 2-unit quad courses to 3-unit semester long courses, pending faculty approval of ACS proposals. The labs associated with these courses would also increase in length from a quad to a semester which would then allow us to meet the laboratory experience guideline.

4. Are there courses that should be eliminated? Why or why not.

No courses should be eliminated. The set of courses that we have are appropriate.

5. Are there courses that could be merged? Why or why not.

No.

6. Are there courses that should be added? Why or why not. Note that in general, in order to create the space to add a new course, another course will need to be eliminated or taught less frequently.

We don't think we need to add additional courses in order to meet the guild standards. We simply need to modify the courses that we currently have.

7. What did you learn about your overall curricular structure in terms of its complexity, breadth and depth in light of the guild standards and our institutional size and scope? Are there any structural changes that need to be made in light of your analysis (e.g. sequencing of courses, % and or grouping of electives, overall units required, use of concentrations, etc…)?

Because we have designed our curriculum based on ACS guidelines, we are close to meeting these guild standards. With some minor changes, we would likely be eligible for ACS approval. The key structural changes that need to be made are that two of our 2-unit quad courses (CHE326 and 468) need to be converted to 3-unit semester long courses, pending faculty approval of our APC proposals. In addition, some of our alternate year courses would need to be offered every year. These changes would allow us to meet the guild standards in which we were deficient, including meeting the lab hour requirements, with the associated labs being converted to semester long labs.

If using comparator institutions:

1. Begin by working with your Dean to identify a list of 5-8 comparator schools to use. In selecting schools, consideration should be given to type of institution, mission of the institution and the number of students majoring in the program.

While we are focusing our curriculum analysis on the ACS standards mentioned above, we did also compare our program to a number of similar institutions:

1. Seattle Pacific University
2. Trinity College
3. Westmont College
4. Calvin College
5. Santa Clara University
6. University of Redlands
7. University of San Diego
8. Hope College

1-3 are considered PLNU's comparator institutions while 4-6 are aspirant institutions. All of these institutions have ACS approved programs except Seattle Pacific University and Westmont College. Westmont College is in the final stages of the application process for ACS approval.

Gather the curricular requirements for the program in question at each of the comparator institutions.

2. Use this collection of curricular requirements to develop a list of curricular features that are essential for programs of this type. In addition, make note of any innovative or creative curricular feature that may be useful in enhancing the quality of you program.

Since all of these programs are modeled after the ACS guild standards, the curricular standards are the same as outlined in #1 on page 23.

Review this list with your Dean before using it to analyze your own curriculum.

3. Indicate how your curriculum compares to the list of curricular features from your analysis (this can be done in a table or narrative form).

Our curricular analysis based on the comparator institutions is consistent with what we observed from comparison with the ACS guidelines (see #s 2 & 3 on p. 24 above). Specifically, all of our comparator institutions offer the equivalent of two semesters of Physical Chemistry (ranging from 3-5 units of lecture per semester), along with a full semester of Advanced Inorganic Chemistry (ranging from 3-5 lecture units). We also noticed that our program is particularly lean compared to our comparators; with the exception of Seattle Pacific University, all of our comparators offer some degree of electivity to the Chemistry majors, which we currently do not.

Based on the analysis of comparator programs and reflection on the menu and elective ratio above:

4. Are there courses in your program that should be modified? Why or why not.

Yes. To bring us in line with our comparators and with ACS guidelines, we should adjust our Physical Chemistry course to two full-semester courses, and expand Advanced Inorganic Chemistry to a full semester course. The APC proposals that we submitted to make these changes have been approved by APC and are waiting for faculty approval. (See also #3 on p. 24, above.)

5. Are there courses that should be eliminated? Why or why not.

No. Our program is already leaner than any of our comparators' programs. (See also #4 on p. 24, above.)

6. Are there courses that could be merged? Why or why not.

No.

7. Are there courses that should be added? Why or why not. Note that in general, in order to create the space to add a new course, another course will need to be eliminated or taught less frequently.

Although electivity is desirable, at this time we are not asking to add additional courses. We feel that modifying the courses that we currently have will be sufficient to put us in line with guild standards and our comparators. (See also #6 on p. 24, above.)

8. What did you learn about your overall curricular structure in terms of its complexity, breadth and depth in light of the comparator schools and our institutional size and scope? Are there any structural changes that need to be made in light of your analysis (e.g. sequencing of courses, % and or grouping of electives, overall units required, use of concentrations, etc…)?

PLNU and our comparators all have designed curricula based on ACS guidelines. As a result, our programs are quite similar in complexity, breadth and depth. Two minor changes, currently in process, would put us more in line with our comparators, namely two of our 2-unit quad courses (CHE326 and 468) need to be converted to 3-unit semester long courses, pending faculty approval of APC proposals. (See also #7 on p. 24, above.)

Burning Glass Skills Data Chemistry		
1. Communication Skills ***Virtually every course. Between presentations of primary literature articles, data communication, and scientific writing (see Curriculum map)***	5. Problem Solving ***Every course.***	9. Planning ***CHE152, CHE153, CHE294, CHE304, CHE213, CHE325, CHE450***
2. Writing ***Virtually every course and particularly in upper division laboratory courses.***	6. Quality Assurance and Control ***CHE294, CHE304, CHE466, CHE325, CHE351, CHE370 and CHE468***	10. Project Management ***CHE499***
3. Research ***CHE454, CHE499***	7. Detail-Oriented ***Most courses, but especially CHE213, 370, and 326.***	11. Management ***Teaching Assistant Program* Summer Research Program****
4. Organizational Skills ***Virtually every course.***	8. Leadership ***Teaching Assistant Program* Summer Research Program****	12. Multi-Tasking ***Virtually all laboratory courses.***

* While the Teaching Assistant Program is not a required course, we highly encourage every student within the major to participate and many of them do. As a TA, they directly interface with the students in laboratory courses, providing assistance with data collection, analysis and report generation. Some are also in charge of lab set-up, breakdown, writing weekly quizzes and grading lab reports. It is a position designed to develop basic skills in leadership, management, and supervisory capacities.

**The Summer Research Program is not a required course, but it is very highly recommended and all of the Chemistry majors who applied have participated within the Chemistry Department. Participating students are required to commit to two summers so that many labs have some new students and some returning students. As such, the returning students act as mentors working with the new students. This situation highly encourages the development of basic skills in leadership, management, and supervisory capacities.

Analysis of the curriculum against preparation for employment

9. The Burning Glass data provides a list of skills for students entering common professions that are often linked to your major. Indicate in the table if and where each skill is being taught in your program. Based on reflecting on this data, are there changes you would recommend making to your curriculum?

As you can see from the table above, most of these skills are being taught and developed in multiple courses, while some skills are actually a part of all of our courses. Problem solving and an orientation to minding details are a natural part of a standard chemistry curriculum. Much of the quality assurance and control aspects are a foundational part of certain Chemistry labs, where students study and perform analytical chemistry. Other skills like project management and management could be gained through on-the-job experience or through Business classes. Students who are interested in careers where those skills would be crucial, in addition to their Chemistry background, also have the option of the Science-Business minor. We do not recommend making any curriculum changes based on this data.

10. Some programs may serve to prepare students with professional qualities and skills that can serve them well in a great variety of professions that may not show up in data sets like Burning Glass. If this is indicative of your program, please identify the unique skills and/or professional qualities that your program develops in your students and indicate where in the curriculum this is being taught or developed.

We have broken down the categories of communication skills, reading and writing, and research into several other aspects that we believe to be important skills for our students. See the curriculum map for course association.

Communication skills	Students can effectively express scientific information in standard science formats, including overall purpose, introduction, methods, results, discussion, and overall conclusions.
	Students can effectively analyze and communicate data using graphs, tables, and appropriate scientific figures.
	Students can effectively interpret and communicate scientific information orally (journal club, oral presentations of experiments, etc.).
Reading and understanding primary scientific literature	Students can understand, describe, and analyze key components - including hypothesis, background rationale, data, results, discussion of results and conclusions - of scientific literature. Students are able to evaluate whether the data and conclusions are valid, including evaluation of proper controls, statistics, and appropriate assumptions. This is accomplished through both course work and the Summer Research Program.
Research	Students can perform important techniques, including the use of technical instrumentation. Students can also determine which techniques and equipment are appropriate for various experimental purposes.
	Students design, implement, and evaluate research experiments through upper-division courses, summer research and Honor's projects.
	Students can generate valid hypotheses.
	Students utilize appropriate statistical and quantitative methods to analyze data.

The fact that nearly every chemistry class has an associated lab is crucial to the skill set of Chemistry majors. In these labs, students learn not only laboratory skills, but also how to formulate hypotheses, and how to evaluate data. Many will also learn how to do independent research. Students hone these skills even further through our intensive summer research program.

Analysis of the teaching of your curriculum

11. How do the pedagogical features of your program compare with the best practices for teaching in your discipline?

The American Chemical Society (ACS) has stated in their Guidelines for Bachelor's Degree Programs the following regarding pedagogy: "An approved program should use effective pedagogies in classroom and laboratory course work. Programs should teach their courses in a challenging, engaging, and inclusive manner that accommodates a variety of learning styles. Additionally, a program should provide opportunities for faculty to maintain their knowledge of effective practices in chemistry education and modern theories of learning and cognition in science. An approved program should regularly review its pedagogical approaches to ensure that they promote student learning and build the skills needed to be an effective professional. Faculty should incorporate pedagogies that have been shown to be effective in undergraduate chemistry education. Examples include problem- or inquiry based learning, peer-led instruction, learning communities, and technology-aided instruction such as the use of personal response systems and flipped or hybrid classes. Laboratory work provides a particularly attractive opportunity for inquiry-driven and open-ended investigations that promote independent thinking, critical thinking and reasoning, and a perspective of chemistry as a scientific process of discovery."

The pedagogical features used in our program compare favorably with the best practices from within our discipline. The details of pedagogy used in our program are described in #12.

12. What new pedagogical practices have been tried by members of your department in the last few years? What has your department learned from these experiments?

Chemistry faculty participate in many activities designed to understand best practices in teaching, and to put them to use on a daily basis. Chemistry faculty have attended a variety of events directed at LEARNING about best practices which include:

- Scientific Faculty Learning Community
- Chemical Education session at national ACS conference
- Project Kaleidoscope (conferences in STEM education)
- Team-Based Learning Workshop
- NSF funded project developing interdisciplinary course modules
- Training opportunities offered by Center for Teaching and Learning

Chemistry faculty have also been invited to give talks related to teaching best practices in the following areas:

- General Chemistry Technology with McGraw-Hill Publishing
- Student engagement techniques at SDSU
- Use of iClickers for assessment at Claremont Colleges

Some of the pedagogical features used in our courses includes:

- Team-Based Learning
- Inquiry-Based Learning
- Use of sophisticated modeling software
- Use of clickers
- Enhancement of student engagement using mini whiteboards and iPads
- Online homework systems

As a faculty, we value student engagement and will continue to strive for the best possible student learning experience. In the Chemistry Department, new pedagogical practices have been added incrementally over the last 5 years and some of these practices (Team Based Learning and Inquiry-based learning) are still limited to a few courses. Since these methods are more recent, we have not yet collected data to see the direct impact on students. However, it is broadly accepted that student engagement is directly correlated with improved learning and long term retention of concepts. One example is the use of group activities and modeling software (PyMOL) in Biochemistry. These two pedagogical features have greatly improved our students' understanding of proteins and their function. The understanding was such that in Bioinorganic Chemistry (CHE 466, usually taken the following spring semester) students were able to apply these concepts readily without any need for a refresher. Therefore, the course content was shifted to a more in-depth understanding of metals in biology rather than basics of biochemistry which had to be done in the past.

Overall, we have learned that student centered teaching is worth applying and, while it will look different from one class to another, it improves student retention and student learning. Finally, these strategies allow for a stronger faculty-student interaction, thus fulfilling our mission to shape our students.

13. Are there new developments in pedagogy in your discipline? What would be required to implement these changes in pedagogy in your department?

The ACS guidelines regarding pedagogy that are shown above lists recent developments in pedagogy such as problem- or inquiry based learning, peer-led instruction, learning communities, and technology-aided instruction (e.g. personal response systems and flipped or hybrid classes). Faculty training (e.g. ACS Chemical Education, AAC&U, PKAL, and CTL resources) would be required to implement more of these pedagogy changes into our classes.

Chem-F4) Potential Impact of National Trends

Top Burning Glass Occupations for the Program Chemistry		
Occupation	**Hiring Demand**	**Salary Range**
Actuary	Medium	$92K - $98K
Chemist	Medium	$64K - $68K
Clinical Research Coordinator	Medium	$46K - $50K
Data/Data Mining Analyst	Medium	$70K - $73K
Medical Laboratory Technologist	Medium	$58K - $60K
Quality Control Analyst	Medium	$50K - $54K
Chemical Technician	Low	$32K - $56K
Environmental Compliance Specialist	Low	$42K - $65K
Physical Science Technician	Low	$39K - $46K
Physical Scientist	Low	$91K - $101K
Quantitative Analyst	Low	$109K - $123K
Research Manager	Low	$59K - $69K
Research Scientist	Low	$60K - $87K
Researcher/Research Associate	Low	$41K - $45K

Note that some programs do not have as many professions listed in the Burning Glass data as others do. In these cases we will want to get a list of professions from the chair/school dean to supplement the Burning Glass data.

1. Which professions in the Burning Glass data were you already aware of and for which are you already intentionally preparing students and does the hiring demand in these professions signal anything about the future that you need to be aware of regarding the design and structure of your program?

We are aware of most of the jobs in the burning glass data. We have been intentionally preparing students to be able to enter the scientific workforce. We are intentional and successful at helping students who are interested in obtaining jobs soon after graduation as research associates or lab technicians. Our students are highly sought-after due to the extensive lab experience they receive in our program. Although the hiring demand for these positions is listed as low, our students are finding positions because they are highly qualified and we are supporting them in their efforts to find a job.

Several of the jobs listed, such as research scientist and chemist, would most likely require a graduate degree. The success rate for alumni who apply to graduate or professional schools has been well over 90% for at least 20 years. This can be attributed to our coursework and our summer research program. Admissions committees often look for students who were successful undergraduate researchers and publications are a huge plus. Our faculty are publishing in peer reviewed journals, with student authorship, as well as attending national conferences in order to maintain recognition in our field, which helps students applying to competitive programs.

In terms of preparation for graduate school, we know that our inorganic and quantum chemistry coursework has been a weak point. We are submitting APC proposals to address these issues by changing these from quad to semester-long courses.

Historically, we have done a wonderful job of sending students into the medical field. Now that we have a more diversified faculty (beyond Organic Chemistry), we are in a position to open doors to a variety of other career paths as well. One concrete way in which we could better prepare our graduates for these careers is by seeking the curricular approval of the American Chemical Society (ACS). Graduate schools and companies would recognize ACS approved programs as an external validation of our chemistry program at PLNU. As we compete for top notch chemistry students going forward, this external validation will prove especially important. It is noteworthy to mention that in San Diego, we are the only four year university for which the chemistry program is not ACS approved.

2. Are there additional professions in the Burning Glass list or from your knowledge of occupations your alumni have entered, for which you should be preparing students?

Our alumni have also become medical doctors, pharmacists, and public health workers. In addition to STEM jobs in industry, data indicated that there will be significant growth in the need for K-12 science teachers due to the retirement of the Sputnik generation. As we continue to strengthen our department, we should be able to recruit excellent students planning for professions in this area as well.

3. What changes in your program would be necessary in order to prepare students for the skills and professional qualities needed to succeed in these additional professions?

We have previously mentioned national employment trends for the STEM subjects, but there are also changes in the expectation of students applying for postgraduate programs in medicine. The Medical College Admission Test (MCAT) was modified in 2015 and currently includes a section covering biochemistry. We have been intentionally evaluating and modifying our program to thoroughly prepare students for that part of the exam. In addition, the new MCAT exam now includes a section covering psychology and sociology. In the near future we may ask to substitute General Psychology (PSY103) for PSY101 to meet this expectation.

4. Are there national trends in higher education or industry that are particularly important to your discipline? If yes, how is your program reacting to those trends?

There are two major trends in higher education and sciences that we are paying particular attention to. 1) The political, social, and economic climate toward STEM. There is a huge push from all three of the aforementioned spheres of influence to prepare more STEM graduates, which bodes well for the future of Chemistry graduates. 2) Increased incorporation of authentic research experiences for students. Our department has done an excellent job being ahead of the curve in this area for decades. Students have the opportunity to complete full-time, intensive research in the summer, part-time research during the semester, and some courses have open-ended research experiences within them. In addition to the chemistry-specific skills that students get from research, they also develop other transferable skills, including the ability to conduct literature research, presentation and writing skills, and problem-solving skills. These additional skills are desirable even for jobs outside of science (e.g. actuary in the Burning Glass data).

Chem-F5) Quality Markers

Retention/Graduation Rates (First-Time Freshmen)							
	Matriculation Term						
Chemistry	**Fall 2008**	**Fall 2009**	**Fall 2010**	**Fall 2011**	**Fall 2012**	**Fall 2013**	**Fall 2014**
First-Year Retention	**100.0%**	**100.0%**	**sm**	**sm**	**Sm**	**80.0%**	**sm**
PLNU First-Year Retention	*84.2%*	*84.1%*	*81.1%*	*82.9%*	*89.3%*	*84.5%*	*84.5%*
	Matriculation Term						
Chemistry	**Fall 2005**	**Fall 2006**	**Fall 2007**	**Fall 2008**	**Fall 2009**	**Fall 2010**	**Fall 2011**
Four-Year Graduation Rate	**sm**	**sm**	**sm**	**100.0%**	**87.5%**	**sm**	**sm**
PLNU Four-Year Graduation Rate	*62.0%*	*65.2%*	*61.7%*	*59.1%*	*63.4%*	*62.2%*	*63.2%*
	Matriculation Term						
Chemistry	**Fall 2003**	**Fall 2004**	**Fall 2005**	**Fall 2006**	**Fall 2007**	**Fall 2008**	**Fall 2009**
Six-Year Graduation Rate	**sm**	**sm**	**sm**	**sm**	**Sm**	**100.0%**	**100.0%**
PLNU Six-Year Graduation Rate	*72.4%*	*73.2%*	*73.0%*	*74.9%*	*72.2%*	*73.6%*	*75.0%*
Degree Completions							
Majors	**2008-09**	**2009-10**	**2010-11**	**2011-12**	**2012-13**	**2013-14**	**2014-15**
Chemistry	**0**	**4**	**5**	**7**	**8**	**2**	**4**
Share of PLNU Bachelor's Degrees	*0.0%*	*0.8%*	*0.9%*	*1.3%*	*1.4%*	*0.3%*	*0.7%*
Minors	**2008-09**	**2009-10**	**2010-11**	**2011-12**	**2012-13**	**2013-14**	**2014-15**
No minors in this program							
FTF Time to Degree *(in semesters)*	**sm**	**sm**	**sm**	**8.0**	**8.0**	**sm**	**sm**
PLNU FTF Time to Degree	*8.2*	*8.2*	*8.3*	*8.2*	*8.3*	*8.3*	*8.3*
Study Abroad Participants		3	1				
sm = cell size too small							

1. Based on comparing the quality marker data for your program with the PLNU averages:
   a. What does this tell you about your program?

Retention, graduation rates and FTF time to degree are generally at or above the PLNU average, or too small to compare, which suggests that we are doing a good job of keeping students in the major and on-track to graduation.

   b. If your values are below the PLNU averages, what changes could you make to address any areas of concern?

N/A

   c. If your values are above the PLNU averages, what do you believe contributes to this success?

We have been able to recruit strong students who are the most capable of returning. First-year students in our program take at least two courses in their major each semester and make early connections with faculty, older students, and fellow new students in the department, enhancing their first-year experience. A higher percentage of our students may have academic scholarships allowing them to persist in their studies beyond the first year or two.

2. Describe regular opportunities for students to apply their knowledge (internships, practicums, research projects, senior projects, etc.). Estimate what percentage of your students in this program participates in these kinds of opportunities.

We have an intensive undergraduate research program, where students gain an 800-hour research experience over the course of two summers. Since our summer research program began, more than 280 students have participated. Of the Chemistry students who graduated in the past twenty years over 62% (63% of those who graduated 2010 to 2015) have participated in an intensive research experience. Of those who didn't participate in our summer research program, some were involved in other career related external experiences like internships and student teaching.

In addition, students are highly encouraged to participate in the life of the department, including work as laboratory assistants, graders, review session leaders, tutors, and stockroom workers. This helps students apply their knowledge by making solutions, setting up reagents, working with advanced equipment and instrumentation, and teaching fellow students. While the professor is the main instructor for every course and lab, these opportunities of engagement for the students also help facilitate learning within the student community. In the last few years, essentially all (>95%) of our chemistry students have been involved in the department through these various positions, often taking on different roles over several semesters and multiple courses.

3. Describe any public scholarship of your undergraduate and graduate students in this program (conference presentations, publications, performances, etc.). What percentage of your undergraduate students are involved in these kinds of activities?

As described above, about 62% of our Chemistry students are involved in the intensive research experience with the faculty. Each year all of our second year researchers attend and make presentations (oral and poster) of their research at conferences such as the American Chemical Society (ACS) National Meeting, West Coast Biological Student Undergraduate Research Conference (WCBSURC), Regional ACS undergraduate conferences, and Western Spectroscopy Association meetings. Students have also completed senior honors projects and presented their work during the honors conference. In addition, the work of our student researchers has been published in 153 peer-reviewed journal articles over the past 50 years (26 in the last five years).

4. How many of your students participate in study abroad opportunities in general? Describe any study abroad opportunities specifically organized by your program. What percentage of your majors are involved annually (annualize the number)? How many students outside of your department participate in this departmentally organized program (Annualize the number)?

A very small number of our chemistry students participate in study abroad opportunities. Our department does not organize any study abroad opportunities.

5. What are any other distinctives of your program? Describe how they contribute to the program's success.

A top priority of our department is for students to do chemistry, not just learn about chemistry. To accomplish this, we have a laboratory rich curriculum. Almost all of our classes have a required laboratory experience. We are proud of the deliberate mentoring of students that occurs while they are at PLNU and the relationships we have been able to maintain with a large number of our alums. Our students work as stockroom workers, graders, review session leaders, tutors, and lab assistants under the supervision of faculty. Our alumni are constantly giving back through guest lectures, mentoring, shadowing opportunities, etc., and are extremely willing to help current students. Alumni tell us that they are very well prepared for post-baccalaureate education and jobs in the discipline.

All of the chemistry full-time faculty and our lab manager earned a Ph.D. prior to coming to PLNU. Moreover, all of our faculty hired since 1990 have completed postdoctoral research beyond the Ph.D. This indicates that our program has a track record of attracting faculty highly-qualified in both teaching and scientific research.

Another distinctive is our pre-health professions advising. We have a dedicated advisor (currently Sara Choung) for students preparing for medical, dental, optometry, pharmacy, or veterinary school. This program includes two preparatory interviews for the students, sessions with alumni and local health professionals, and a committee-written letter of recommendation. This program has almost certainly contributed to the high rate of acceptance of our students into the health professions schools (over 90% for over 15 years).

6. Does your program have an advisory board? If so, describe how it has influenced the quality of your program? If not, could it benefit from creating one?

N/A

7. Describe any current joint interdisciplinary degrees (majors or minors) offered by your department. Are there additional areas where interdisciplinary programs should be considered?

The Biology-Chemistry major and the Environmental Science major are joint with Biology. There are also science-business and science-marketing minors for business or science majors and the computational science minor. We are not currently considering additional interdisciplinary programs.

8. Describe your success with students acquiring jobs related to their discipline.

As mentioned previously, an alumni survey was conducted by the Biology and Chemistry Departments in January 2015 that included graduates from 2004 – 2014. From this most recent alumni survey, 91% of our alumni were attending graduate school or employed in a Chemistry or STEM-related field. In addition, our acceptance rate of students into graduate and health professions schools continues to be at least 90%. Of the 16 Chemistry majors who responded to the survey, 81% are employed or in graduate school in a STEM-related field.

9. Describe your undergraduate and graduate student success rate for passing licensure or credentialing exams (if they exist in your discipline).

N/A

10. Describe your success with undergraduate student acceptance into post-baccalaureate education.

A large number of our graduates continue their education at health professions schools or graduate schools and they have been very successful at getting into these various programs. As mentioned previously, the success rate for alumni who apply to graduate or professional schools has been well over 90% for at least 20 years. In recent years, students have gone to prestigious programs at University of California San Diego, University of California Irvine, Yale University, Georgia Tech University, Vanderbilt University, etc. For dental, medical, optometry, pharmacy, and veterinary schools, there have been 166 acceptances out of 181 applicants (91.7%) between 2004 – 2014. They have gone on to a number of schools across the country such as University of California San Diego, University of Southern California, Loma Linda University, University of Washington, Duke University, Purdue University, etc. Between 2001 and 2011, 46 biology and Chemistry Department alumni earned a Ph.D. This speaks very highly of their undergraduate preparation in both the chemistry and biology courses.

11. What kind of support does your program provide for students encountering academic difficulties? How do you intentionally facilitate these students' connection with institutional support services?

Our department has multiple means of supporting students with academic difficulties. First, we offer a weekly tutorial for students in the first semester of General Chemistry (CHE151), as well as student-led weekly review sessions for both semesters of General Chemistry and Organic Chemistry. Second, we encourage students to attend office hours and work with faculty as well as making tutoring appointments in the tutorial center. Third, during the twice yearly advising sessions, we meet with our advisees for 15-30 minutes and discuss both academic and non-academic factors, as well as vocation. Fourth, on some occasions, we have directly referred students to the Wellness Center, the DRC, or even contacted Caye Smith, Jeff Bolster, or Mark Pitts, depending on the situation. Finally, we are hoping to use the new capabilities of the SSC to bolster these efforts by identifying students who may be in the middle ground but could use some resources to make their college experience even better.

Chem-F6) Infrastructure and Staffing

Full-Time Faculty Program Contribution **Department of Chemistry** (duplicated in other program-level sections)			
	2012-13	**2013-14**	**2014-15**
Percentage of UG classes taught by FT faculty	68.8%	71.6%	65.5%
PLNU percentage of UG classes taught by FT Faculty	*TBD*	*TBD*	*TBD*
Includes: regular lectures, labs, seminars Excludes: independent studies, private lessons, internships			

1. Are your program's current technological resources and support adequate? If not, what is needed? Do you foresee any additional needs in this area?

Special instrument funds accompanying the building of Sator Hall allowed for the addition of several state-of-the-art instruments for use in the Chemistry major courses and related research. These instruments include an Inductively Coupled Plasma – Optical Emission Spectrometer (ICP-OES), high performance liquid chromatograph (HPLC), infrared (IR) spectrometer, fluorescence spectrometer, glove box, lyophilizer, microwave reactor, magnetic susceptibility balance, potentiostat, and spectrometers. Additional funding from the Provost's office made possible the purchase of a much-needed, used 400 MHz nuclear magnetic resonance (NMR) spectrometer. We also negotiate access to remaining necessary equipment via local connections (at UCSD, USD, and TSRI).

In order to keep these instruments running, we do need ongoing support for instrumentation. Currently, the institution has no replacement schedule (or line item in the budget) for scientific equipment. The new instruments mentioned above require solvents, gases, cryogens and consumables in order to run, while older instruments (like our ultraviolet and visible spectrophotometer (UV-vis), gas chromatographs (GCs), and gas chromatograph-mass spectrometer (GC-MS)), are likely to require maintenance and repairs in the near future beyond what is covered in our existing budget.

We still need at least two additional instruments commonly used in an undergraduate chemistry curriculum: an X-ray diffractometer and a liquid chromatograph-mass spectrometer (LC-MS). As mentioned above, faculty actively pursue grants to support department needs. It will require continuing support (external and institutional) to provide our graduates with the most up-to-date educational experiences necessary to maintain our competitive edge.

2. Are your program's current facilities adequate? If not, what is needed? Do you foresee any additional needs in this area?

The classrooms and facilities in Sator and Latter halls are excellent and are expected to be adequate for our needs assuming stable enrollment in our courses that serve other departments such as Nursing and Kinesiology. Maintaining one general purpose teaching laboratory in Rohr Science would provide capacity for growth.

Office space in the Chemistry Department is old and inadequate, with no space for adjunct faculty. It would also be great if students had a space to congregate to study together and work on projects together.

3. Is your program's current staffing (administrative, clerical, technical and instructional) adequate? If not, what is needed? Do you foresee any additional needs in this area?

Our instructional staffing is not adequate. We are in need of a Physical Chemist to replace Ken Martin, who is in the final year of his phased retirement. Physical chemistry is one of the five pillars of a solid chemistry curriculum and no one else in the department is trained to teach those courses.

Current and projected enrollments in Chemistry Department programs as well as other departments/programs served by Chemistry have been growing dramatically. As a result, enrollments in our largest courses have more than doubled in the past ten years (the numbers of students in CHE103, CHE152, and CHE153 have grown by 38.5%, 165.0%, and 129.5%, respectively). With the hire of a full-time Physical Chemist, the number of teaching units taught by full-time faculty would still be below 80% each academic year (2016-2017: 78.9%, 2017-2018: 76.2%).

Moreover, a Physical Chemist is necessary to maintain the curricular balance required of a quality chemistry teaching and research program, and to successfully seek American Chemical Society (ACS) Program Approval.

Chem-F7) Challenges and Opportunities

1. Are there any particular challenges regarding this program that have not been addressed through the analysis and reflection on data or questions in sections F1-F6 that you would like to include here?

- Increase student recruitment and retention
- Staffing for Physical Chemistry courses (if we are not approved to search for a replacement in 2016-2017)
- Long-term instrument maintenance and replacement
- Funding our growing summer research program (student participation has doubled in the last decade)
- Continuing to maintain our relationship with department alumni, in particular Research Associates, as senior members of the department retire

2. Are there any particular opportunities regarding this program that have not been addressed through the analysis and reflection on data or questions in sections F1-F6 that you would like to include here?

- Build stronger community among our majors
- Expand use of ACS recommended pedagogies in more of our classes and have departmental discussions about pedagogies and best practices (considering pedagogies and teaching strategies used at other universities)
- Expanding our connections with local companies for possible internships and job opportunities for our students
- More formal advising for students who are planning to attend graduate school or enter the workforce
- Re-designing GE courses (e.g. more topics based like “chemistry and cooking”)
- Re-design lab experience for General Chemistry I and II (possibly adding an honors lab section)

Chem-F8) Recommendations for Program Improvement

List the recommendations you are making regarding this program analysis with a brief rationale for each recommendation.

1) Hire a physical chemist as a replacement for a retiring faculty member (#3 on page 36).
2) Make changes to courses to align our curriculum with ACS guidelines (APC proposals approved by APC, pending faculty approval).
   a) Change Physical Chemistry II (CHE326) from a 2-unit quad course to a 3-unit semester course.
   b) Change Physical Chemistry II Laboratory (CHE327) from a 1-unit quad lab to a 1-unit semester lab.
   c) Change Inorganic Chemistry II (CHE468) from a 2-unit quad course to a 3-unit semester course.
   d) Change Inorganic Chemistry Laboratory (CHE467) from a 1-unit quad lab to a 1-unit semester lab.
3) Apply for ACS approval for our B.S. in Chemistry. Most universities have ACS approved degrees or desire to make their degrees ACS approved. For years we have conformed as closely as possible to ACS guidelines. With the diversity and expertise of our current staff attaining ACS approval is a logical next step, and it will be an important student recruiting tool moving forward. More of our competitors have ACS approved programs and an increasing number of students and their parents are asking why our program is not ACS approved. Getting ACS approval for our program is well within reach and it will provide a further endorsement of the quality of our programs.
4) Explore outreach opportunities to local high school chemistry teachers as a recruiting tool.

Program Level Analysis (Bio-Chem)

Bachelor of Science in Biology-Chemistry

BCHM-F1) Trend and Financial Analysis

First-Time Freshman Admissions Funnel							
Biology-Chemistry	**Fall 2009**	**Fall 2010**	**Fall 2011**	**Fall 2012**	**Fall 2013**	**Fall 2014**	**Fall 2015**
Inquiries	**370**	**651**	**771**	**987**	**848**	**1,097**	**674**
Share of PLNU inquiries	*3.3%*	*4.3%*	*4.7%*	*5.4%*	*4.6%*	*5.0%*	*4.0%*
Completed Applications	**65**	**85**	**106**	**112**	**96**	**85**	**75**
Share of PLNU Applications	*3.1%*	*3.2%*	*3.8%*	*3.9%*	*3.2%*	*3.2%*	*3.0%*
Applicant Conversion Rate	**17.6%**	**13.1%**	**13.7%**	**11.3%**	**11.3%**	**7.7%**	**11.1%**
PLNU Applicant Conversion Rate	*18.6%*	*17.3%*	*17.0%*	*15.7%*	*16.1%*	*12.1%*	*15.0%*
Admits	**61**	**74**	**89**	**80**	**75**	**77**	**69**
Share of PLNU Admits	*3.3%*	*3.8%*	*4.6%*	*4.0%*	*3.6%*	*3.6%*	*3.4%*
Selection Rate	**93.8%**	**87.1%**	**84.0%**	**71.4%**	**78.1%**	**90.6%**	**92.0%**
PLNU Selection Rate	*87.4%*	*72.9%*	*68.9%*	*69.0%*	*70.5%*	*79.5%*	*79.8%*
New Transfer Admissions Funnel							
Biology-Chemistry	**Fall 2009**	**Fall 2010**	**Fall 2011**	**Fall 2012**	**Fall 2013**	**Fall 2014**	**Fall 2015**
Inquiries	**12**	**12**	**20**	**16**	**20**	**41**	**29**
Share of PLNU inquiries	*1.5%*	*1.7%*	*2.2%*	*1.0%*	*1.3%*	*2.3%*	*1.4%*
Completed Applications	**7**	**8**	**13**	**5**	**14**	**15**	**7**
Share of PLNU Applications	*1.7%*	*2.0%*	*2.6%*	*1.1%*	*2.8%*	*2.2%*	*1.5%*
Applicant Conversion Rate	**58.3%**	**66.7%**	**65.0%**	**31.3%**	**70.0%**	**36.6%**	**24.1%**
PLNU Applicant Conversion Rate	*50.2%*	*55.5%*	*56.2%*	*28.4%*	*33.2%*	*36.9%*	*21.7%*
Admits	**7**	**5**	**11**	**3**	**9**	**14**	**4**
Share of PLNU Admits	*2.2%*	*2.2%*	*4.0%*	*1.1%*	*2.8%*	*3.3%*	*1.1%*
Selection Rate	**100.0%**	**62.5%**	**84.6%**	**60.0%**	**64.3%**	**93.3%**	**57.1%**
PLNU Selection Rate	*79.3%*	*57.9%*	*54.8%*	*60.5%*	*65.4%*	*64.1%*	*79.2%*

1. What does this data tell you about the external demand for your program? What does this say about the future viability of your program?

External demand for the Biology-Chemistry major seems to be growing as the first-time freshman inquiries have steadily been increasing, with the exception of Fall 2015. The applicant conversion rate was lower than the PLNU rate for all years perhaps because these students are generally highly qualified and have a lot of options for schools. The selection rate has been greater than the PLNU rate for all years because these highly qualified applicants meet or exceed PLNU's acceptance criteria. New transfer inquiries have also increased over the years and the applicant conversion rate and selection rate has mostly been higher than the PLNU rate. Future viability of this program seems positive since awareness and interest in the program is growing.

The Biology Department has proposed limiting enrollment of all of their majors (Biology-BA, Biology-BS, Biology-Chemistry-BS, Environmental Science-BS). The Chemistry Department has capacity for more majors and is opposed to limiting enrollment of the joint majors (Biology-Chemistry-BS and Environmental Science-BS). Discussions are ongoing.

First-Time Freshman Admissions Yield							
Biology-Chemistry	**Fall 2009**	**Fall 2010**	**Fall 2011**	**Fall 2012**	**Fall 2013**	**Fall 2014**	**Fall 2015**
Admits	61	74	89	80	75	77	69
Matriculants	**20**	**29**	**38**	**23**	**20**	**25**	**22**
Share of PLNU Matriculants	*3.7%*	*4.9%*	*7.1%*	*3.8%*	*3.1%*	*4.3%*	*3.7%*
Yield Rate	**32.8%**	**39.2%**	**42.7%**	**28.8%**	**26.7%**	**32.5%**	**31.9%**
PLNU Yield Rate	*29.3%*	*30.5%*	*27.7%*	*30.3%*	*31.0%*	*27.9%*	*29.9%*
New Transfer Admissions Yield							
Biology-Chemistry	**Fall 2009**	**Fall 2010**	**Fall 2011**	**Fall 2012**	**Fall 2013**	**Fall 2014**	**Fall 2015**
Admits	7	5	11	3	9	14	4
Matriculants	**4**	**3**	**7**	**0**	**3**	**7**	**3**
Share of PLNU Matriculants	*2.4%*	*2.2%*	*4.7%*	*0.0%*	*2.1%*	*3.5%*	*1.7%*
Yield Rate	**57.1%**	**60.0%**	**63.6%**	**sm**	**33.3%**	**50.0%**	**sm**
PLNU Yield Rate	*51.1%*	*60.2%*	*54.7%*	*47.3%*	*44.6%*	*46.0%*	*48.0%*
sm = cell sizes too small							

2. How does your yield rate (percentage of students who enroll at PLNU after being admitted) compare to the PLNU average? If your rate is more than 8 percentage points above the PLNU average, what factors do you believe are contributing to this positive outcome? If your rate is more than 8 percentage points below the PLNU average for more than one year, what factors do you believe are contributing to this difference?

Yield rates for this major have mostly been above or close to the PLNU yield rate. This may be due to the fact that our science programs have built a good reputation and have a number of opportunities for students. With a decrease in the number of matriculants over the last few years, the Chemistry Department has room for more Biology-Chemistry majors.

Enrollment							
Majors	**Fall 2009**	**Fall 2010**	**Fall 2011**	**Fall 2012**	**Fall 2013**	**Fall 2014**	**Fall 2015**
Biology-Chemistry	**59**	**69**	**87**	**85**	**89**	**89**	**87**
Share of PLNU Undergraduates	*2.5%*	*2.9%*	*3.7%*	*3.5%*	*3.5%*	*3.5%*	*3.3%*
Minors	**Fall 2009**	**Fall 2010**	**Fall 2011**	**Fall 2012**	**Fall 2013**	**Fall 2014**	**Fall 2015**
No minors for this program							
Major Migration of Completers*							
Top Importing Programs:	**2009/10**	**2010/11**	**2011/12**	**2012/13**	**2013/14**	**2014/15**	**6-yr Total**
Undeclared			1	1	1	2	5
Biology (BS)			1		1	2	4
Business Administration	1		1		1		3
Biology (BA)			1	1			2
Pre-Nursing	1					1	2
Top Export Destinations:	**2009/10**	**2010/11**	**2011/12**	**2012/13**	**2013/14**	**2014/15**	**6-yr Total**
Biology (BS)	5	7	3	6	10	8	39
Exercise Science		2	2	2		2	8
Applied Health Science					2	3	5
Business Administration	2				3		5
Nursing				2	1	1	4
* Based on degree completions of students who either started or finished within the program and who originally matriculated as first-time freshmen							

3. What does this data tell you about the internal demand for your program? Does this raise any questions about the viability and/or sustainability of your program as it is currently configured? Explain why or why

not. Are there any actionable strategies that you can do that might make a difference if your trends are in the wrong direction?

The migration to and from this major is mostly from other science majors and/or majors who have students preparing for careers in the health professions. Interestingly, there is some migration to and from Business Administration. Overall there seems to be a net migration to the biology major, a net migration from the undeclared major, and only migration to (not from) the Applied Heath Science/Exercise Science major. This program is both viable and sustainable. It would be interesting to investigate students' reasons for switching out of the Biology-Chemistry major.

General Education and Service Credit Hour Production
Department of Chemistry
(duplicated in other program-level sections)

	2011/12	2012/13	2013/14	2014/15
Total Dept UG student credit hours	3,247	3,071	3,479	3,445
Number of GE sections taught	7	7	9	9
% of SCH that are GE	47.7%	48.9%	54.3%	51.8%
Share of PLNU GE SCH	*4.5%*	*4.2%*	*5.2%*	*5.0%*
Number of service course sections taught	No service courses in this program			
% of SCH that are service				
Share of PLNU service SCH				

4. What does this data tell you about how your program is impacted by the needs of GE and other academic disciplines? Does this raise any questions about the viability and/or sustainability of your program if these non-programmatic trends continue? Explain why or why not.

About half of our department's SCH are in GE courses. Our GE courses are CHE101, CHE103, CHE152, and PSC110. This high percentage is a little misleading because most of the students who take CHE103 and CHE152 are required to take these courses for their major and are not solely taking them to fulfill their physical science (with a lab) GE requirement. Although none of our courses meet the definition being used for service courses, we serve a large number of students from other departments and schools, such as Biology, Physics and Engineering, Kinesiology, and Nursing. We also serve pre-health students, who are required to take chemistry courses such as CHE103, CHE152, CHE153, CHE294, and CHE304. In addition, chemistry students do not take CHE103 and the majority of students in CHE152, CHE153, CHE294, and CHE304 are not chemistry students. We do not anticipate a decrease in these SCH, and therefore do not think it raises questions about viability or sustainability.

Delaware Study Data
Department of Chemistry
(duplicated in other program-level sections)

	2010/11			2011/12			2012/13			2013/14		
Program Cost per SCH	**$268**			**$284**			**$279**			**$258**		
Benchmark Percentiles	$194	$240	$271	$177	$242	$293	$183	$233	$292	$191	$247	$306
Ranking	Medium			Medium			Medium			Medium		

5. We know that the following factors influence the Delaware cost per credit hour:
   - Large amount of GE and service classes taught by the program
   - The career stage of the program faculty (early career faculty are less expensive)
   - The number of elective courses in the program

- The amount of unfunded load (faculty receiving more credit for a course than the number of units received by a student – e.g. 4 units of faculty load for teaching a 3 unit class)
- The amount of release time associated with the program
- Faculty members on sabbatical
- The size of the department budget and the cost of specialized equipment

Please reflect on your program's Delaware data in light of this information. In particular, what factors contribute to your program having a high (above 75th percentile), medium (50th-75th percentile), or low (below 50th percentile) ranking?

Our cost per SCH falls consistently in the medium range compared to the Delaware Data benchmarks. The 2013-2014 academic year had the lowest cost of the 4 years reported above. Chemistry education may be more expensive than other PLNU programs, but compared to similar programs elsewhere we are delivering good value at a comparable cost to other schools.

6. Recognizing that not all factors above are under departmental control, what kinds of adjustments might be made to reduce the cost per student credit hour?

Because of prioritization, we changed the unit structure of CHE103 from a 5 unit lecture and 0 unit lab to 4 unit lecture and 1 unit lab. We made a similar change to PSC110 from a 4 unit lecture and 0 unit lab to 3 unit lecture and 1 unit lab. With the larger labs in the new science building, we will be offering two fewer lab sections of CHE103 and one fewer lab section of CHE294 in the fall compared to last fall and we already offered one fewer lab section of CHE304 this spring. These changes decrease the cost per SCH..

***** Future *****
Financial Data: (possibly delayed to the future)
Extra Revenue Generated by Program (lab fees, studio fees, etc.)
Extra Revenue per student credit hour
Extra Costs for the program (equipment not purchased outside of department budget, etc.)
Extra costs per student credit hour
Modified Delaware values: Delaware – extra revenue per SCH + extra costs per SCH

7. Do these modified Delaware values tell you anything new about the future viability and/or sustainability of your program as it is currently configured? Please explain.

N/A because no modified Delaware values.

BCHM-F2) Findings from Assessment

Links to the department's assessment wheel
• Student Learning Outcomes • Curriculum Maps • Assessment Plan • Evidence of Student Learning • Use of the Evidence of Student Learning

Reflection on longitudinal assessment of student learning data:

1. What have you learned from this program's student learning assessment data?

*Since this is a joint major, only the Chemistry-specific assessment will be addressed here. The Biology-specific assessment will be addressed in their program review document.

Our first priority as an academic department is to ensure that our students are learning the essential concepts of chemistry. We use the ETS Major Field Test in Chemistry to measure the performance of our undergraduates in five major areas of Chemistry: Analytical Chemistry, Biochemistry, Inorganic Chemistry, Organic Chemistry, and Physical Chemistry. The 2014-2015 data demonstrated that the graduating senior Biology-Chemistry majors who took the Chemistry Seminar course had an overall average that placed them at the 87th percentile, on this nationally normed exam. The sample sizes are small, however, so multiple years of data are required before any conclusions should be drawn.

We also want our students to be able to use standard instrumentation and laboratory equipment to conduct scientific experiments and perform chemical characterization and analyses. Because of this, we have designed a lab rich curriculum and many opportunities for students to gain experience with instrumentation and laboratory equipment through their roles as researchers and teaching assistants. Direct assessment began this year because this PLO was modified at the end of 2014-2015. With that being said, we are confident that all 2015 Biology-Chemistry graduates are able to use each of the various instruments with little or no guidance based on their course and lab curriculum and various positions as teaching assistants.

Another priority of our department is that our students will participate in the life of the department by involvement in research, science clubs, and/or in various positions of responsibility such as graders, tutors, stockroom workers, and/or teaching assistants. In 2014-2015, 94% of our graduating Biology-Chemistry students had participated in at least one of these activities.

Having our students gain admittance to graduate programs and careers is also a top priority. In our most recent alumni survey, 91% of our alumni were attending graduate school or employed in a Chemistry or STEM-related field. In addition, our acceptance rate of students into graduate and health professions schools continues to be at least 90%. Of the 32 Biology-Chemistry majors who responded to the survey, 97% are employed or in graduate school in a STEM-related field.

2. What changes (curricular and others) have you made based on the student learning assessment data?

No changes have been made related to the student learning assessment data mentioned above because we need to obtain longitudinal data so better conclusions and necessary changes can be made.

3. What additional changes are you recommending based on your review of the student learning assessment data?

No changes recommended at this time.

DQP Outcomes with Scores
***** TBD *****
DQP Definitions
Intellectual Skills Intellectual Skills define proficiencies that transcend the boundaries of particular fields of study: analytic inquiry, use of information resources, engaging diverse perspectives, ethical reasoning, quantitative fluency, and communicative fluency.
Specialized Knowledge What students in any specialization should demonstrate with respect to the specialization, often called the major field. All fields call more or less explicitly for proficiencies involving terminology, theory, methods, tools, literature, complex problems or applications and cognizance of limits.
Applied and Collaborative Learning Applied learning suggests what graduates can do with what they know. This area focuses on the interaction of academic and non-academic settings and the corresponding integration of theory and practice, along with the ideal of learning with others in the course of application projects.
Broad and Integrative Knowledge Students integrate their broad learning by exploring, connecting and applying concepts and methods across multiple fields of study to complex questions—in the student's areas of specialization, in work or other field-based settings and in the wider society.
Civic and Global Learning Civic and Global Learning proficiencies rely principally on the types of cognitive activities (describing, examining, elucidating, justifying) that are within the direct purview of the university, but they also include evidence of civic activities and learning beyond collegiate settings. These proficiencies reflect the need for analytic inquiry and engagement with diverse perspectives.

Reflection on DQP related data:

Understanding that the DQP framework provides one particular lens on the meaning, quality and integrity of your curriculum, reflect on the DQP data and framework provided for your program.

4. What have you learned from this program's DQP comparison?

The DQP roll-up is based on current department assessment, so we have nothing to add here.

5. What changes (curricular and others) have you made based on the DQP comparison?

None.

6. What additional changes are you recommending based on your review of the DQP comparison?

None.

Links to stakeholder assessment data (if present this will be department housed data)
• Surveys • Focus Groups • Market Analysis • Etc…

Reflection on stakeholder feedback data:

7. What have you learned from this program's stakeholder assessment data? If you do not have stakeholder data, please provide a plan for how you will regularly collect this in the future.

We conducted an alumni survey in 2015. 408 alumni from 2004-2014 were mailed and 115 replied (28% response). 60% of the respondents were currently in a graduate program or had already obtained an advanced degree. The most common occupations were currently in a graduate program (35%), health professional (23%), research (12%: biotechnology, academic, government, etc.) and K-12 teacher (5%). 73% of the respondents overall said that they felt well-prepared scientifically. Of the 27 Biology-Chemistry majors who answered this question, 25 said that they felt well-prepared scientifically. As mentioned above, of the 32 Biology-Chemistry majors who responded to the survey (27% response rate for this major), 97% are employed or in graduate school in a STEM-related field.

8. What changes (curricular and others) have you made based on the stakeholder assessment data?

None.

9. What additional changes are you recommending based on your review of the stakeholder assessment data?

None.

BCHM-F3) Curriculum Analysis

In looking at your curriculum, the program review process is asking you to analyze it through three different lenses. The first lens is looking at your content and structure from the perspective of guild standards or standards gleaned from looking at programs at comparator institutions. The second lens that of employability and is asking you to look at your curriculum and educational experiences from the perspective of skills and professional qualities that you are developing in your students that will serve them will in their future work and vocational callings. The third lens is that of pedagogy and is asking you to look at the delivery of your curriculum to ensure a high quality student learning experience.

Menu and Elective Unit Analysis Biology-Chemistry	
Number of menu and elective units required by the program	2
Number of menu and elective units offered by the program	0
Menu/Elective Ratio	0.00
Longitudinal Class Section Enrollment Data	
• Link to Class Section Enrollment Report	

Comparison of current curriculum to guild standards and/or comparator institutions.

If your guild standards are associated with a specialized accreditation that your program has, these should be the basis of your analysis. If your guild standards are associated with specialized accreditation that we do not have, then you should primarily use comparator institutions as the basis for your analysis.

If your guild has standards that are not associated with specialized accreditation, then you may choose to use those standards and/or comparator institutions.

After consultation with your Dean, provide the set of guild standards or a list of the comparator institutions that you are using in your analysis.

If using guild standards:

1. Please provide a list of the guild standards that you are using to evaluate your curriculum.

Our Biology-Chemistry program is fairly unique with regards to its pseudo-double major nature. Most "Biochemistry" programs are in fact programs within the specialized field of biochemistry. Thus, it would not be appropriate to compare our major with those programs. Thus, in order to compare ourselves nationally, we have aligned the courses within the Biology-Chemistry major to the nationally-accepted core competencies within the biology and chemistry programs.

Biology: We have chosen to use the biology core competencies defined by the BioCore guide [Brownell SE, et. al., BioCore Guide: A Tool for Interpreting the Core Concepts of Vision and Change for Biology Majors, CBE—Life Sciences Education. Vol. 13, 200–211, Summer 2014]. This is a publication based on the recommendations of the Vision and Change in Undergraduate Biology Education and is the same source that we used for content and curriculum mapping for the Bio-BA and Bio-BS majors.

Chemistry: We use guild standards as defined by the American Chemical Society (ACS). http://www.acs.org/content/dam/acsorg/about/governance/committees/training/2015-acs-guidelines-for-bachelors-degree-programs.pdf The ACS promotes excellence in chemistry education for undergraduate students through approval of baccalaureate chemistry programs. While the Biology-Chemistry major cannot be ACS certified for the reasons stated above, the major standards of Organic, Physical, Analytical, Biochemistry and Inorganic chemistry will be followed and assessed throughout the curriculum. The level of mastery is different than for our Chemistry major in certain areas yet we keep consistent standards.

2. Indicate if and how your curriculum satisfies the standards (this can be done in a table or narrative form). If applicable, indicate areas where your curriculum falls short of the standards.

Background: In the Biology-Chemistry major, students are exposed to the fundamentals of both biology and chemistry. While this is not a double major, it is intended to apply many of the principles of a double major whereby students get a strong basis of understanding of both programs. However, unlike a traditional double major, this program is also designed to help students understand the core connections between these two linked disciplines.

Unlike a full double major, these students cannot possibly obtain and master all of the content that would be required of a full Chemistry major and/or a full Biology major. These two disciplines are extremely diverse in their specialties, with biology encompassing ecology, evolution, organismal biology, physiology, biochemistry, and cellular / molecular biology, and chemistry encompassing general, physical, organic, analytical, inorganic and biochemistry. We believe that the Biology-Chemistry major gives the students a broad exposure to the breadth of both disciplines as listed above, with the ability to master the core competencies that bridge the two disciplines. The electives also allow students some flexibility to specialize in, and therefore master, areas of particular interest. This is particularly important for our population of students who chose the Biology-Chemistry major, many of whom are pre-health (~80%).

Results: Indirect measurements, including surveys from current and former students in the Biology-Chemistry program, suggest that the connecting principles between biology and chemistry are important, and evident, to our students. In a recent survey (2015) of 45 current students, over 73% of the students responded that the connections between biology and chemistry were either sufficiently, or abundantly clear. Only 4% responded that it felt like two separate majors.

Biology: BioCore analysis of Curriculum content (see Appendix A): The biology curriculum of the Biology-Chemistry major was mapped to the principles outlined by the BioCore guide. While not all of these principles can be mastered in a program such as this, which encompasses biology and chemistry together, all of the 40 principles are introduced in the required course sequence. All except four of these (red highlights) are at least developed within the required course sequence, and within the remaining group of 36 principles, all except five (yellow highlights) can be mastered depending on which electives the student chooses to take. It is important to note that only four of the nine highlighted principles are classified within the physiology or molecular / cellular / developmental biology categories towards which the Biology-Chemistry major is emphasized, the rest fall within the ecology / evolution category. Even the four highlighted principles within the physiology or molecular / cellular / developmental biology categories have strong connections to ecology and evolution. Thus, we believe that the students are getting a very strong foundation in these principles.

While ecology and evolution are a very important aspect of all biology, and we definitely feel that all majors should have a strong basis in these principles, these are generally not the areas that our Biology-Chemistry majors specialize in post-graduation. With increased expectations of these majors within the realms of both biology and chemistry, some sacrifices must be made to the breadth of both biology and chemistry. While we considered eliminating some of the major principles that we felt were not as critical to this particular major, we decided to keep every one of the biology principles to determine if there were any important deficiencies generated by these sacrifices. It is important to note that 7 of the 12 ecology / evolution core principles are still able to be mastered within the program and to remind that all of the biology principles are at least introduced, with most introduced and developed. Thus, we believe that our students are exposed to the vast majority of the nationally-recognized core biology principles as defined by the BioCore guide and have the option to master several distinct specialized areas within the breadth of biology. (Mention lab hours)

Chemistry: ACS analysis of Curriculum content http://www.acs.org/content/dam/acsorg/about/governance/committees/training/2015-acs-guidelines-for-bachelors-degree-programs.pdf: The Chemistry curriculum of the Biology-Chemistry major was mapped to the principles outlined by the American Chemical Society guide. According to the ACS: “The content areas encompass five of the traditional subdisciplines of chemistry: analytical, biochemistry, inorganic, organic, and physical, and include both small molecules and macromolecules.” All the Biology-Chemistry majors have to take two semesters of General Chemistry thus meeting the ACS standards, which states that: “The introductory or general chemistry experience plays a vital role in educating all students.” Moreover, this chemistry course provides at least 100 hours of hands on laboratory experience where the use instrumentation and laboratory equipment is introduced.

The Biology-Chemistry major also includes a variety of required foundation chemistry courses such as Organic Chemistry (2 semesters + 3.5 hour laboratory), Analytical Chemistry (1 semester + 3.5-hour laboratory), Physical Chemistry (1 semester + 3.5 hour laboratory), Biochemistry (1 semester + 3 hour laboratory) and Bioinorganic chemistry (1 quad course). The ability to apply key concepts and principles of quantitative analysis, Biochemistry, Bioinorganic Chemistry, Organic Chemistry, Physical Chemistry (Kinetics and Thermodynamics) are mastered in Analytical Chemistry, Biochemistry, Bioinorganic Chemistry, Organic Chemistry II and Physical Chemistry I courses, respectively.

The ACS standards require instruction equivalent to a one-semester course of at least three semester credit hours in each of the five traditional sub-disciplines of chemistry: Analytical chemistry, Biochemistry, Inorganic chemistry, Organic chemistry, and Physical Chemistry. We can conclude that the Biology-Chemistry major fulfills the ACS standards with the exceptions of inorganic chemistry. We understand that teaching a Bioinorganic Chemistry course does not meet the ACS inorganic chemistry standards yet it fits our population of students better.

Finally, as highlighted earlier, all of our foundation courses and most upper division courses require a laboratory with the exception of Bioinorganic chemistry. The ACS standards require at least 400 hours of laboratory experience and our Biology-Chemistry major meets this requirement.

Based on the analysis of standard and reflection on the menu and elective ratio above, consider and discuss the following questions:

3. Are there courses in your program that should be modified? Why or why not.

Biology: Based on ETS data, the Biology department recently split BIO215 into two separate required courses for Biology and Biology-Chemistry majors. BIO215, which incorporated ecology, evolution, and organismal biology, was separated into BIO211 (ecology and evolution), and BIO212 (organismal biology). This was based on the idea that to teach all of those three major concepts in a single semester course was unreasonable, particularly for our students who often require a bit more focus on evolution in order to bridge science and faith (another of our program learning outcomes). This was further proven by the relatively low performances by the Biology-Chemistry majors in the ecology and organismal areas of the ETS exam. Although still early, initial indications demonstrate improvement in these areas since this course was split.

Chemistry: Similar modifications took place in the chemistry portion of the curriculum in 2013. The Chemistry Department rearranged the units assigned to the organic chemistry sequence, CHE294 and CHE304, from 5 units and 2 units to 4 units and 4 units. This more closely aligns with how most universities assign units for this sequence. At the same time the unit credit for the analytical chemistry course, CHE213, was increased from 2 to 3 to more closely conform with common practice. An upper division 2 unit course was removed from the chemistry requirements to keep these changes unit neutral. With the arrival of Matthieu Rouffet the department had a faculty member prepared to teach a bioinorganic chemistry course more appropriate for the needs and interests of the Biology-Chemistry students. That course, CHE466, was then substituted for the previously required, traditional advanced inorganic chemistry course. The latter became an upper-division elective for those who want to go deeper. These modifications are evidence of the continuous monitoring of student needs and the recognized best practices in the discipline. They have also been enabled by the expansion of the number and expertise of the Chemistry Department faculty.

Most recently with the addition of Ariane Jansma in the Chemistry Department and Kris Koudelka in the Biology Department, Advanced Biochemistry (BIO/CHE450) and Molecular Biology (BIO380) have been reconceived into a cohesive two course sequence. Instructors are guest lecturing in each other's class, and careful planning is ensuring thorough coverage of these complementary fields.

We have no recommendations for further modification of courses at this time. All of the goals of the program appear to be met appropriately. As mentioned above, over 73% of the students surveyed in 2015 responded that the connections between biology and chemistry were either sufficiently or abundantly clear.

4. Are there courses that should be eliminated? Why or why not.

No. We carefully considered the question of eliminating courses 2 years ago in the prioritization process. The conclusion then was that our curriculum was lean and efficient. Nothing has changed in the intervening time. All courses are full and the program is currently achieving its goals. Also, each course in the major is a required or elective course in the individual biology or Chemistry majors, therefore achieving multiple purposes.

5. Are there courses that could be merged? Why or why not.

No. All courses are full and the program is currently achieving its goals. Again this question was previously considered during prioritization and the same conclusions were drawn.

6. Are there courses that should be added? Why or why not. Note that in general, in order to create the space to add a new course, another course will need to be eliminated or taught less frequently.

At this time, there are no courses that we feel need to be added.

7. What did you learn about your overall curricular structure in terms of its complexity, breadth and depth in light of the guild standards and our institutional size and scope? Are there any structural changes that need to be made in light of your analysis (e.g. sequencing of courses, % and or grouping of electives, overall units required, use of concentrations, etc…)?

Some of the curricular changes made in the last few years, although beneficial, have created some sequencing problems that may need attention. In particular, we may need to give students more consistent advice about when to take the newly required organismal biology courses, BIO212, and the newly expanded analytical chemistry course, CHE213. Right now some students are taking those as late as their senior year.

The set of topics on the newly revised MCAT exam has been expanded. This could affect the sequencing of courses. For example, with the exam now containing biochemistry questions it is more advisable for pre-med Biology-Chemistry majors to take Biochemistry BIO450/CHE450 in their junior year before taking the MCAT. That would be more specific instruction than we have given in the past.

Other changes that could be beneficial for pre-health students in this major involve courses in the GE program. Biology-Chemistry students could benefit from a more specialized required writing course as a substitute for the general writing they take now. They could also benefit by taking a general psychology course, PSY103 (now a topic on the MCAT) instead of the currently required PSY101.

On a positive note, this program review exercise has once again reminded us of the strength of these two departments and of the wisdom of this major. The curriculum offered has never before been so diverse and so well taught. As a consequence, the students graduating with this major have never before been so well prepared to find work, or pursue advanced degrees. That claim is significant since many of our departments' most accomplished alumni are graduates of this major.

If using comparator institutions:

1. Begin by working with your Dean to identify a list of 5-8 comparator schools to use. In selecting schools, consideration should be given to type of institution, mission of the institution and the number of students majoring in the program.

Institution 1 Institution 2 Institution 3 Institution 4 Institution 5 Institution 6

Gather the curricular requirements for the program in question at each of the comparator institutions.

2. Use this collection of curricular requirements to develop a list of curricular features that are essential for programs of this type. In addition, make note of any innovative or creative curricular feature that may be useful in enhancing the quality of you program.

N/A

Review this list with your Dean before using it to analyze your own curriculum.

3. Indicate how your curriculum compares to the list of curricular features from your analysis (this can be done in a table or narrative form).

N/A

Based on the analysis of comparator programs and reflection on the menu and elective ratio above:

4. Are there courses in your program that should be modified? Why or why not.

N/A

5. Are there courses that should be eliminated? Why or why not.

N/A

6. Are there courses that could be merged? Why or why not.

N/A

7. Are there courses that should be added? Why or why not. Note that in general, in order to create the space to add a new course, another course will need to be eliminated or taught less frequently.

N/A

8. What did you learn about your overall curricular structure in terms of its complexity, breadth and depth in light of the comparator schools and our institutional size and scope? Are there any structural changes that need to be made in light of your analysis (e.g. sequencing of courses, % and or grouping of electives, overall units required, use of concentrations, etc…)?

N/A

Burning Glass Skills Data Biology-Chemistry		
1. Communication Skills ***Virtually every course between presentations of primary***	5. Quality Assurance and Control ***Che294, 304, 325, 351, 370, 466, 468.***	9. Planning ***Bio210, 211, 301, 345, 380, 390, 400.***

literature articles, data communication, and scientific writing.		***Che 152, 153, 213, 294, 304, 325, 450.***
2. Writing ***Virtually every course with assigned lab reports and scientific writing.***	6. Problem Solving ***Bio210, 211, 301, 345, 380, 390, 400.*** ***Virtually every Chemistry course.***	10. Management ***Basic skills developed in our teaching assistant* and summer research programs**, as well as in Biology internships.***
3. Research ***Virtually every course as each science course has a required, associated lab portion. This is also mastered with summer research opportunities, Bio499, Biology internships, and honor's projects.***	7. Leadership ***Basic skills developed in our teaching assistant* and summer research programs**, as well as in Biology internships.***	11. Project Management ***None.***
4. Organizational Skills ***Bio210, 211, 301, 345, 380, 350, 400.*** ***Che152, 153, 213, 294, 304, 325, 450.***	8. Detail-Oriented ***Bio210, 211, 301, 345, 380, 350, 390.*** ***Che152, 153, 213, 304, 325.***	12. Supervisory Skills ***Basic skills developed in our teaching assistant* and summer research programs**, as well as in Biology internships.***

* While the Teaching Assistant Program is not a required course, we highly encourage every student within the major to participate and many of them do. As a TA, they directly interface with the students in laboratory courses, providing assistance with data collection, analysis and report generation. Some are also in charge of lab set-up, breakdown, writing weekly quizzes and grading lab reports. It is a position designed to develop basic skills in leadership, management, and supervisory capacities.

**The Summer Research Program is not a required course, but it is very highly recommended and the majority of our majors participate, either within the Chemistry Department or the Biology department. Participating students are required to commit to two summers so that many labs have some new students and some returning students. As such, the returning students act as mentors working with the new students. This situation highly encourages the development of basic skills in leadership, management, and supervisory capacities.

Analysis of the curriculum against preparation for employment

9. The Burning Glass data provides a list of skills for students entering common professions that are often linked to your major. Indicate in the table if and where each skill is being taught in your program. Based on reflecting on this data, are there changes you would recommend making to your curriculum?

Interestingly, we had already decided as a department what skills are important for our majors to have, and we added them to the AAAS document discussed above (see Appendix A and answer to #10). The top four Burning Glass skills are a close match with the skills we had already identified, and they are all highly developed in our curriculum, as shown in Appendix A. In addition, problem solving and an orientation to minding details are a natural part of a standard chemistry or biology curriculum. The other skills listed above (e.g. project management, supervisory skills) could be gained through on-the-job experience or through Business classes. Students who are interested in careers in Biotechnology or the Pharmaceutical Industry, where those skills would be crucial in addition to their Biology background, also have the option of the Science-Business minor.

Finally, much of the quality assurance and control aspects are a foundational part of certain Chemistry labs, where students study and perform analytical chemistry.

10. Some programs may serve to prepare students with professional qualities and skills that can serve them well in a great variety of professions that may not show up in data sets like Burning Glass. If this is indicative of your program, please identify the unique skills and/or professional qualities that your program develops in your students and indicate where in the curriculum this is being taught or developed.

We have broken down the categories of communication skills, reading and writing, and research into several other aspects that we believe to be important skills for our students. See the curriculum map for course association.

Communication skills	Students can effectively express scientific information in standard science formats, including overall purpose, introduction, methods, results, discussion, and overall conclusions.
	Students can effectively analyze and communicate data using graphs, tables, and appropriate scientific figures.
	Students can effectively interpret and communicate scientific information orally (journal club, oral presentations of experiments, etc.).
Reading and understanding primary scientific literature	Students can understand, describe, and analyze key components, including hypothesis, background rationale, data, results, discussion of results and conclusions, of scientific literature. Students are able to evaluate if the data and conclusions are valid, including evaluation of proper controls, statistics, and appropriate assumptions. This is accomplished through both course work and the Summer Research Program.
Research	Students can perform important techniques, including the use of technical instrumentation. Students can also determine which techniques and equipment are appropriate for various experimental purposes.
	Students design, implement, and evaluate research experiments through upper-division courses, summer research and Honor's projects.
	Students can generate valid hypotheses.
	Students utilize appropriate statistical and quantitative methods to analyze data.

As mentioned previously, the fact that nearly every Biology and Chemistry class has an associated lab is crucial to the skill set of Biology-Chemistry majors. In these labs, students learn not only laboratory skills, but also how to formulate hypotheses, and how to evaluate data. Many will also learn how to do independent research, and how to write a research proposal.

Through our intensive summer research program, students hone these skills even further. Yet, since only two-thirds of our Biology-Chemistry students participate in the intensive summer research program, it is crucially important that the laboratory courses remain a foundational part of our curriculum.

Analysis of the teaching of your curriculum

11. How do the pedagogical features of your program compare with the best practices for teaching in your discipline?

The American Chemical Society (ACS) has stated in their Guidelines for Bachelor's Degree Programs the following regarding pedagogy: "An approved program should use effective pedagogies in classroom and laboratory course work. Programs should teach their courses in a challenging, engaging, and inclusive manner that accommodates a variety of learning styles. Additionally, a program should provide opportunities for faculty to maintain their knowledge of effective practices in chemistry education and modern theories of learning and cognition in science. An approved program should regularly review its pedagogical approaches to ensure that they promote student learning and build the skills needed to be an effective professional. Faculty should incorporate pedagogies that have been shown to be effective in undergraduate chemistry education. Examples include problem- or inquiry based learning, peer-led instruction, learning communities, and technology-aided instruction such as the use of personal response systems and flipped or hybrid classes. Laboratory work provides a particularly attractive opportunity for inquiry-driven and open-ended investigations that promote independent thinking, critical thinking and reasoning, and a perspective of chemistry as a scientific process of discovery."

The pedagogical features used in our program compare favorably with the best practices from within our discipline. The details of pedagogy used in our program are described in #12 on page 54.

Note: This is the same answer for all of the undergraduate programs for Biology.

In 2011, the National Science Foundation (NSF) and the American Association for the Advancement of Science (AAAS) issued a report articulating much needed changes in biology education across the country. The document, titled "Vision and Change in Undergraduate Biology Education: A Call to Action," argued for a transition from faculty-centered education to student-centered education. As a Department, we have chosen the guidance in this document as our benchmarks for best practices in the discipline. Below, we describe each Vision and Change benchmark and then discuss how our program falls short, meets, or exceeds the standard.

The student-centered classroom, sometimes called active learning, is one that is "interactive, inquiry-driven, cooperative, collaborative, and relevant." In short, it is designed with student learning in mind rather than faculty teaching in mind. One approach to accomplishing a student-centered classroom is by way of what is commonly referred to as "scientific teaching", or sometimes "backward design." This strategy for designing a course starts not with the teacher's favorite topics or what they will say in class. Instead, careful time and attention are given to developing and precisely articulating learning outcomes. Once the learning outcomes are clear, the teacher designs the best assessments to determine if the students have achieved the desired outcomes. Finally, teaching methods are considered that can provide the best opportunity for the students to achieve the stated learning outcomes.

PLNU Biology Department faculty members have been proactive in learning new techniques for student-centered teaching. We have three Ph.D.-trained science educators in our department who consult with each of us frequently and regularly offer training sessions. Many of us have attended workshops on active learning, such as the National Academies Summer Institute on Undergraduate Education in Biology offered by HHMI and NSF. We participate in a twice-monthly Faculty Learning Community focused on teaching in the STEM disciplines. Many of us take advantage of (and sometimes help lead) training opportunities offered by the Center for Teaching and Learning, such as the hugely successful Teachers Noticing Teachers program. We meet every Thursday for lunch to discuss teaching issues, and have read books (e.g., *Scientific Teaching* by Handelsman et al.) and journal articles (e.g., *Active Learning Increases Student Performance in Science, Engineering, and Mathematics* by Freeman et al. PNAS 2013) together on active learning.

Some of the student-centered teaching techniques recommended in the Vision and Change document include authentic research experiences, case studies, immediate feedback assessment technique, personal response systems, inquiry-driven learning, concept mapping, peer-led team learning, problem-based learning, process-oriented guided inquiry learning, and team-based learning. We have already implemented many of these techniques and are in the process of experimenting with others.

For example, the lab component of our upper division Microbiology course was converted several years ago to a research experience. Students learn fundamental microbiological lab techniques in the context of a bona fide research project within the expertise of the instructor. At the end of the semester, student teams present their research to the campus community in a mini-conference poster session, complete with judges and prizes.

Another example takes place in Developmental Biology. Students study assigned pieces of a complex story at home, then in class they meet in groups to bring their pieces together (process-oriented guided inquiry learning).

Several Biology professors further make use of flipped classrooms, case studies, online adaptive learning tools, personal response systems (clickers), concept mapping, peer-led team learning, and team-based learning, to name a few.

12. What new pedagogical practices have been tried by members of your department in the last few years? What has your department learned from these experiments?

Chemistry faculty participate in many activities designed to understand best practices in teaching, and to put them to use on a daily basis. Chemistry faculty have attended a variety of events directed at LEARNING about best practices which include:

- Scientific Faculty Learning Community
- Chemical Education session at national ACS conference
- Project Kaleidoscope (conferences in STEM education)
- Team-Based Learning Workshop
- NSF funded project developing interdisciplinary course modules
- Training opportunities offered by Center for Teaching and Learning

Chemistry faculty have also been invited to give talks related to teaching best practices in the following areas:

- General Chemistry Technology with McGraw-Hill Publishing
- Student engagement techniques at SDSU
- Use of iClickers for assessment at Claremont Colleges

Some of the pedagogical features used in our courses includes:

- Team-Based Learning
- Inquiry-Based Learning
- Use of sophisticated modeling software
- Use of clickers
- Enhancement of student engagement using mini whiteboards and iPads
- Online homework systems

As a faculty, we value student engagement and will continue to strive for the best possible student learning experience. In the Chemistry Department, new pedagogical practices have been added incrementally over the last 5 years and some of these practices (Team Based Learning and Inquiry-based learning) are still limited to a few courses. Since these methods are more recent, we have not yet collected data to see the direct impact on students. However, it is broadly accepted that student engagement is directly correlated with improved learning and long term retention of concepts. One example is the use of group activities and modeling software (PyMOL) in Biochemistry. These two pedagogical features have greatly improved our students' understanding of proteins and their function. The understanding was such that in Bioinorganic Chemistry (CHE 466, usually taken the following spring semester) students were able to apply these concepts readily without any need for a refresher. Therefore, the course content was shifted to a more in-depth understanding of metals in biology rather than basics of biochemistry which had to be done in the past.

Overall, we have learned that student centered teaching is worth applying and, while it will look different from one class to another, it improves student retention and student learning. Finally, these strategies allow for a stronger faculty-student interaction, thus fulfilling our mission to shape our students.

See answer to #11 on page 53 for Biology.

13. Are there new developments in pedagogy in your discipline? What would be required to implement these changes in pedagogy in your department?

The ACS guidelines regarding pedagogy that are shown above lists recent developments in pedagogy such as problem- or inquiry based learning, peer-led instruction, learning communities, and technology-aided instruction (e.g. personal response systems and flipped or hybrid classes). Faculty training (e.g. ACS Chemical Education, AAC&U, PKAL, and CTL resources) would be required to implement more of these pedagogy changes into our classes.

BCHM-F4) Potential Impact of National Trends

Top Burning Glass Occupations for the Program Biology-Chemistry		
Occupation	**Hiring Demand**	**Salary Range**
Chemist	Medium	$64K - $68K
Clinical Research Coordinator	Medium	$46K - $50K
Medical Laboratory Technologist	Medium	$58K - $60K
Quality Control Analyst	Medium	$50K - $54K
Biochemist	Low	$55K - $112K
Chemical Technician	Low	$32K - $56K
Environmental Compliance Specialist	Low	$42K - $65K
Microbiologist	Low	$48K - $92K
Physical Scientist	Low	$91K - $101K
Research Scientist	Low	$60K - $87K

Note that some programs do not have as many professions listed in the Burning Glass data as others do. In these cases we will want to get a list of professions from the chair/school dean to supplement the Burning Glass data.

1. Which professions in the Burning Glass data were you already aware of and for which are you already intentionally preparing students and does the hiring demand in these professions signal anything about the future that you need to be aware of regarding the design and structure of your program?

We are aware of all of these positions and are appropriately preparing our majors. The majority of Biology-Chemistry majors are actually pre-health (medicine, dentistry, etc.). These possible positions are not included in the Burning Glass data. In the pre-health fields we have an excellent track record of getting our graduates into the appropriate professional school (above 90%). Of the Burning Glass careers that are listed, we prepare our students through a lab intensive curriculum that mimics the skills and problem-solving situations they will encounter in these occupations. Although the Burning Glass data above list hiring demand as medium or low, the national trend for employment of our STEM majors is quite encouraging. 76% of all STEM job postings required at least a bachelor's degree. Of those postings that were entry-level, 48% required a bachelor's degree or higher. For every newly minted STEM graduate, there are an average of 2.5 entry-level job postings, and this number is continuing to grow. This is especially positive when considering all non-STEM graduates average 1.1 entry-level job postings per graduate. Finally, entry-level STEM jobs that require a bachelor's degree in the sciences have an average salary that is 26% higher than non-STEM entry-level positions. 65% of STEM job postings were in the field of healthcare, which historically the Biology-Chemistry major does an outstanding job of preparing our students for.

2. Are there additional professions in the Burning Glass list or from your knowledge of occupations your alumni have entered, for which you should be preparing students?

All of the pre-health careers, and we are doing an excellent job preparing these students.

3. What changes in your program would be necessary in order to prepare students for the skills and professional qualities needed to succeed in these additional professions?

There are no current changes required.

4. Are there national trends in higher education or industry that are particularly important to your discipline? If yes, how is your program reacting to those trends?

There are two major trends in higher education and sciences that we are paying particular attention to. 1) The political, social, and economic climate toward STEM. There is a huge push from all three of the aforementioned spheres of influence to prepare more STEM graduates, which bodes well for the future of Biology-Chemistry graduates. 2) Increased incorporation of authentic research experiences for students. Our departments have done an excellent job being ahead of the curve in this area for decades. Students have the opportunity to complete full-time, intensive research in the summer, part-time research during the semester, and many required and elective courses have open-ended research experiences within them.

BCHM-F5) Quality Markers

Retention/Graduation Rates (First-Time Freshmen)							
	Matriculation Term						
Biology-Chemistry	**Fall 2008**	**Fall 2009**	**Fall 2010**	**Fall 2011**	**Fall 2012**	**Fall 2013**	**Fall 2014**
First-Year Retention	**92.3%**	**88.9%**	**90.0%**	**96.9%**	**88.5%**	**90.5%**	**91.3%**
PLNU First-Year Retention	*84.2%*	*84.1%*	*81.1%*	*82.9%*	*89.3%*	*84.5%*	*84.5%*
	Matriculation Term						
	Fall 2005	**Fall 2006**	**Fall 2007**	**Fall 2008**	**Fall 2009**	**Fall 2010**	**Fall 2011**
Four-Year Graduation Rate	**81.0%**	**61.9%**	**40.0%**	**61.5%**	**72.7%**	**71.4%**	**56.5%**
PLNU Four-Year Graduation Rate	*62.0%*	*65.2%*	*61.7%*	*59.1%*	*63.4%*	*62.2%*	*63.2%*
	Matriculation Term						
	Fall 2003	**Fall 2004**	**Fall 2005**	**Fall 2006**	**Fall 2007**	**Fall 2008**	**Fall 2009**
Six-Year Graduation Rate	**47.8%**	**100.0%**	**81.0%**	**61.9%**	**60.0%**	**69.2%**	**81.8%**
PLNU Six-Year Graduation Rate	*72.4%*	*73.2%*	*73.0%*	*74.9%*	*72.2%*	*73.6%*	*75.0%*
Degree Completions							
Majors	**2008-09**	**2009-10**	**2010-11**	**2011-12**	**2012-13**	**2013-14**	**2014-15**
Biology-Chemistry	**18**	**14**	**4**	**10**	**11**	**15**	**16**
Share of PLNU Bachelor's Degrees	*3.0%*	*2.7%*	*0.7%*	*1.8%*	*1.9%*	*2.5%*	*2.9%*
Minors	**2008-09**	**2009-10**	**2010-11**	**2011-12**	**2012-13**	**2013-14**	**2014-15**
No minors in this program							
FTF Time to Degree *(in semesters)*	**8.0**	**8.0**	**sm**	**8.4**	**8.7**	**8.4**	**8.4**
PLNU FTF Time to Degree	*8.2*	*8.2*	*8.3*	*8.2*	*8.3*	*8.3*	*8.3*
Study Abroad Participants	3	3	1	2	1	1	1
sm = cell size too small							

1. Based on comparing the quality marker data for your program with the PLNU averages:
   a. What does this tell you about your program?

Retention, graduation rates and FTF time to degree is generally at or above the PLNU average.

   b. If your values are below the PLNU averages, what changes could you make to address any areas of concern?

N/A

   c. If your values are above the PLNU averages, what do you believe contributes to this success?

N/A

2. Describe regular opportunities for students to apply their knowledge (internships, practicums, research projects, senior projects, etc.). Estimate what percentage of your students in this program participates in these kinds of opportunities.

Both Biology and Chemistry have an intensive undergraduate research program, where students gain an 800-hour research experience over the course of two summers. Of the Biology-Chemistry students who graduated from 2007-2015, 66% participated in an intensive research experience. This percentage is higher than the rates for Biology BA and Biology BS majors, in part because Biology-Chemistry majors have the opportunity to do research in two departments, rather than in just the Biology department. Biology-Chemistry majors also tend to be stronger students than the straight Biology majors.

Since 2013 the Biology department has been trying to develop more internship opportunities for our students as an alternative way of developing crucial career skills in the students who do not participate in the intensive research experience. In Spring 2015, six students interned throughout San Diego county and in Fall 2015 eight students interned. The intern sites include everything from entering and analyzing research data (e.g. at Cabrillo National Monument), to learning to care for animals (e.g. Project Wildlife), or working in a science classroom (e.g. St. Charles Borromeo Middle School). Over the past two years, we have expanded the number of internship opportunities to about 10. It should be noted that this requires a lot of effort! To truly expand these opportunities for our students, we would need release time for an internship coordinator (see Biology program recommendations). A coordinator would (a) cultivate new internship opportunities, (b) act as a liaison between the organization and the PLNU biology department, (c) meet with interns one-on-one to identify appropriate internship possibilities, (d) assist students with internship applications (when needed), (e) communicate regularly with the students during the internship, (f) communicate with the site internship supervisor to follow up on the progress and success of the student intern.

In addition, students are highly encouraged to participate in the life of the department, including work as Teaching Assistants and/or graders for the courses, particularly the laboratory portions. This helps students apply their knowledge by making solutions, setting up reagents, working with advanced equipment, and teaching fellow students as part of their TA position. While the professor is the main instructor for every course, these opportunities of engagement for the students also help facilitate learning within the student community. In the last few years, over 50% of our students have participated as TAs in the department, many TAing for several semesters and multiple courses. However, we do not have this data broken down into individual programs within the departments.

3. Describe any public scholarship of your undergraduate and graduate students in this program (conference presentations, publications, performances, etc.). What percentage of your undergraduate students are involved in these kinds of activities?

As described above, about 66% of our Biology-Chemistry students are involved in the intensive research experience with the faculty. At least half of these students then have peer-reviewed publications and/or presentations based on this research. Many of them present at the West Coast Undergraduate Research Conference in Biology, which the Biology department hosts every 2-3 years. Biology-Chemistry students who do their research in the Chemistry Department are also frequently co-authors on peer-reviewed publications and attend annual conferences to present their research findings.

4. How many of your students participate in study abroad opportunities in general? Describe any study abroad opportunities specifically organized by your program. What percentage of your majors are involved annually (annualize the number)? How many students outside of your department participate in this departmentally organized program (Annualize the number)?

Because of the large size of the Biology-Chemistry major (68-70 units), most of these students have a difficult time studying abroad. We have one opportunity that is organized by our department, Costa Rica Study Abroad, which is described in the Biology-BA/BS sections. However, students who bring in AP credit or do summer school are able to spend a semester abroad. These are individualized programs designed by the student in consultation with the Study Abroad Office.

5. What are any other distinctives of your program? Describe how they contribute to the program's success.

A top priority of our departments is for students to do biology and chemistry, not just learn about them. To accomplish this, we have a laboratory rich curriculum. Almost all of our classes have a required laboratory experience. We are proud of the deliberate mentoring of students that occurs while they are at PLNU and the relationships we have been able to maintain with a large number of our alums. Our students work as prep-room workers, graders, review session leaders, tutors, and lab assistants under the supervision of faculty. Our alumni are constantly giving back through guest lectures, mentoring, shadowing opportunities, etc., and are extremely willing to help current students. Alumni tell us that they are very well prepared for post-baccalaureate education and jobs in the discipline.

All of the full-time faculty in biology and chemistry earned a Ph.D. prior to coming to PLNU. Moreover, all of our faculty have completed postdoctoral research beyond the Ph.D. This indicates that our program has a track record of attracting faculty highly-qualified in both teaching and scientific research.

Another distinctive shared by both the Biology and Chemistry Departments is our pre-health professions advising. We have a dedicated advisor (currently Sara Choung) for students preparing for medical, dental, optometry, pharmacy, or veterinary school. This program includes two preparatory interviews for the students, sessions with alumni and local health professionals, and a committee-written letter of recommendation. This program has almost certainly contributed to the high rate of acceptance of our students into the health professional schools (over 90% for over 15 years).

6. Does your program have an advisory board? If so, describe how it has influenced the quality of your program? If not, could it benefit from creating one?

N/A

7. Describe any current joint interdisciplinary degrees (majors or minors) offered by your department. Are there additional areas where interdisciplinary programs should be considered?

The Biology-Chemistry major and the Environmental Science major are joint with Biology. There are also science-business and science-marketing minors for business or science majors and the computational science minor. We are not currently considering additional interdisciplinary programs.

8. Describe your success with students acquiring jobs related to their discipline.

As mentioned previously, we assess these data every five years. In our most recent survey, 88% of our alumni were employed or attending graduate school in a STEM-related field. In addition, our acceptance rate of students into graduate and health professions schools continues to be at least 90%. Of the 32 Biology-Chemistry majors who responded to the survey, 97% are employed or in graduate school in a STEM-related field.

9. Describe your undergraduate and graduate student success rate for passing licensure or credentialing exams (if they exist in your discipline).

N/A

10. Describe your success with undergraduate student acceptance into post-baccalaureate education.

A large number of our graduates continue their education at health professions schools or graduate schools and they have been very successful at getting into these various programs. As mentioned previously, the success rate for alumni who apply to graduate or professional schools has been well over 90% for at least 20 years. In recent years, students have gone to prestigious programs at University of California San Diego, University of California Irvine, Yale University, Georgia Tech University, Vanderbilt University, etc. For dental, medical, optometry, pharmacy, and veterinary schools, there have been 166 acceptances out of 181 applicants (91.7%) between 2004 – 2014. They have gone on to a number of schools across the country such as University of California San Diego, University of Southern California, Loma Linda University, University of Washington, Duke University, Purdue University, etc. Between 2001 and 2011, 46 Biology and Chemistry Department alumni earned a Ph.D. This speaks very highly of their undergraduate preparation in both the chemistry and biology courses.

11. What kind of support does your program provide for students encountering academic difficulties? How do you intentionally facilitate these students' connection with institutional support services?

Our departments have multiple means of supporting students with academic difficulties. First, these students are usually identified in the freshman classes (BIO210 and BIO211), where the instructors contact students who are doing poorly on exams and offer specific advice on study habits, extra office hours, and direction to tutoring. Second, the Chemistry Department offers a weekly tutorial for students in the first semester of General Chemistry (CHE151), as well as student-led weekly review sessions for both semesters of General Chemistry and Organic Chemistry. Third, during the twice yearly advising sessions, we meet with our advisees for 15-30 minutes and discuss both academic and non-academic factors, as well as vocation. Fourth, on some occasions, we have directly referred students to the Wellness Center, the DRC, or even contacted Caye Smith, Jeff Bolster, or Mark Pitts, depending on the situation. Finally, we are hoping to use the new capabilities of the SSC to bolster these efforts by identifying students who may be in the middle ground but could use some resources to make their college experience even better.

BCHM-F6) Infrastructure and Staffing

Full-Time Faculty Program Contribution
Department of Chemistry
(duplicated in other program-level sections)

	2012-13	2013-14	2014-15
Percentage of UG classes taught by FT faculty	68.8%	71.6%	65.5%
PLNU percentage of UG classes taught by FT Faculty	*TBD*	*TBD*	*TBD*
Includes: regular lectures, labs, seminars Excludes: independent studies, private lessons, internships			

1. Are your program's current technological resources and support adequate? If not, what is needed? Do you foresee any additional needs in this area?

Biology: At present our technological resources and support are superior with the recent addition of the Latter Hall classrooms and Sator Hall laboratories. Our current needs are well met; however, instrumental technology is continually evolving. The faculty actively pursues grants to support these needs. In addition, administration has been supportive of many of these changing needs as well. We need this continued support to provide our graduates with the most up-to-date education and experiences to be truly competitive. (Note: This is the same answer as for the Biology-BA/BS.)

Chemistry:
Special instrument funds accompanying the building of Sator Hall allowed for the addition to several state-of-the-art instruments for use in the Chemistry major courses and related research. These instruments include an Inductively Coupled Plasma – Optical Emission Spectrometer (ICP-OES), high performance liquid chromatograph (HPLC), infrared (IR) spectrometer, fluorescence spectrometer, glove box, lyophilizer, microwave reactor, magnetic susceptibility balance, potentiostat, and spectrometers. Additional funding from the Provost's office made possible the purchase of a much-needed, used 400 MHz nuclear magnetic resonance (NMR) spectrometer. We also negotiate access to remaining necessary equipment via local connections (at UCSD, USD, and TSRI).

In order to keep these instruments running, we do need ongoing support for instrumentation. Currently, the institution has no replacement schedule (or line item in the budget) for scientific equipment. The new instruments mentioned above require solvents, gases, cryogens and consumables in order to run, while older instruments (like our ultraviolet and visible spectrophotometer (UV-vis), gas chromatographs (GCs), and gas chromatograph-mass spectrometer (GC-MS)), are likely to require maintenance and repairs in the near future beyond what is covered in our existing budget.

We still need at least two additional instruments commonly used in an undergraduate chemistry curriculum: an X-ray diffractometer and a liquid chromatograph-mass spectrometer (LC-MS). As mentioned above, faculty actively pursue grants to support department needs. It will require continuing support (external and institutional) to provide our graduates with the most up-to-date educational experiences necessary to maintain our competitive edge.

2. Are your program's current facilities adequate? If not, what is needed? Do you foresee any additional needs in this area?

Biology: The classrooms and facilities in the new building are wonderful and adequate, as long there is stable enrollment in the Nursing, Allied Health, and Biology programs. Our office space is not adequate. Cho is in MICS space, which he will soon need to vacate. Koudelka is in a trailer outside the building. We thus need a minimum of two more offices. (Note: This is the same answer as for the Biology-BA/BS.)

Chemistry: The classrooms and facilities in Sator and Latter halls are excellent and are expected to be adequate for our needs assuming stable enrollment in our courses that serve other departments such as Nursing and Kinesiology. Maintaining one general purpose teaching laboratory in Rohr Science would provide capacity for growth. Office space in the Chemistry Department is old and inadequate, with no space for adjunct faculty. It would also be great if students had a space to congregate to study together and work on projects together.

3. Is your program's current staffing (administrative, clerical, technical and instructional) adequate? If not, what is needed? Do you foresee any additional needs in this area?

Biology: Staffing is close to adequate, again as long there is stable enrollment in the Nursing, Allied Health, and Biology programs. Ideally, we need a long-term adjunct or part-time professor so that we can split up the overly large sections of BIO130 and BIO140 that have 72 students. As discussed previously, this would require at least 6 units of extra load per year. (Note: This is the same answer as for the Biology-BA/BS.)

Chemistry:
Our instructional staffing is not adequate. We are in need of a Physical Chemist to replace Ken Martin, who is in the final year of his phased retirement. Physical chemistry is one of the five pillars of a solid chemistry curriculum and no one else in the department is trained to teach those courses.

Current and projected enrollments in Chemistry Department programs as well as other departments/programs served by Chemistry have been growing dramatically. As a result, enrollments in our largest courses have more than doubled in the past ten years (the numbers of students in CHE103, CHE152, and CHE153 have grown by 38.5%, 165.0%, and 129.5%, respectively). With the hire of a full-time Physical Chemist, the number of teaching units taught by full-time faculty would still be below 80% each academic year (2016-2017: 78.9%, 2017-2018: 76.2%).

Moreover, a Physical Chemist is necessary to maintain the curricular balance required of a quality chemistry teaching and research program. A Physical Chemist is also necessary to successfully seek American Chemical Society (ACS) Program Approval.

BCHM-F7) Challenges and Opportunities

1. Are there any particular challenges regarding this program that have not been addressed through the analysis and reflection on data or questions in sections F1-F6 that you would like to include here?

- Increase student recruitment and retention
- Staffing for Physical Chemistry courses (if we are not approved to search for a replacement in 2016-2017)
- Long-term instrument maintenance and replacement
- Funding our growing summer research program (student participation has doubled in the last decade)
- Continuing to maintain our relationship with department alumni, in particular Research Associates, as senior members of the department retire

2. Are there any particular opportunities regarding this program that have not been addressed through the analysis and reflection on data or questions in sections F1-F6 that you would like to include here?

- Build stronger community among our majors
- Expand use of ACS recommended pedagogies in more of our classes and have departmental discussions about pedagogies and best practices (considering pedagogies and teaching strategies used at other universities)
- Expanding our connections with local companies for possible internships and job opportunities for our students
- More formal advising for students who are planning to attend graduate school or enter the workforce
- Re-designing GE courses (e.g. more topics based like “chemistry and cooking”)
- Re-design lab experience for General Chemistry I and II (possibly adding an honors lab section)

BCHM-F8) Recommendations for Program Improvement

List the recommendations you are making regarding this program analysis with a brief rationale for each recommendation.

1) Hire a physical chemist as a replacement for a retiring faculty member (#3 on page 61).
2) Explore outreach opportunities to local high school chemistry teachers as a recruiting tool.

Program Level Analysis (Env Sci)

Bachelor of Science in Environmental Science

ENVS-F1) Trend and Financial Analysis

First-Time Freshman Admissions Funnel							
Environmental Science	**Fall 2009**	**Fall 2010**	**Fall 2011**	**Fall 2012**	**Fall 2013**	**Fall 2014**	**Fall 2015**
Inquiries	**22**	**68**	**82**	**97**	**106**	**133**	**118**
Share of PLNU inquiries	*0.2%*	*0.4%*	*0.5%*	*0.5%*	*0.6%*	*0.6%*	*0.7%*
Completed Applications	**13**	**21**	**17**	**14**	**29**	**25**	**24**
Share of PLNU Applications	*0.6%*	*0.8%*	*0.6%*	*0.5%*	*1.0%*	*0.9%*	*1.0%*
Applicant Conversion Rate	**59.1%**	**30.9%**	**20.7%**	**14.4%**	**27.4%**	**18.8%**	**20.3%**
PLNU Applicant Conversion Rate	*18.6%*	*17.3%*	*17.0%*	*15.7%*	*16.1%*	*12.1%*	*15.0%*
Admits	**12**	**15**	**8**	**11**	**23**	**22**	**20**
Share of PLNU Admits	*0.7%*	*0.8%*	*0.4%*	*0.6%*	*1.1%*	*1.0%*	*1.0%*
Selection Rate	**92.3%**	**71.4%**	**47.1%**	**78.6%**	**79.3%**	**88.0%**	**83.3%**
PLNU Selection Rate	*87.4%*	*72.9%*	*68.9%*	*69.0%*	*70.5%*	*79.5%*	*79.8%*
New Transfer Admissions Funnel							
Environmental Science	**Fall 2009**	**Fall 2010**	**Fall 2011**	**Fall 2012**	**Fall 2013**	**Fall 2014**	**Fall 2015**
Inquiries	**2**	**0**	**1**	**8**	**13**	**14**	**16**
Share of PLNU inquiries	*0.2%*	*0.0%*	*0.1%*	*0.5%*	*0.9%*	*0.8%*	*0.8%*
Completed Applications	**1**	**--**	**1**	**4**	**3**	**3**	**3**
Share of PLNU Applications	*0.2%*	*--*	*0.2%*	*0.9%*	*0.6%*	*0.4%*	*0.7%*
Applicant Conversion Rate	**sm**	**--**	**sm**	**50.0%**	**23.1%**	**21.4%**	**18.8%**
PLNU Applicant Conversion Rate	*50.2%*	*55.5%*	*56.2%*	*28.4%*	*33.2%*	*36.9%*	*21.7%*
Admits	**1**	**--**	**1**	**2**	**3**	**2**	**3**
Share of PLNU Admits	*0.3%*	*--*	*0.4%*	*0.7%*	*0.9%*	*0.5%*	*0.8%*
Selection Rate	**sm**	**--**	**sm**	**sm**	**sm**	**sm**	**sm**
PLNU Selection Rate	*79.3%*	*57.9%*	*54.8%*	*60.5%*	*65.4%*	*64.1%*	*79.2%*
sm = cell sizes too small							

1. What does this data tell you about the external demand for your program? What does this say about the future viability of your program?

External demand for the Environmental Science major seems to be growing as the first-time freshman inquiries have steadily been increasing. The applicant conversion rate was greater than the PLNU rate for all years except 2012. The selection rate has mostly been greater than the PLNU, except for 2010 and 2011, because these students generally are highly qualified applicants. New transfer inquiries have also increased over the years, but the applicant conversion rate has generally been less than the PLNU rate. Future viability of this program seems positive since awareness and interest in the program is growing.

The Biology Department has proposed limiting enrollment of all of their majors (Biology-BA, Biology-BS, Biology-Chemistry-BS, Environmental Science-BS). The Chemistry Department has capacity for more majors and is opposed to limiting enrollment of the joint majors (Biology-Chemistry-BS and Environmental Science-BS). Discussions are ongoing.

First-Time Freshman Admissions Yield							
Environmental Science	**Fall 2009**	**Fall 2010**	**Fall 2011**	**Fall 2012**	**Fall 2013**	**Fall 2014**	**Fall 2015**
Admits	12	15	8	11	23	22	20
Matriculants	**5**	**3**	**1**	**4**	**4**	**6**	**5**
Share of PLNU Matriculants	*0.9%*	*0.5%*	*0.2%*	*0.7%*	*0.6%*	*1.0%*	*0.8%*
Yield Rate	**41.7%**	**20.0%**	**12.5%**	**36.4%**	**17.4%**	**27.3%**	**25.0%**
PLNU Yield Rate	*29.3%*	*30.5%*	*27.7%*	*30.3%*	*31.0%*	*27.9%*	*29.9%*
New Transfer Admissions Yield							
Environmental Science	**Fall 2009**	**Fall 2010**	**Fall 2011**	**Fall 2012**	**Fall 2013**	**Fall 2014**	**Fall 2015**
Admits	1	--	1	2	3	2	3
Matriculants	**1**	**--**	**1**	**1**	**2**	**0**	**1**
Share of PLNU Matriculants	*0.6%*		*0.7%*	*0.7%*	*1.4%*	*0.0%*	*0.6%*
Yield Rate	**sm**	**--**	**sm**	**sm**	**sm**	**sm**	**sm**
PLNU Yield Rate	*51.1%*	*60.2%*	*54.7%*	*47.3%*	*44.6%*	*46.0%*	*48.0%*
sm = cell sizes too small							

2. How does your yield rate (percentage of students who enroll at PLNU after being admitted) compare to the PLNU average? If your rate is more than 8 percentage points above the PLNU average, what factors do you believe are contributing to this positive outcome? If your rate is more than 8 percentage points below the PLNU average for more than one year, what factors do you believe are contributing to this difference?

Yield rates for this major have fluctuated both above and below the PLNU yield rate. This may be due to the fact that the number of admits and matriculants are small compared to the number of PLNU matriculants ≤1.0%. With the small number of matriculants, the Chemistry Department has room for more environmental science majors.

Enrollment							
Majors	**Fall 2009**	**Fall 2010**	**Fall 2011**	**Fall 2012**	**Fall 2013**	**Fall 2014**	**Fall 2015**
Environmental Science	**21**	**22**	**18**	**19**	**22**	**22**	**19**
Share of PLNU Undergraduates	*0.9%*	*0.9%*	*0.8%*	*0.8%*	*0.9%*	*0.9%*	*0.7%*
Minors	**Fall 2009**	**Fall 2010**	**Fall 2011**	**Fall 2012**	**Fall 2013**	**Fall 2014**	**Fall 2015**
No minors in this program							
Major Migration of Completers*							
Top Importing Programs:	**2009/10**	**2010/11**	**2011/12**	**2012/13**	**2013/14**	**2014/15**	**6-yr Total**
Undeclared			2			2	4
Biology-Chemistry			1		2		3
Biology (BA)		1	1				2
Chemistry				1	1		2
Top Export Destinations:	**2009/10**	**2010/11**	**2011/12**	**2012/13**	**2013/14**	**2014/15**	**6-yr Total**
Biology (BA)					1		1
Biology-Chemistry				1			1
Exercise Science				1			1
Philosophy				1			1
* Based on degree completions of students who either started or finished within the program and who originally matriculated as first-time freshmen							

3. What does this data tell you about the internal demand for your program? Does this raise any questions about the viability and/or sustainability of your program as it is currently configured? Explain why or why

not. Are there any actionable strategies that you can do that might make a difference if your trends are in the wrong direction?

The migration to and from this major is mostly from other science majors, so internal demand is good. This program is both viable and sustainable.

General Education and Service Credit Hour Production Department of Chemistry (duplicated in other program-level sections)				
	2011/12	**2012/13**	**2013/14**	**2014/15**
Total Dept UG student credit hours	3,247	3,071	3,479	3,445
Number of GE sections taught	7	7	9	9
% of SCH that are GE	47.7%	48.9%	54.3%	51.8%
Share of PLNU GE SCH	*4.5%*	*4.2%*	*5.2%*	*5.0%*
Number of service course sections taught	No service courses in this program			
% of SCH that are service				
Share of PLNU service SCH				

4. What does this data tell you about how your program is impacted by the needs of GE and other academic disciplines? Does this raise any questions about the viability and/or sustainability of your program if these non-programmatic trends continue? Explain why or why not.

About half of our department's SCH are in GE courses. Our GE courses are CHE101, CHE103, CHE152, and PSC110. This high percentage is a little misleading because most of the students who take CHE103 and CHE152 are required to take these courses for their major and are not solely taking them to fulfill their physical science (with a lab) GE requirement. Although none of our courses meet the definition being used for service courses, we serve a large number of students from other departments and schools, such as Biology, Physics and Engineering, Kinesiology, and Nursing. We also serve pre-health students, who are required to take chemistry courses such as CHE103, CHE152, CHE153, CHE294, and CHE304. In addition, chemistry students do not take CHE103 and the majority of students in CHE152, CHE153, CHE294, and CHE304 are not chemistry students. We do not anticipate a decrease in these SCH and therefore do not think it raises questions about viability or sustainability.

Delaware Study Data Department of Chemistry (duplicated in other program-level sections)												
	2010/11			**2011/12**			**2012/13**			**2013/14**		
Program Cost per SCH	**$268**			**$284**			**$279**			**$258**		
Benchmark Percentiles	$194	$240	$271	$177	$242	$293	$183	$233	$292	$191	$247	$306
Ranking	Medium			Medium			Medium			Medium		

5. We know that the following factors influence the Delaware cost per credit hour:
   - Large amount of GE and service classes taught by the program
   - The career stage of the program faculty (early career faculty are less expensive)
   - The number of elective courses in the program
   - The amount of unfunded load (faculty receiving more credit for a course than the number of units received by a student – e.g. 4 units of faculty load for teaching a 3 unit class)
   - The amount of release time associated with the program
   - Faculty members on sabbatical
   - The size of the department budget and the cost of specialized equipment

Please reflect on your program's Delaware data in light of this information. In particular, what factors contribute to your program having a high (above 75th percentile), medium (50th-75th percentile), or low (below 50th percentile) ranking?

Our cost per SCH falls consistently in the medium range compared to the Delaware Data benchmarks. The 2013-2014 academic year had the lowest cost of the 4 years reported above. Chemistry education may be more expensive than other PLNU programs, but compared to similar programs elsewhere we are delivering good value at a comparable cost to other schools.

6. Recognizing that not all factors above are under departmental control, what kinds of adjustments might be made to reduce the cost per student credit hour?

Because of prioritization, we changed the unit structure of CHE103 from a 5 unit lecture and 0 unit lab to 4 unit lecture and 1 unit lab. We made a similar change to PSC110 from a 4 unit lecture and 0 unit lab to 3 unit lecture and 1 unit lab. With the larger labs in the new science building, we will be offering two fewer lab sections of CHE103 and one fewer lab section of CHE294 in the fall compared to last fall and we already offered one fewer lab section of CHE304 this spring. These changes decrease the cost per SCH.

***** Future *****
Financial Data: (possibly delayed to the future)
Extra Revenue Generated by Program (lab fees, studio fees, etc.)
Extra Revenue per student credit hour
Extra Costs for the program (equipment not purchased outside of department budget, etc.)
Extra costs per student credit hour
Modified Delaware values: Delaware – extra revenue per SCH + extra costs per SCH

7. Do these modified Delaware values tell you anything new about the future viability and/or sustainability of your program as it is currently configured? Please explain.

N/A because no modified Delaware values.

ENVS-F2) Findings from Assessment

Links to the department's assessment wheel
• Student Learning Outcomes • Curriculum Maps • Assessment Plan • Evidence of Student Learning • Use of the Evidence of Student Learning

Reflection on longitudinal assessment of student learning data:

1. What have you learned from this program's student learning assessment data?

*Since this is a joint major, only the Chemistry-specific assessment will be addressed here. The Biology-specific assessment will be addressed in their program review document.

Our first priority as an academic department is to ensure that our students are learning the essential concepts of chemistry. We started using the American Chemical Society (ACS) standardized exam in Analytical Chemistry to measure the performance of Environmental Science majors in analytical chemistry including quantitative and instrumental analysis. The criterion for success that we set is that the overall group mean will be at or above the 35th percentile. (Only 36 of the 50 questions were pertinent to the topics covered in this class, so the 35th percentile was chosen instead of the 50th percentile.) The 2014-2015 data demonstrated that our graduating senior environmental science majors did not meet the criterion for success. This was the first time the ACS standardized exam in Analytical Chemistry was given, so we will continue to administer this exam each spring to obtain longitudinal data so better conclusions can be drawn and necessary changes can be made.

We also want our students to be able to use standard instrumentation and laboratory equipment to conduct scientific experiments and perform chemical characterization and analyses. Because of this, we have designed a lab-rich curriculum and many opportunities for students to gain experience with instrumentation and laboratory equipment through their roles as researchers and teaching assistants. Direct assessment began this year because this PLO was modified at the end of 2014-2015. With that being said, we are confident that all 2015 Environmental Science graduates are able to use each of the various instruments with little or no guidance based on their course and lab curriculum and various positions as teaching assistants.

Another priority of our department is that our students will participate in the life of the department by involvement in research, science clubs, and/or in various positions of responsibility such as graders, tutors, stockroom workers, and/or teaching assistants. In 2014-2015, 100% of our graduating environmental-science students had participated in at least one of these activities.

Having our students gain admittance to graduate programs and careers is also a top priority. In our most recent alumni survey, 91% of our alumni were attending graduate school or employed in a Chemistry or STEM-related field. In addition, our acceptance rate of students into graduate and health professions schools continues to be greater than 90%. Of the eight Environmental Science majors who responded to the survey, 88% are employed or in graduate school in a STEM-related field. Additional records kept by Mike McConnell indicate that 29 Environmental Science students have graduated since the program began, of which we know outcomes for 19. Of these, 14 are either in graduate school or in the environmental sciences (74%). 18 of the 19 are in STEM-related fields, and the remaining graduate is currently applying for graduate school in environmental science.

2. What changes (curricular and others) have you made based on the student learning assessment data?

No changes have been made related to the student learning assessment data mentioned above because we need to obtain longitudinal data so better conclusions can be drawn and necessary changes can be made.

3. What additional changes are you recommending based on your review of the student learning assessment data?

We are recommending changes based on surveys of comparator institutions (see below).

DQP Outcomes with Scores
***** TBD *****
DQP Definitions
Intellectual Skills Intellectual Skills define proficiencies that transcend the boundaries of particular fields of study: analytic inquiry, use of information resources, engaging diverse perspectives, ethical reasoning, quantitative fluency, and communicative fluency.
Specialized Knowledge What students in any specialization should demonstrate with respect to the specialization, often called the major field. All fields call more or less explicitly for proficiencies involving terminology, theory, methods, tools, literature, complex problems or applications and cognizance of limits.
Applied and Collaborative Learning Applied learning suggests what graduates can do with what they know. This area focuses on the interaction of academic and non-academic settings and the corresponding integration of theory and practice, along with the ideal of learning with others in the course of application projects.
Broad and Integrative Knowledge Students integrate their broad learning by exploring, connecting and applying concepts and methods across multiple fields of study to complex questions—in the student's areas of specialization, in work or other field-based settings and in the wider society.
Civic and Global Learning Civic and Global Learning proficiencies rely principally on the types of cognitive activities (describing, examining, elucidating, justifying) that are within the direct purview of the university, but they also include evidence of civic activities and learning beyond collegiate settings. These proficiencies reflect the need for analytic inquiry and engagement with diverse perspectives.

Reflection on DQP related data:

Understanding that the DQP framework provides one particular lens on the meaning, quality and integrity of your curriculum, reflect on the DQP data and framework provided for your program.

4. What have you learned from this program's DQP comparison?

The DQP roll-up is based on current department assessment, so we have nothing to add here.

5. What changes (curricular and others) have you made based on the DQP comparison?

None.

6. What additional changes are you recommending based on your review of the DQP comparison?

None.

Links to stakeholder assessment data (if present this will be department housed data)
• Surveys • Focus Groups • Market Analysis • Etc…

Reflection on stakeholder feedback data:

7. What have you learned from this program's stakeholder assessment data? If you do not have stakeholder data, please provide a plan for how you will regularly collect this in the future.

We conducted an alumni survey in 2015. 408 alumni from 2004-2014 were mailed and 115 replied (28% response). 60% of the respondents were currently in a graduate program or had already obtained an advanced degree. The most common occupations were currently in a graduate program (35%), health professional (23%), research (12%: biotechnology, academic, government, etc.) and K-12 teacher (5%). 73% of the respondents overall said that they felt well-prepared scientifically. Of the six Environmental Science majors who answered this question, all said that they felt well-prepared scientifically. As mentioned above, of the eight Environmental Science majors who responded to the survey (33% response rate for this major), 88% are employed or in graduate school in a STEM-related field. Additionally, the McConnell alumni data records indicate that 18 of 19 graduates are in STEM-related fields, and the remaining graduate is currently applying for graduate school in environmental science.

8. What changes (curricular and others) have you made based on the stakeholder assessment data?

None based on stakeholder data.

9. What additional changes are you recommending based on your review of the stakeholder assessment data?

None based on stakeholder data.

ENVS-F3) Curriculum Analysis

In looking at your curriculum, the program review process is asking you to analyze it through three different lenses. The first lens is looking at your content and structure from the perspective of guild standards or standards gleaned from looking at programs at comparator institutions. The second lens that of employability and is asking you to look at your curriculum and educational experiences from the perspective of skills and professional qualities that you are developing in your students that will serve them will in their future work and vocational callings. The third lens is that of pedagogy and is asking you to look at the delivery of your curriculum to ensure a high quality student learning experience.

Menu and Elective Unit Analysis Environmental Science	
Number of menu and elective units required by the program	14
Number of menu and elective units offered by the program	0
Menu/Elective Ratio	0.00
Longitudinal Class Section Enrollment Data	
• Link to Class Section Enrollment Report	

Comparison of current curriculum to guild standards and/or comparator institutions.

If your guild standards are associated with a specialized accreditation that your program has, these should be the basis of your analysis. If your guild standards are associated with specialized accreditation that we do not have, then you should primarily use comparator institutions as the basis for your analysis.

If your guild has standards that are not associated with specialized accreditation, then you may choose to use those standards and/or comparator institutions.

After consultation with your Dean, provide the set of guild standards or a list of the comparator institutions that you are using in your analysis.

If using guild standards:

1. Please provide a list of the guild standards that you are using to evaluate your curriculum.

N/A

2. Indicate if and how your curriculum satisfies the standards (this can be done in a table or narrative form). If applicable, indicate areas where your curriculum falls short of the standards.

N/A

Based on the analysis of standard and reflection on the menu and elective ratio above, consider and discuss the following questions:

3. Are there courses in your program that should be modified? Why or why not.

N/A

4. Are there courses that should be eliminated? Why or why not.

N/A

5. Are there courses that could be merged? Why or why not.

N/A

6. Are there courses that should be added? Why or why not. Note that in general, in order to create the space to add a new course, another course will need to be eliminated or taught less frequently.

N/A

7. What did you learn about your overall curricular structure in terms of its complexity, breadth and depth in light of the guild standards and our institutional size and scope? Are there any structural changes that need to be made in light of your analysis (e.g. sequencing of courses, % and or grouping of electives, overall units required, use of concentrations, etc…)?

N/A

If using comparator institutions:

1. Begin by working with your Dean to identify a list of 5-8 comparator schools to use. In selecting schools, consideration should be given to type of institution, mission of the institution and the number of students majoring in the program.

1. Abilene Christian 2. Bethel University 3. Biola University 4. Cedarville University 5. Geneva College 6. Goshen College 7. Grace College 8. North Park University 9. Southern Nazarene University 10. Tabor College 11. Taylor University 12. Whitworth University 13. Messiah College 14. Redeemer College 15. Calvin College 16. Wheaton College 17. University of Redlands 18. Trinity University 19. University of San Diego Note that 1-14 are considered "comparator" institutions, while 15-19 are "aspirant" institutions. Institutions 1-16 are members of the CCCU and are participating colleges with the Au Sable Institute of Environmental Studies. We included these particular institutions to ensure that our survey contained primarily institutions like us (small Christian liberal arts institutions involved in Christian environmental education), as well as 5 institutions that are larger, have more resources, and are renowned for their environmental programs. (Note that we obtained curriculum data for Redeemer College but they never responded to our interview questions.)

Gather the curricular requirements for the program in question at each of the comparator institutions.

2. Use this collection of curricular requirements to develop a list of curricular features that are essential for programs of this type. In addition, make note of any innovative or creative curricular feature that may be useful in enhancing the quality of you program.

General Overview of Environmental Science Programs

Given the wide range of resources and academic specializations represented by the comparison institutions, there was significant variation in the curricula of the environmental science programs surveyed. The total number of units to complete major courses ranged from 42-78 (mean = 59). PLNU is towards the upper end of required units for our environmental science major (71-72 units). Most programs were housed in the Biology Department and had a foundation of biology and chemistry coursework similar to our program. Required biology courses in the core curriculum ranged from 1-8 courses (4-29 units; mean = 16 units), with PLNU requiring 7 biology courses (23 units) in the core ENVS program. Required chemistry courses in the core ranged from 1-6 courses (3-24 units; mean = 10 units), with PLNU's chemistry requirement being the heaviest with 6 courses. Some programs were housed or allied with other departments, such as Geology, Agriculture, or Environmental Science, and included core courses in those areas. About a third of the programs had a single option program like ours. However, two-thirds of the programs (12/18 = 67%) had 2-4 concentrations (tracks) or had both a BA and BS option. Thus, most programs offered more flexibility in areas of specialization than we currently do. Depending on historical aspects of their location, faculty strengths, or facilities, some programs included emphases in agricultural ecology, wildlife biology, urban ecology, marine biology, outdoor education, field technology and survey skills, environmental public policy, and so forth. Thus many programs offered a variety of elective courses, some of which were unique to their faculty strengths (e.g., Agribusiness Management, Rangeland Ecology, Human Impacts on Coral Reefs, Environmental Geology, Environmental Literature, Environmental Law and Policy). Since many offerings of comparator institutions are not replicable for most schools, we chose to focus our attention on areas of the curriculum that were common to most programs beyond foundational courses in biology and chemistry.

We note that there was significant variation in the science content among the different programs. We therefore conducted an additional "sub-survey" using only programs that called themselves Environmental "Science" as opposed to Environmental "Studies", presuming that the former programs have a strong science focus like our program, while the latter programs would be more interdisciplinary. Of the 19 programs surveyed, 13 called themselves "Environmental Science" (one "Environmental Biology") compared with 6 that called themselves "Environmental Studies." Looking only at the 13 environmental science programs, total units required in the major ranged from 42-75, with the mean being the same as with the full survey. Required biology courses ranged from 2-7 courses (6-29 units), and required chemistry courses ranged from 1-6 courses (3-18 units), with PLNU again having the heaviest Chemistry requirements. Nine of the 13 programs had multiple options (69%), essentially the same as the full survey (67%).

Geographical Information Systems (GIS) – The survey showed that 50% of all programs surveyed and 38% of the Environmental Science programs had a dedicated course in GIS, and many offered more than one course. GIS involves taking geospatial data from GPS points to map features in space using sophisticated software like the Arc GIS system. The elements that are incorporated into GIS maps may be biological, geological, hydrological, or other environmental aspects including human features. GIS has become an essential skill in many disciplines, not just in the sciences, and those students that have a background in GIS are highly sought after by employers.

Environmental Chemistry – The survey showed that 40% of all programs surveyed and 54% of Environmental Science programs offered an Environmental Chemistry course, which is an interdisciplinary science that includes atmospheric, aquatic, and soil chemistry, and relies heavily on analytical chemistry. Environmental chemistry is used by environmental agencies and research bodies around the world to detect and identify the nature and source of pollutants, including heavy metals, nutrients that produce eutrophication and dead zones, urban runoff, and organometallic compounds.

Environmental Ethics – The survey showed that 50% of all programs surveyed and 54% of Environmental Science programs have some sort of environmental ethics course. Environmental Ethics is the discipline in philosophy that studies the moral status of nature and the ethical relationship of human beings to the environment. Such a course addresses the question of "Why should we care for the environment when there is no economic incentive to do so?" At a Christian institution such as ours, such a course would be heavily based on creation theology and biblical stewardship.

Physics – Surprisingly, the survey showed that 75% of all programs surveyed and 85% of Environmental Science programs DO NOT have a Physics requirement. Although some graduate programs require Physics, we realized that many career options in the environmental science field do not require a strong background in physics.

Internship Program – The survey showed that 61% of all programs surveyed and 54% of Environmental Science programs required either an internship or a research experience. The internship requirement ranged from 30 hours to 180 hours. In addition, some programs required their students to do a presentation to their peers on their internship experience in addition to a paper or reflection assignment. Internship programs address the importance for students to acquire non-academic skills such as communication, writing, organization, planning, and project management.

Review this list with your Dean before using it to analyze your own curriculum.

3. Indicate how your curriculum compares to the list of curricular features from your analysis (this can be done in a table or narrative form).

In structure and content, our environmental science program does not differ substantially from those we surveyed in our comparator and aspirant institutions. Our program is stronger in the science emphasis than many other programs, with our biology and chemistry requirements at the top end of the range, as is the total required units for the major. We are unusual among most programs in requiring 2 semesters of Physics. Our major is also in the minority in that we do not offer a dedicated course for GIS, Environmental Chemistry, or Environmental Ethics. We also have an internship option, although historically most of our ENVS majors have not chosen to do an internship, nor have we emphasized the importance of internships enough. Finally, our program is weaker than many others in the interdisciplinary upper division course offerings that help environmental science students incorporate other disciplinary skills into their training.

Based on the analysis of comparator programs and reflection on the menu and elective ratio above:

4. Are there courses in your program that should be modified? Why or why not.

Internship Program – We believe that the internship program is essential in helping our students gain the non-academic skills required to obtain a job in the environmental field, and we propose to strengthen it. Given that ENVS students already have the requirement of completing 8-12 units of an off-campus field immersion program (either as semester abroad or the summer Au Sable program), we do not think it wise to make it a requirement for students to do an internship, as some other programs do. However, we all agree that we should strongly encourage and expect students to participate in at least one internship or research experience in order to develop non-academic skills that will both prepare them for professional careers and simultaneously help them decide on their career path. We will put this expectation into the wording of the catalog description of the major. We would also like to develop an internship directory to help students obtain internships in the area (and also communicate that internships are really valuable and expected, although not required). Such a directory has been a valuable tool at Wheaton College, which graduates highly employable students able to obtain entry-level positions in the environmental field. Finally, and as mentioned elsewhere in this report, we believe that the hiring of an internship coordinator for all the Biology and Chemistry majors (including ENVS majors) is essential to take our program to the next level.
(Note that internships also come up in question 8 on page 76 under Non-academic Skills and question 9 on page 78.)

5. Are there courses that should be eliminated? Why or why not.

Physics – In order to make room for the new courses we will propose below, we intend to remove the 2-semester Physics requirement, thus opening up 8 units. Because the variety of disciplinary directions that ENVS graduates could take is so great, it is impossible to predict whether graduates would even need Physics, and as mentioned above, most environmental science programs do not have a physics requirement. [Note: Paul Schmelzenbach has been approached regarding this change and has no problem with it.]

6. Are there courses that could be merged? Why or why not.

No, although some elements of Instrumental Analysis will be incorporated into the new Environmental Chemistry course.

7. Are there courses that should be added? Why or why not. Note that in general, in order to create the space to add a new course, another course will need to be eliminated or taught less frequently.

Geographical Information Systems (3 unit semester course) – Walter Cho will develop an introductory course to GIS that will teach students the fundamentals they need to work in the field. Although the GIS course would be required for ENVS students, it would be offered as an upper division elective for other science majors and other majors across campus. Walter will reach out to other PLNU departments whose students may benefit from this course (e.g., Sociology, History Political Science, Business, Computer Science). We believe this would be a popular course that would attract students from across many departments, especially if it can be offered as one requiring minimal prerequisites.

Environmental Chemistry (3 unit semester course + 1 unit lab) – Tracey Schalnat will develop this course. Because of overlap with the new course material, CHE 370-Instrumental Chemistry will be dropped as a requirement for ENVS students and the new Environmental Chemistry course will become the requirement. However, ENVS students will still be able to take Instrumental Chemistry as an elective if they take Physics.

Environmental Ethics – Although this is a course that we have identified as one that is common to other environmental science programs and that we lack, our faculty do not have the expertise to develop such a course. One option would be to collaborate with Theology faculty. We will explore with Mark Wright the feasibility of incorporating a module on environmental ethics to THE 306-Ethics to try to bring this piece into the curriculum. We believe that such an addition will be valuable for other students as well.

Statistics – An existing course, MTH 363-Calculus-based Statistics (3 units), is currently required for ENVS majors. This course was just expanded to a 3-unit semester course and will be made a required upper division for ENVS students. Of the 8 comparator institutions that require a statistics course, all offer a full-semester course of 3-4 units. We have found that computational skills are essential for graduate studies and employment in many areas of environmental science.

Interdisciplinary Electives – In the general overview of the survey, we observed that many programs had broader offerings of interdisciplinary electives than we do. We therefore intend to find ways to deepen and broaden our lower and upper division electives outside of biology and chemistry. This acknowledges that many of the jobs available in the environmental field are not purely science, but require interdisciplinary skills. Environmental planners, land managers, environmental educators, and technical staff must be proficient in writing, speaking, planning, networking, and so forth, as noted in the section on the Internship program above.

First, we will add the following existing courses into the elective offerings for the major:

- POL 290-World Regional Geography (3 units) will be added to "Public Policy and Stewardship Electives" (note that this course will not count for upper division credits).
- BUS 475-Sustainability in Action will be added to "Public Policy and Stewardship" (the BIO 102/105 prerequisite will be waived).

Second, we intend to reach out to different departmental faculty to assess their interest in developing a series of 490-Special Topics courses that would incorporate an environmental module. In our reaching out, we hope to emphasize the benefits to both their department and the ENVS students. In particular, we think that the following faculty may be interested in developing the following Special topics courses that could be offered every 2-3 years and would increase the interdisciplinary offerings for our ENVS students:

- Environmental Economics – Harry Watkins
- Environmental History – Rick Kennedy
- Environmental Writing/Journalism – currently being developed at LJML
- Environmental Philosophy/Ethics – Mark Wright, see Environmental Ethics above
- Environmental Policy – Lindsey Lupo
- Environmental Social Justice – Jamie Gates
- Environmental Theology – Mike Lodahl

8. What did you learn about your overall curricular structure in terms of its complexity, breadth and depth in light of the comparator schools and our institutional size and scope? Are there any structural changes that need to be made in light of your analysis (e.g. sequencing of courses, % and or grouping of electives, overall units required, use of concentrations, etc…)?

Environmental Studies B.A. Major

As mentioned earlier, several of the comparator programs offered an Environmental "Studies" B.A. option as a "science light" option. We discussed the desirability of exploring an 'Environmental Studies BA' major that would have fewer science courses and room for more electives compared with the Environmental Science B.S. We agreed that this option would be worth exploring for several reasons: (1) An Environmental Studies B.A. would provide a way to retain those students that find the science part of the ENVS B.S. major too daunting. Rather than have them transfer to a completely different discipline (e.g., Psychology, Business), it would enable this pool of students to remain in the field of their passion by preparing them to work with scientists but not be scientists themselves; (2) Many jobs in the environmental field are not purely science, but only require a broad understanding of science. Instead, they must be proficient in non-science areas such as writing, speaking, planning, networking, GIS, and so forth; (3) Such a major would be highly interdisciplinary and thus very desirable from a liberal arts perspective. The science curriculum for an Environmental Studies major might include: foundational sequence of Biology and Chemistry, Research Methods, Statistics, Conservation Ecology, Environmental Chemistry, Global Information Systems, and a range of both science and interdisciplinary electives. The interdisciplinary courses to be developed might include scientific writing, speaking, and management. We would want to start a conversation with the provost, deans, and other departments that would need to be involved.

Non-academic Skills

Although the focus of this section is on the academic curriculum of the ENVS program, an important finding of the survey was the high priority given by virtually all these programs to providing opportunities for students to acquire "non-academic" skills vital to employment in the environmental field. An important insight emerging from this process is that academic qualifications are not enough to obtain an environmental job, especially for the recently graduated student trying to get their first entry-level position in the field. Employers are looking at much more than courses taken and grades obtained. While students will have opportunities to practice some of these non-academic skills in our core curriculum (see question 9 below), this is not enough. Students will need to seek out a variety of experiences to develop these skills and articulate them in a resume. In our program review, we worked to (1) identify the set of non-academic skills sought by employers in the environmental field, and (2) identify the most effective strategies for helping our students obtain those skills.

We identified the most sought-after skills through the following sources:

- 'Graduate student's guide to necessary skills for nonacademic conservation careers'. This is a recent publication that analyzed job advertisements and interview data (Blickley et al. 2012, Conservation Biology 27: 24-34). The skills highlighted in this publication ran parallel to the Burning Glass Skills data.
- Burning Glass Skills Data for Environmental Science, discussed below.
- An interview with a local environmental consultant, Mike Page, who has many years of experience in the field and is involved in the hiring of new personnel.

Mike Page identified the following skill sets that are desired by environmental consultants –

1. A well-rounded and intelligent person who can communicate.
2. A generalist biologist who has a broad knowledge base.
3. Ability to write well, communicate orally, synthesize material, and analytical skills.
4. Extracurricular work that is pertinent to environmental work (e.g., student environmental club).
5. Volunteer work with local parks, conservancies, environmental education, etc.
6. Summer jobs or internships in positions that demonstrate leadership, planning, and work ethic.
7. Understanding of environmental economics and government policy.
8. Technical skills such as understanding of GIS, CAD and Arc GIS applications, watershed skills.

These skill sets are widely confirmed by the top ten nonacademic skills of the 'Graduate Student Guide':

1. Project management – managing complex projects
2. Interpersonal – ability to engage in cooperative projects with a team of people
3. Written communication – ability to write effectively in any relevant forum
4. Program leadership – leading and developing projects
5. Networking – ability to bring together many individuals on the basis of common goals
6. Personnel leadership – managing people in an organization
7. Oral communication – ability to speak effectively in any relevant forum
8. Outreach communication – ability to connect ideas or practices to other people
9. Self-starter, independent – motivated to accomplish new endeavors on his/her own
10. Fund raising, monetary – experience raising money or managing budgets

The Burning Glass Skills Data list also mentions most of these skillsets (see below).

We identified the best strategies for helping students obtain important non-academic skills through interviews with 18 comparator institutions in which we asked about their internship program and field immersion opportunities for environmental science students.

o Internships – The survey revealed that 67% (12/18) of comparator institutions have an internship requirement, and those that do not require an internship strongly encourage students to do one in order to gain experience and skills. We are making efforts to significantly improve and expand internship opportunities for the ENVS students, as detailed under question 4.

o Field Immersion Experiences – The ENVS major requires that students complete a minimum of 8 units in an Off Campus Program (OCP) that is characterized by "field immersion" in which at least 25% of teaching and learning occurs in the field. Virtually every other program we surveyed either required or encouraged students to get this kind of field immersion experience either through the Au Sable summer program, semester abroad programs such as School for Field Studies, or programs uniquely associated with the institution's own field station, reserve, summer program, or study abroad program. The ENVS major currently has 4 field immersion programs that are approved by the ENVS program and supported by OGS (Au Sable Institute of Environmental Studies, Creation Care Study Program, Quetzal Education Research Center, and School for Field Studies). These types of programs are often life-changing experiences for our students, especially the Au Sable program.

Burning Glass Skills Data Environmental Science		
1. Communication Skills ***Virtually every course between presentations of primary literature articles, data communication, and scientific writing.***	5. Project Management ***None.***	9. Quality Assurance and Control ***Che294, 304, 325, 351, 370, 466, 468.***
2. Writing ***Virtually every course with assigned lab reports and scientific writing.***	6. Leadership ***Basic skills developed in our teaching assistant* and summer research programs**, as well as in Biology internships.***	10. Supervisory Skills ***Basic skills developed in our teaching assistant* and summer research programs**, as well as in Biology internships.***
3. Organizational Skills ***Bio210, 211, 301, 345, 363, 430. Che152, 153, 213, 294, 304, 325.***	7. Research ***Virtually every course as each science course has a required,***	11. Budgeting ***None.***

	associated lab portion. This is also mastered with summer research opportunities, Bio499, Biology internships, and honor's projects.	
4. Planning ***Bio210, 211, 301, 345, 363, 430. Che 152, 153, 213, 294, 304, 325, 450.***	8. Management ***Basic skills developed in our teaching assistant* and summer research programs**, as well as in Biology internships.***	12. Problem Solving ***Bio210, 211, 301, 345, 490, 499. Virtually every Chemistry course.***

* While the Teaching Assistant Program is not a required course, we highly encourage every student within the major to participate and many of them do. As a TA, they directly interface with the students in laboratory courses, providing assistance with data collection, analysis and report generation. Some are also in charge of lab set-up, breakdown, writing weekly quizzes and grading lab reports. It is a position designed to develop basic skills in leadership, management, and supervisory capacities.

**The Summer Research Program is not a required course, but it is very highly recommended and the majority of our majors participate, either within the Chemistry Department or the Biology department. Participating students are required to commit to two summers so that many labs have some new students and some returning students. As such, the returning students act as mentors working with the new students. This situation highly encourages the development of basic skills in leadership, management, and supervisory capacities.

Analysis of the curriculum against preparation for employment

9. The Burning Glass data provides a list of skills for students entering common professions that are often linked to your major. Indicate in the table if and where each skill is being taught in your program. Based on reflecting on this data, are there changes you would recommend making to your curriculum?

The Burning Glass data by itself does not cause us to recommend changes to the curriculum, although (as mentioned in question 4 above), we intend to strengthen our Internship Program and to encourage more students to take advantage of internship opportunities as a means of obtaining these valuable non-academic skills.

10. Some programs may serve to prepare students with professional qualities and skills that can serve them well in a great variety of professions that may not show up in data sets like Burning Glass. If this is indicative of your program, please identify the unique skills and/or professional qualities that your program develops in your students and indicate where in the curriculum this is being taught or developed.

The required Off Campus Program (OCP), characterized by "field immersion", provides students with a practical knowledge of environmental stewardship and, in the case of experience abroad, cross-cultural adaptability as well. In addition, the OCP typically equips students with marketable skills in field data collection, report writing, data analysis, and other research skills.

Analysis of the teaching of your curriculum

11. How do the pedagogical features of your program compare with the best practices for teaching in your discipline?

The American Chemical Society (ACS) has stated in their Guidelines for Bachelor's Degree Programs the following regarding pedagogy: "An approved program should use effective pedagogies in classroom and laboratory course work. Programs should teach their courses in a challenging, engaging, and inclusive manner

that accommodates a variety of learning styles. Additionally, a program should provide opportunities for faculty to maintain their knowledge of effective practices in chemistry education and modern theories of learning and cognition in science. An approved program should regularly review its pedagogical approaches to ensure that they promote student learning and build the skills needed to be an effective professional. Faculty should incorporate pedagogies that have been shown to be effective in undergraduate chemistry education. Examples include problem- or inquiry based learning, peer-led instruction, learning communities, and technology-aided instruction such as the use of personal response systems and flipped or hybrid classes. Laboratory work provides a particularly attractive opportunity for inquiry-driven and open-ended investigations that promote independent thinking, critical thinking and reasoning, and a perspective of chemistry as a scientific process of discovery."

The pedagogical features used in our program compare favorably with the best practices from within our discipline. The details of pedagogy used in our program are described in #12 on page 81.

Biology: In 2011, the National Science Foundation (NSF) and the American Association for the Advancement of Science (AAAS) issued a report articulating much needed changes in biology education across the country. The document, titled "Vision and Change in Undergraduate Biology Education: A Call to Action," argued for a transition from faculty-centered education to student-centered education. As a Department, we have chosen the guidance in this document as our benchmarks for best practices in the discipline. Below, we describe each Vision and Change benchmark and then discuss how our program falls short, meets, or exceeds the standard.

The student-centered classroom, sometimes called active learning, is one that is "interactive, inquiry-driven, cooperative, collaborative, and relevant." In short, it is designed with student learning in mind rather than faculty teaching in mind. One approach to accomplishing a student-centered classroom is by way of what is commonly referred to as "scientific teaching", or sometimes "backward design." This strategy for designing a course starts not with the teacher's favorite topics or what they will say in class. Instead, careful time and attention are given to developing and precisely articulating learning outcomes. Once the learning outcomes are clear, the teacher designs the best assessments to determine if the students have achieved the desired outcomes. Finally, teaching methods are considered that can provide the best opportunity for the students to achieve the stated learning outcomes.

PLNU Biology Department faculty members have been proactive in learning new techniques for student-centered teaching. We have three Ph.D.-trained science educators in our department who consult with each of us frequently and regularly offer training sessions. Many of us have attended workshops on active learning, such as the National Academies Summer Institute on Undergraduate Education in Biology offered by HHMI and NSF. We participate in a twice-monthly Faculty Learning Community focused on teaching in the STEM disciplines. Many of us take advantage of (and sometimes help lead) training opportunities offered by the Center for Teaching and Learning, such as the hugely successful Teachers Noticing Teachers program. We meet every Thursday for lunch to discuss teaching issues, and have read books (e.g., *Scientific Teaching* by Handelsman et al.) and journal articles (e.g., *Active Learning Increases Student Performance in Science, Engineering, and Mathematics* by Freeman et al. PNAS 2013) together on active learning.

Some of the student-centered teaching techniques recommended in the Vision and Change document include authentic research experiences, case studies, immediate feedback assessment technique, personal response systems, inquiry-driven learning, concept mapping, peer-led team learning, problem-based learning, process-oriented guided inquiry learning, and team-based learning. We have already implemented many of these techniques and are in the process of experimenting with others.

For example, students in Conservation Ecology are required to complete a field research project conducted in collaboration with local conservation organizations. These bona fide research projects are designed to collect useful data that can be used to further local conservation action. Another example is Animal Behavior, a popular upper division elective course in which student teams conduct behavioral research at the San Diego Zoo, concentrating on projects requested by the Zoo to assist them in improving their management.

Several Biology professors further make use of flipped classrooms, case studies, online adaptive learning tools, personal response systems (clickers), concept mapping, peer-led team learning, and team-based learning, to name a few.

12. What new pedagogical practices have been tried by members of your department in the last few years? What has your department learned from these experiments?

Chemistry faculty participate in many activities designed to understand best practices in teaching, and to put them to use on a daily basis. Chemistry faculty have attended a variety of events directed at LEARNING about best practices which include:

- Scientific Faculty Learning Community
- Chemical Education session at national ACS conference
- Project Kaleidoscope (conferences in STEM education)
- Team-Based Learning Workshop
- NSF funded project developing interdisciplinary course modules
- Training opportunities offered by Center for Teaching and Learning

Chemistry faculty have also been invited to give talks related to teaching best practices in the following areas:

- General Chemistry Technology with McGraw-Hill Publishing
- Student engagement techniques at SDSU
- Use of iClickers for assessment at Claremont Colleges

Some of the pedagogical features used in our courses includes:

- Team-Based Learning
- Inquiry-Based Learning
- Use of sophisticated modeling software
- Use of clickers
- Enhancement of student engagement using mini whiteboards and iPads
- Online homework systems

As a faculty, we value student engagement and will continue to strive for the best possible student learning experience. In the Chemistry Department, new pedagogical practices have been added incrementally over the last 5 years and some of these practices (Team Based Learning and Inquiry-based learning) are still limited to a few courses. Since these methods are more recent, we have not yet collected data to see the direct impact on students. However, it is broadly accepted that student engagement is directly correlated with improved learning and long term retention of concepts. One example is the use of group activities and modeling software (PyMOL) in Biochemistry. These two pedagogical features have greatly improved our students' understanding of proteins and their function. The understanding was such that in Bioinorganic Chemistry (CHE 466, usually taken the following spring semester) students were able to apply these concepts readily without any need for a refresher. Therefore, the course content was shifted to a more in-depth understanding of metals in biology rather than basics of biochemistry which had to be done in the past.

Overall, we have learned that student centered teaching is worth applying and, while it will look different from one class to another, it improves student retention and student learning. Finally, these strategies allow for a stronger faculty-student interaction, thus fulfilling our mission to shape our students.

See answer to #11 on page 79-80 for Biology.

13. Are there new developments in pedagogy in your discipline? What would be required to implement these changes in pedagogy in your department?

The ACS guidelines regarding pedagogy that are shown above lists recent developments in pedagogy such as problem- or inquiry based learning, peer-led instruction, learning communities, and technology-aided instruction (e.g. personal response systems and flipped or hybrid classes). Faculty training (e.g. ACS Chemical Education, AAC&U, PKAL, and CTL resources) would be required to implement more of these pedagogy changes into our classes.

ENVS-F4) Potential Impact of National Trends

Top Burning Glass Occupations for the Program Environmental Science		
Occupation	**Hiring Demand**	**Salary Range**
Project Manager	Very High	$84K - $87K
Environmental Scientist / Specialist	Medium	$54K - $57K
Geographer / GIS Specialist	Medium	$61K - $67K
Alternative Energy Manager	Low	$67K - $86K
Environmental Compliance Specialist	Low	$42K - $65K
Environmental Engineering Technician	Low	$41K - $59K
Environmental Planner	Low	$64K - $72K
Fish / Game Warden	Low	$31K - $41K
Fish Hatchery Manager / Technician	Low	$30K - $33K
Meteorologist	Low	$39K - $60K
Park Ranger / Naturalist	Low	$35K - $38K
Research Manager	Low	$59K - $69K
Sustainability Specialist	Low	$51K - $83K
Water Resource Specialist	Low	$88K - $156K
Wildlife Biologist	Low	$48K - $54K

Note that some programs do not have as many professions listed in the Burning Glass data as others do. In these cases we will want to get a list of professions from the chair/school dean to supplement the Burning Glass data.

1. Which professions in the Burning Glass data were you already aware of and for which are you already intentionally preparing students and does the hiring demand in these professions signal anything about the future that you need to be aware of regarding the design and structure of your program?

We were already aware of most of the professions listed in the Burning Glass data. We have a strong science focus to our curriculum, and have been intentionally preparing students for many of these careers, especially the more STEM-related careers. However, our program has been weaker at preparing students for some of the more policy or geography focused jobs. As part of program review, we are proposing several changes to the ENVS major, including the addition of two new courses in GIS and Environmental Chemistry, which will better prepare students for many of the listed professions.

Many of these professions require internships or graduate degrees, and we have been successful in preparing students for graduate school (per alumni survey data) and have begun investigating improvements for our internship program.

2. Are there additional professions in the Burning Glass list or from your knowledge of occupations your alumni have entered, for which you should be preparing students?

Based on alumni survey data and the McConnell alumni data mentioned above, most of our students find a STEM-related job or enter graduate school. Not all of these jobs or graduate programs are directly related to the environmental field. Due to the science-heavy nature of our program, many of our graduates are well-qualified to work in the biotech industry or analytical chemistry field as lab technicians, lab assistants, etc.

3. What changes in your program would be necessary in order to prepare students for the skills and professional qualities needed to succeed in these additional professions?

We believe that the proposed curriculum changes for the ENVS program will focus on topics of direct relevance to all of the professions listed above AND address the biggest weaknesses in our program. We are investigating improvements to our internship program that we believe will be instrumental in helping our students forge the network connections they need to find jobs in their field and be successful.

4. Are there national trends in higher education or industry that are particularly important to your discipline? If yes, how is your program reacting to those trends?

The field of environmental science (or studies) should continue to grow as more efforts are placed on finding alternatives to petroleum-based fuels. We continue to have a strong focus on preparing students for STEM-related jobs. However, there is a need to prepare students to work at the interface of science, policy, and business. How do we prepare students for these more interdisciplinary professions? That is a question we are taking to other departments to discuss how we might work together to develop new courses, minors, or programs, such as an Environmental Studies – BA.

ENVS-F5) Quality Markers

Retention/Graduation Rates (First-Time Freshmen)							
	Matriculation Term						
Environmental Science	**Fall 2008**	**Fall 2009**	**Fall 2010**	**Fall 2011**	**Fall 2012**	**Fall 2013**	**Fall 2014**
First-Year Retention	**75.0%**	**sm**	**80.0%**	**sm**	**100.0%**	**80.0%**	**60.0%**
PLNU First-Year Retention	*84.2%*	*84.1%*	*81.1%*	*82.9%*	*89.3%*	*84.5%*	*84.5%*
	Matriculation Term						
Environmental Science	**Fall 2005**	**Fall 2006**	**Fall 2007**	**Fall 2008**	**Fall 2009**	**Fall 2010**	**Fall 2011**
Four-Year Graduation Rate	**sm**	**sm**	**sm**	**54.5%**	**sm**	**57.1%**	**--**
PLNU Four-Year Graduation Rate	*62.0%*	*65.2%*	*61.7%*	*59.1%*	*63.4%*	*62.2%*	*63.2%*
	Matriculation Term						
Environmental Science	**Fall 2003**	**Fall 2004**	**Fall 2005**	**Fall 2006**	**Fall 2007**	**Fall 2008**	**Fall 2009**
Six-Year Graduation Rate	**--**	**--**	**sm**	**sm**	**sm**	**77.8%**	**sm**
PLNU Six-Year Graduation Rate	*72.4%*	*73.2%*	*73.0%*	*74.9%*	*72.2%*	*73.6%*	*75.0%*
Degree Completions							
Majors	**2008-09**	**2009-10**	**2010-11**	**2011-12**	**2012-13**	**2013-14**	**2014-15**
Environmental Science	**1**	**3**	**4**	**7**	**4**	**5**	**3**
Share of PLNU Bachelor's Degrees	*0.2%*	*0.6%*	*0.7%*	*1.3%*	*0.7%*	*0.8%*	*0.5%*
Minors	**2008-09**	**2009-10**	**2010-11**	**2011-12**	**2012-13**	**2013-14**	**2014-15**
No minors in this program							
FTF Time to Degree *(in semesters)*	**sm**	**sm**	**sm**	**8.7**	**sm**	**sm**	**sm**
PLNU FTF Time to Degree	*8.2*	*8.2*	*8.3*	*8.2*	*8.3*	*8.3*	*8.3*
Study Abroad Participants	1	3	4	6	3	4	2
sm = cell size too small							

1. Based on comparing the quality marker data for your program with the PLNU averages:
   a. What does this tell you about your program?

With the small number of Environmental Science students, it is difficult to see any trends or draw conclusions from this data.

   b. If your values are below the PLNU averages, what changes could you make to address any areas of concern?

Same answer as above.

   c. If your values are above the PLNU averages, what do you believe contributes to this success?

Same answer as above.

2. Describe regular opportunities for students to apply their knowledge (internships, practicums, research projects, senior projects, etc.). Estimate what percentage of your students in this program participates in these kinds of opportunities.

Both the Biology and Chemistry Departments have an intensive undergraduate research program, where students gain 800-hours of research experience over the course of two summers. This research program is the primary source of these opportunities. Because the Environmental Science major is a joint major, students can do research in either department. Of the Environmental Science graduates from 2007-2015, 48% participated in an intensive research experience. In addition, Environmental Science majors are required to take a minimum of 8 units of upper-division electives from approved environmental off-campus programs.

Some students have participated in internships. Since 2013 the Biology Department has been trying to develop more internship opportunities for our students as an alternative way of developing crucial career skills in the students who do not participate in the intensive research experience. In Spring 2015, six students interned throughout San Diego county and in Fall 2015 eight students interned. The intern sites include everything from entering and analyzing research data (e.g. at Cabrillo National Monument), to learning to care for animals (e.g. Project Wildlife), or working in a science classroom (e.g. St. Charles Borromeo Middle School). Over the past two years, we have expanded the number of internship opportunities to about 10. It should be noted that this requires a lot of effort! To truly expand these opportunities for our students, we would need release time for an internship coordinator (see program recommendations on page 91). A coordinator would (a) cultivate new internship opportunities, (b) act as a liaison between the organization and the PLNU biology department, (c) meet with interns one-on-one to identify appropriate internship possibilities, (d) assist students with internship applications (when needed), (e) communicate regularly with the students during the internship, (f) communicate with the site internship supervisor to follow up on the progress and success of the student intern.

In addition, students are highly encouraged to participate in the life of the department, including work as Teaching Assistants and/or graders for the courses, particularly the laboratory portions. This helps students apply their knowledge by making solutions, setting up reagents, working with advanced equipment, and teaching fellow students as part of their TA position. While the professor is the main instructor for every course, these opportunities of engagement for the students also help facilitate learning within the student community. In the last few years, over 50% of our students have participated as TAs in the department, many TAing for several semesters and multiple courses. However, we do not have this data broken down into individual programs within the departments.

3. Describe any public scholarship of your undergraduate and graduate students in this program (conference presentations, publications, performances, etc.). What percentage of your undergraduate students are involved in these kinds of activities?

As stated above, 48% of the Environmental Science graduates from 2007-2015 participated in an intensive research experience. At least half of these students then have publications and/or presentations based on this research. Many of them present at the West Coast Undergraduate Research Conference in Biology, which the Biology department hosts every 2-3 years.

4. How many of your students participate in study abroad opportunities in general? Describe any study abroad opportunities specifically organized by your program. What percentage of your majors are involved annually (annualize the number)? How many students outside of your department participate in this departmentally organized program (Annualize the number)?

The Environmental Science major requires an off-campus field-immersion experience (8 units). Some of these students choose to attend the Au Sable Institute of Environmental Studies in the summer.

5. What are any other distinctives of your program? Describe how they contribute to the program's success.

A top priority of our departments is for students to do biology and chemistry, not just learn about them. To accomplish this, we have a laboratory rich curriculum. Almost all of our classes have a required laboratory experience. We are proud of the deliberate mentoring of students that occurs while they are at PLNU and the relationships we have been able to maintain with a large number of our alums. Our students work as stockroom workers, graders, review session leaders, tutors, and lab assistants under the supervision of faculty. Our alumni are constantly giving back through guest lectures, mentoring, shadowing opportunities, etc., and are extremely willing to help current students. Alumni tell us that they are very well prepared for post-baccalaureate education and jobs in the discipline.

All of the full-time faculty in biology and chemistry earned a Ph.D. prior to coming to PLNU. Moreover, all of our faculty have completed postdoctoral research beyond the Ph.D. This indicates that our program has a track record of attracting faculty highly-qualified in both teaching and scientific research.

Another distinctive shared by both the Biology and Chemistry Departments is our pre-health professions advising. We have a dedicated advisor (currently Sara Choung) for students preparing for medical, dental, optometry, pharmacy, or veterinary school. This program includes two preparatory interviews for the students, sessions with alumni and local health professionals, and a committee-written letter of recommendation. This program has almost certainly contributed to the high rate of acceptance of our students into the health professional schools (over 90% for over 15 years).

6. Does your program have an advisory board? If so, describe how it has influenced the quality of your program? If not, could it benefit from creating one?

N/A

7. Describe any current joint interdisciplinary degrees (majors or minors) offered by your department. Are there additional areas where interdisciplinary programs should be considered?

The Biology-Chemistry major and the Environmental Science major are joint with Biology. There are also science-business and science-marketing minors for business or science majors and the computational science minor. We are not currently considering additional interdisciplinary programs.

8. Describe your success with students acquiring jobs related to their discipline.

In our most recent alumni survey, 91% of our alumni were attending graduate school or employed in a Chemistry or STEM-related field. In addition, our acceptance rate of students into graduate and health professions schools continues to be at least 90%. Of the eight Environmental Science majors who responded to the survey, 88% are employed or in graduate school in a STEM-related field.

In looking through a list of the types of jobs that our alumni have, you would see that our students are successful at acquiring jobs in a wide variety of professions. These professional areas include but are not limited to forensic chemistry, environmental science, biotechnology and pharmaceutical research, education, public health, medicine, dentistry, optometry, pharmacy, veterinary medicine, etc. 134 out of 188 (71%) alumni who graduated from the Biology and Chemistry Departments between 2006 and 2010 and 115 out of 135 (71%) alumni who graduated between 2001 and 2005 are in teaching, science, or health related fields. 48 biology and chemistry alumni currently hold faculty positions at 38 different institutions.

9. Describe your undergraduate and graduate student success rate for passing licensure or credentialing exams (if they exist in your discipline).

N/A

10. Describe your success with undergraduate student acceptance into post-baccalaureate education.

A large number of our graduates continue their education at health professions schools or graduate schools and they have been very successful at getting into these various programs. As mentioned previously, the success rate for alumni who apply to graduate or professional schools has been well over 90% for at least 20 years. In recent years, students have gone to prestigious programs at University of California San Diego, University of California Irvine, Yale University, Georgia Tech University, Vanderbilt University, etc. For dental, medical, optometry, pharmacy, and veterinary schools, there have been 166 acceptances out of 181 applicants (91.7%) between 2004 – 2014. They have gone on to a number of schools across the country such as University of California San Diego, University of Southern California, Loma Linda University, University of Washington, Duke University, Purdue University, etc. Between 2001 and 2011, 46 Biology and Chemistry Department alumni earned a Ph.D. This speaks very highly of their undergraduate preparation in both the chemistry and biology courses.

11. What kind of support does your program provide for students encountering academic difficulties? How do you intentionally facilitate these students' connection with institutional support services?

Our departments have multiple means of supporting students with academic difficulties. First, these students are usually identified in the freshman classes (BIO210 and BIO211), where the instructors contact students who are doing poorly on exams and offer specific advice on study habits, extra office hours, and direction to tutoring. Second, the Chemistry Department offers a weekly tutorial for students in the first semester of General Chemistry (CHE151), as well as student-led weekly review sessions for both semesters of General Chemistry and Organic Chemistry. Third, during the twice yearly advising sessions, we meet with our advisees for 15-30 minutes and discuss both academic and non-academic factors, as well as vocation. Fourth, on some occasions, we have directly referred students to the Wellness Center, the DRC, or even contacted Caye Smith, Jeff Bolster, or Mark Pitts, depending on the situation. Finally, we are hoping to use the new capabilities of the SSC to bolster these efforts by identifying students who may be in the middle ground but could use some resources to make their college experience even better.

ENVS-F6) Infrastructure and Staffing

Full-Time Faculty Program Contribution Department of Chemistry (duplicated in other program-level sections)			
	2012-13	**2013-14**	**2014-15**
Percentage of UG classes taught by FT faculty	68.8%	71.6%	65.5%
PLNU percentage of UG classes taught by FT Faculty	*TBD*	*TBD*	*TBD*
Includes: regular lectures, labs, seminars Excludes: independent studies, private lessons, internships			

1. Are your program's current technological resources and support adequate? If not, what is needed? Do you foresee any additional needs in this area?

Biology: At present our technological resources and support are superior with the recent addition of the Latter Hall classrooms and Sator Hall laboratories. Our current needs are well met; however, instrumental technology is continually evolving. The faculty actively pursues grants to support these needs. In addition, administration has been supportive of many of these changing needs as well. We need this continued support to provide our graduates with the most up-to-date education and experiences to be truly competitive. (Note: This is the same answer as for the Biology-BA/BS.)

Chemistry:
Special instrument funds accompanying the building of Sator Hall allowed for the addition to several state-of-the-art instruments for use in the Chemistry major courses and related research. These instruments include an Inductively Coupled Plasma – Optical Emission Spectrometer (ICP-OES), high performance liquid chromatograph (HPLC), infrared (IR) spectrometer, fluorescence spectrometer, glove box, lyophilizer, microwave reactor, magnetic susceptibility balance, potentiostat, and spectrometers. Additional funding from the Provost's office made possible the purchase of a much-needed, used 400 MHz nuclear magnetic resonance (NMR) spectrometer. We also negotiate access to remaining necessary equipment via local connections (at UCSD, USD, and TSRI).

In order to keep these instruments running, we do need ongoing support for instrumentation. Currently, the institution has no replacement schedule (or line item in the budget) for scientific equipment. The new instruments mentioned above require solvents, gases, cryogens and consumables in order to run, while older instruments (like our ultraviolet and visible spectrophotometer (UV-vis), gas chromatographs (GCs), and gas chromatograph-mass spectrometer (GC-MS)), are likely to require maintenance and repairs in the near future beyond what is covered in our existing budget.

We still need at least two additional instruments commonly used in an undergraduate chemistry curriculum: an X-ray diffractometer and a liquid chromatograph-mass spectrometer (LC-MS). As mentioned above, faculty actively pursue grants to support department needs. It will require continuing support (external and institutional) to provide our graduates with the most up-to-date educational experiences necessary to maintain our competitive edge.

2. Are your program's current facilities adequate? If not, what is needed? Do you foresee any additional needs in this area?

Biology: The classrooms and facilities in the new building are wonderful and adequate, as long there is stable enrollment in the Nursing, Allied Health, and Biology programs. Our office space is not adequate. Cho is in MICS space, which he will soon need to vacate. Koudelka is in a trailer outside the building. We thus need a minimum of two more offices. (Note: This is the same answer as for the Biology-BA/BS.)

Chemistry: The classrooms and facilities in Sator and Latter halls are excellent and are expected to be adequate for our needs assuming stable enrollment in our courses that serve other departments such as Nursing and Kinesiology. Maintaining one general purpose teaching laboratory in Rohr Science would provide capacity for growth. Office space in the Chemistry Department is old and inadequate, with no space for adjunct faculty. It would also be great if students had a space to congregate to study together and work on projects together.

3. Is your program's current staffing (administrative, clerical, technical and instructional) adequate? If not, what is needed? Do you foresee any additional needs in this area?

Biology: Staffing is close to adequate, again as long there is stable enrollment in the Nursing, Allied Health, and Biology programs. Ideally, we need a long-term adjunct or part-time professor so that we can split up the overly large sections of BIO130 and BIO140 that have 72 students. As discussed previously, this would require at least 6 units of extra load per year.

Chemistry:
Our instructional staffing is not adequate. We are in need of a Physical Chemist to replace Ken Martin, who is in the final year of his phased retirement. Physical chemistry is one of the five pillars of a solid chemistry curriculum and no one else in the department is trained to teach those courses.

Current and projected enrollments in Chemistry Department programs as well as other departments/programs served by Chemistry have been growing dramatically. As a result, enrollments in our largest courses have more than doubled in the past ten years (the numbers of students in CHE103, CHE152, and CHE153 have grown by 38.5%, 165.0%, and 129.5%, respectively). With the hire of a full-time Physical Chemist, the number of teaching units taught by full-time faculty would still be below 80% each academic year (2016-2017: 78.9%, 2017-2018: 76.2%).

Moreover, a Physical Chemist is necessary to maintain the curricular balance required of a quality chemistry teaching and research program, and to successfully seek American Chemical Society (ACS) Program Approval.

Note that two of the recommendations we will make in section F8 on pages 91 and 92 have staffing implications and we have two immediate staffing-related requests: 1) We request a 4-unit course release each for Tracey Schalnat and Walter Cho, who will need this time to develop the Environmental Chemistry and GIS courses, respectively. 2) If approved, these new courses will each correspond to an additional 3 units of teaching load per year.

ENVS-F7) Challenges and Opportunities

1. Are there any particular challenges regarding this program that have not been addressed through the analysis and reflection on data or questions in sections F1-F6 that you would like to include here?

Environmental Science is an interdisciplinary field of study focused on understanding the natural processes of how the world works and also how humans interact with and affect it. This draws on aspects from the natural and social sciences as well as the humanities. Relative to environmental science programs at comparator and aspirant schools, our program has a strong emphasis on the natural sciences and provides our students with an excellent background in these related fields. A significant challenge to our program is developing the social science and humanities-related aspects of environmental science that are focused on studying the interaction and impacts of humans with the natural world. The development of courses such as Environmental Economics, Environmental History, Environmental Writing/Journalism, Environmental Philosophy/Ethics, Environmental Policy, Environmental Social Justice, and Environmental Theology would ideally fill this current limitation in the program. These topics, however, are beyond the expertise of the faculty in the Biology and Chemistry Departments and the development of relevant courses would require the participation of other schools and departments at PLNU that have faculty with these expertise, such as the Fermanian School of Business, the School of Theology & Christian Ministry, and the departments of History & Political Science, Literature, Journalism, and Modern Languages, and Sociology and Social Work. This challenge also provides a unique opportunity for interdisciplinary collaboration at PLNU as this need provides a clear context within which multiple departments could work together to improve the major. However, to progress further, this interdisciplinary collaboration would require significant investment from the different schools and departments involved and would also require support from the administration.

Another challenge faced by students in the major is the issue of "identity." ENVS students have greater difficulty in envisioning how their passion for the environment can direct them to an eventual career, more so than Biology and Chemistry majors that may be following a more traditional career path to professional or graduate school. In order to meet this challenge, we can help our students grapple with these questions and get some answers. This may result in retaining more ENVS majors, and attracting new students to the major. Some possible ways to address this issue include the development and improvement of internship opportunities for students through the appointment of an internship coordinator, the development of a directory of possible internships, and exposing students to internship opportunities with presentations of previous internship experiences shared by peers.

We may also try to foster a greater sense of community within the major through multiple avenues, including the coordination of periodic events that can bring students in the major together, such as career development workshop events, greater promotion and investment in student clubs such as Students for Environmental Action and Awareness (SEAA) and the Association of Environmental Professionals (AEP), the development of a monthly e-newsletter for ENVS (and other "environmental" students) with highlights of what other students are doing, more intentional advising of ENVS majors (perhaps including a group pre-advising session to bring majors together for an overview of the major) and the exploration of a few specific career paths supported by the program that could be the focus of workshops, newsletters, advising, etc. (e.g., environmental public health, environmental chemistry, conservation ecology, zoo conservation). These activities would help students gain both a sense of identity and community as well as have practical benefits by developing clear career goals, pathways to achieve those goals, and help students gain technical skills that would be beneficial in their future careers.

2. Are there any particular opportunities regarding this program that have not been addressed through the analysis and reflection on data or questions in sections F1-F6 that you would like to include here?

The interdisciplinary nature of the environmental science major provides unique opportunities for interdisciplinary collaboration among the different schools and departments at PLNU. Our current program does an excellent job developing the natural sciences aspect of the major, by providing students with a strong background in understanding how the world operates. The challenge mentioned in Question 1 of F7 page 89 is providing our students with an adequate background in those aspects of environmental science focused on understanding the human interactions and impacts on the environment from fields related to the social sciences and humanities. In addition to the development of particular courses to help students gain this background, an exciting opportunity would be the development of an Environmental Studies BA major that would incorporate more non-science skills, and have a greater emphasis on the humanities and social science aspects of the field. This major would be appropriate for those students who have a passion for the environment but may not be interested in the scientific research aspect of environmental science, but rather in the various non-technical related fields, such as environmental writing, policy, and sustainability. An Environmental Studies BA would provide students with sufficient scientific background to be proficient in relating to scientists but also the non-technical skills which would allow them to be successful in the various support roles. The development of such a major would require significant investment from the different schools and departments involved and would also require support from the administration.

Another opportunity is to better promote the Environmental Science major and introduce it to prospective students as a great option. We can work with the Admissions office by providing relevant statistics that show evidence of the success of our alumnae (such as the fact that 88% of our alumni were employed or attending graduate school in a STEM-related field; the acceptance rate of students into graduate and health profession's schools continues to be at least 90%; of the eight Environmental science majors who responded to the most recent alumnae survey, 88% were employed or in graduate school in a STEM-related field). In addition to promoting the major in the traditional way as a means of managing, protecting, and restoring the environment, this field can also be marketed in relation to the public health applications of two critical issues of growing importance, the alarming rate of biodiversity loss and the explosion of emerging infectious diseases. Both of these issues are of growing importance and have dramatic consequences for the human population. Environmental Science is a field that is particularly relevant in studying the impact humans have had on these issues and also possible solutions.

ENVS-F8) Recommendations for Program Improvement

List the recommendations you are making regarding this program analysis with a brief rationale for each recommendation.

• Remove the Physics requirement (PHY 141/142 or PHY 241/242) from the major (8 units) – A survey of comparator and aspirant schools revealed that 75% of the programs do not have a Physics requirement and many career options in the environmental science field do not require a strong background in physics.

• Add a new required 3 unit course in Geographical Information Systems (GIS) (to be developed) – A survey of comparator and aspirant schools revealed that 50% of the programs had a dedicated course in GIS. The ability to think and conduct analyses in a geospatial context is an essential skill in environmental science as well as many other disciplines (anthropology, biology, economics, history, political science, sociology, etc.) and a valuable skill for those seeking employment. In support of this recommendation, we request a 4-unit course release for Walter Cho in order to develop the course. It should also be noted that several other departments are interested in having this course as an option for their students, including Engineering students, Business students in the Sustainability Minor, and Sociology/Social Work students.

• Add a new required 3 unit course in Environmental Chemistry (to be developed) – A survey of comparator and aspirant schools revealed that 40% of the programs offered an Environmental Chemistry course, an interdisciplinary science that includes atmospheric, aquatic, and soil chemistry, and relies heavily on analytical chemistry. Environmental chemistry is used by environmental agencies and research bodies around the world to detect and identify the nature and source of pollutants, including heavy metals, nutrients that produce eutrophication and dead zones, urban runoff, and organometallic compounds. In support of this recommendation, we request a 4-unit course release for Tracey Schalnat in order to develop the course.

• Add POL 290-World Regional Geography (3 units) as a possible course to fulfill the "Public Policy and Stewardship Electives" requirement (note that this course will not count for upper division credits). Environmental science is an interdisciplinary field of study focused on understanding the natural processes of how the world works and also how humans interact with and affect it. This course draws on aspects from the natural and social sciences as well as the humanities. The addition of POL 290 will provide students in the major a greater opportunity to take courses outside of the sciences and study the social aspects related to the Environmental science major.

• Add BUS 475-Sustainability in Action (3 units) as a possible course to fulfill the "Public Policy and Stewardship Electives" requirement (the BIO 102/105 prerequisite will be waived). Environmental science is an interdisciplinary field of study focused on understanding the natural processes of how the world works and also how humans interact with and affect it. This draws on aspects from the natural and social sciences as well as the humanities. The addition of BUS 475 will provide students in the major a greater opportunity to take courses outside of the sciences and study the social aspects related to the Environmental science major.

• Emphasize the importance of internships for students in the major by emphasizing its importance in the catalog description of the major. A robust internship program is essential in helping our students gain the non-academic skills required to obtain a job in the environmental field, as identified by the Burning Glass Skills data and interviews with comparator and aspirant schools and local professionals in the field. We have ramped up our internship opportunities over the past two years and have also begun intentionally advising students to take advantage of these opportunities. From 2012-14, we only had 1-4 units of student internships. In both 2014-15 and 2015-16, we had 12-14 units of student internships per year. Currently, four different faculty are overseeing various internships and being paid overload pay to coordinate them. In order to make this program more effective, we request 1 unit of load release per year for an internship coordinator, which is the standard rate for 12 internship units. This coordinator would (a) cultivate new internship opportunities, (b) act as a liaison between the organization and the PLNU biology department, (c) meet with interns one-on-one to identify appropriate internship possibilities, (d) assist students with internship applications, (e) communicate regularly with the students during the internship, and (f) communicate with the site internship supervisor to follow up on the progress and success of the student intern. This coordinator would interact with the students in all of the undergraduate Biology programs, hence this recommendation will be made in each program section.

• Explore opportunities for interdisciplinary collaboration and expand the exposure students in the major have to topics related to environmental science in the social sciences and humanities:
1) Investigate the feasibility of incorporating a module on environmental ethics to THE 306-Ethics – A survey of comparator and aspirant schools revealed that 50% of environmental science programs had a course related to environmental ethics. As current faculty lack expertise in this area we will investigate the possibility of collaborating with the Theology faculty to bring this piece into the curriculum.
2) Assess the interest of faculty from other departments in developing a series of 490-Special Topics courses that would incorporate an environmental module (Environmental Economics, Environmental History, Environmental Writing/Journalism, Environmental Philosophy/Ethics, Environmental Policy, Environmental Social Justice, Environmental Theology). Environmental science is an interdisciplinary field of study focused on understanding the natural processes of how the world works and also how humans interact with and affect it. This draws on aspects from the natural and social sciences as well as the humanities. The development of such courses will provide students in the major a greater opportunity to take courses outside of the natural sciences and study the social aspects related to the Environmental science major.

• Investigate the possibility of an Environmental Studies B.A. major – This major would have a sequence of core science courses but then have space for more electives in related social science and humanities courses. The creation of such a major would enable students that are passionate about environmental issues to remain in the field of their passion, but not be overwhelmed by the rigorous science course requirements of the traditional Environmental Science B.S. In addition, there is a growing demand for jobs within the environmental field which require a broad understanding of science but also have a greater emphasis on non-scientific technical skills such as writing, communication, planning, networking, GIS, etc. This would also provide a unique opportunity for interdisciplinary collaboration.

• Improve promotion of the Environmental Science B.S. major and work with Admissions staff to improve promotion materials. The enrollment in the program may increase with more active promotion of the program with relevant statistics and support.

• Promote the Au Sable program as a way for students to complete a semester of upper division electives (16 units) in 10 weeks of the summer and be able to move into an internship for their final (8th) semester, especially if there are ways to make more financial aid available for summer studies. This would allow students to fulfill the field immersion requirement of the program while at the same time gain important field experience and non-academic skills important for employment and/or graduate school in environmental science.

Departmental Level Synthesis

G) Synthesis of Program Recommendations

Please create a combined list of program recommendations and rank order that list according to the department's priorities. Please provide a brief rationale for the ranking.

1) Hire a physical chemist as a replacement for a retiring faculty member (#3 on pages 36, 61, and 88).
2) Make changes to courses to align our curriculum with ACS guidelines (APC proposals approved by APC, pending faculty approval).
   a) Change Physical Chemistry II (CHE326) from a 2-unit quad course to a 3-unit semester course.
   b) Change Physical Chemistry II Laboratory (CHE327) from a 1-unit quad lab to a 1-unit semester lab.
   c) Change Inorganic Chemistry II (CHE468) from a 2-unit quad course to a 3-unit semester course.
   d) Change Inorganic Chemistry Laboratory (CHE467) from a 1-unit quad lab to a 1-unit semester lab.
3) Apply for ACS approval for our B.S. in Chemistry. Most universities have ACS approved degrees or desire to make their degrees ACS approved. For years we have conformed as closely as possible to ACS guidelines. With the diversity and expertise of our current staff attaining ACS approval is a logical next step and it will be an important student recruiting tool moving forward. More of our competitors have ACS approved programs and an increasing number of students and their parents are asking why our program is not ACS approved. Getting ACS approval for our program is well within reach and it will provide a further endorsement of the quality of our programs.
4) Make the following interlinked changes to the Environmental Science – BS major, of which we note that this is its first program review since its inception:
   a) Drop the PHY141/142 (or PHY241/242) requirement (8 units)
   b) Add a required course in GIS (Geographical Information Systems) (3 units)
   c) Add a required course in Environmental Chemistry (4 units)
5) In order to make the changes above, we request 4 units of load release for Walter Cho to develop the GIS course, and 4 units of load release for Tracey Schalnat to develop the Environmental Chemistry course. (These courses cannot be developed without load release as they will require significant research to develop. For example, Walter will need to take a course in GIS before developing the PLNU course.)
6) The other changes proposed are minor APC changes that can easily be accomplished, e.g. add POL290 and BUS475 to the Public Policy and Stewardship electives for the Environmental Science-BS program.
7) Explore outreach opportunities to local high school chemistry teachers as a recruiting tool.
8) Explore offering an interdisciplinary Environmental Studies – BA with the humanities departments on campus. This recommendation would require administrative support from both Holly Irwin and Jim Daichendt.

Rationale for Ranking:
Hiring a replacement physical chemist is our top priority. This is essential to achieving recommendations 2 and 3, to covering our departmental teaching load, and to maintaining an appropriate curricular balance. The changes to Physical and Inorganic Chemistry proposed in recommendation 2 will satisfy the remaining recommendation from prioritization, while bringing us more closely in line with our comparators and ACS guidelines, and setting the stage for seeking ACS approval (recommendation 3). These curricular changes have already been approved by APC and are awaiting a vote by the full faculty. Pending the proposed changes in recommendation 2, we strongly recommend seeking ACS approval for our Chemistry major, a longstanding goal of our department which is finally within reach. Recommendations 4-6 will improve the Environmental Science major, while also adding an exciting new chemistry course (Environmental Chemistry) to our departmental offerings; a similar course is already offered by several of our comparators. Recommendations 7 and 8 are longer-term goals that we are beginning to explore.

H) Action Plan Considerations for MOU

Review your prioritized recommendation list with the Dean and in partnership with the Dean develop a draft action plan and timeline to be considered as part of the MOU.

Click here to enter text.

Dean Level

I) Compliance Checklist

In addition to the Dean roles above, The Dean will be responsible to evaluate and generate a brief report on the following areas to be included with the self-study that is sent to the PR committee and external reviewers.

Check the Academic Unit's Assessment Wheel for each program:

1. Do they have learning outcomes? Are they adequate? Are they up to date?
2. Are their syllabi posted? Are they up to date?
3. Do they have course learning outcomes? Are they adequate? Are they up to date?
4. Do they have a curriculum map? Is it adequate? Is it up to date?
5. Do they have a multi-year assessment plan? Is it adequate? Is it up to date?
6. Do they have methods of assessment? Are they adequate? Are they up to date?
7. Do they have direct methods of assessment? Are they adequate? Are they up to date?
8. Do they have evidence of student learning? Are they adequate? Are they up to date?
9. Have they established the criteria of success? Are they adequate? Are they up to date?
10. Have they analyzed their findings? Are they adequate? Are they up to date?
11. Have they made changes based on evidence? Are they adequate? Are they up to date?
12. Credit Hour: Are the courses in the program in compliance with credit hour expectations?
13. Does the department have evidence posted on the assessment wheel for the Core Competencies?

When complete, the Dean signs off on the self-study as being ready to submit to the Program Review Committee and external reviewers (if no outside accreditation exists)

Program Review Committee and External Review

Once the Self-Study is ready, send it to the chair of the Program Review Committee and the Dean approved External Reviewers for their consideration. The Program Review Committee will incorporate the external reviewer feedback into a combined report that will go back to the Dean and Academic unit for their response. The academic unit leader, the Dean and the Provost will finalize an MOU with action plan for cabinet approval. The self-study, the compliance checklist, the PR committee report, the departmental response and the cabinet-approved MOU will comprise a completed program review.

HARVEY MUDD COLLEGE

Department of Chemistry
301 Platt Boulevard | Claremont, CA 91711 | **hmc.edu**

November 5, 2016

Dear Kerry Fulcher, Provost
Point Loma Nazarene University

It has been a pleasure for me to participate in the evaluation of the Point Loma Nazarene University Chemistry Department over the past few weeks. My meeting with the Chemistry Department faculty clearly showed to me their collegiality with one another and their commitment to undergraduate education in all forms. This sentiment was shared by the students who unanimously reported good, close interactions with the faculty. In my meetings with other department and staff representatives (Biology, Kinesiology, Nursing, and Admissions), their respect for the chemistry department was clear; everyone I met shared extremely positive interactions with the department. The department is responsive to needs of other majors, and collaborates to minimize scheduling conflicts.

The Chemistry curricular offerings are complete, addressing all the major sub-disciplines of chemistry with both lecture and laboratory components. The curriculum seems very close to meeting the ACS-CPT guidelines for an approved program; the recent changes to inorganic and physical chemistry should allow the department to state that their curriculum meets those standards without much additional work. The joint major in Biology and Chemistry is similarly rigorous, seeking to deliver a curriculum that is strong in both biology and chemistry. Importantly, both majors feature a hands-on approach in both lecture and laboratory so the students can experience *doing* chemistry. Faculty indicated their use of a number of teaching modalities in the classroom, from straight lecture to the use of interactive devices (clickers), small group work, and group projects. Faculty are attending conferences on pedagogy and are aware of best practices in this area. Students reported the faculty to be very approachable and caring in their delivery of material in the classroom. There is evidence of strong collaboration between faculty members in the general chemistry courses, and faculty work to ensure through appropriate assessment tools that students are well-prepared for life after their time at Point Loma.

The facilities I observed in the new building were excellent and the faculty seemed genuinely appreciative of their new work environment. The new building features open laboratories, flexible classroom environment, and dedicated research space. The instrumentation available for research and teaching is substantial, and while the department has additional needs for research, the number and quality of teaching instruments are quite impressive. Research in the department is

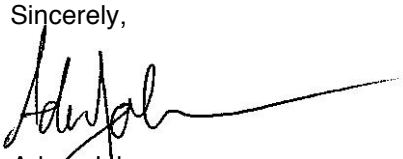
ongoing, mostly during the summer, and both students and faculty report very positive interactions as they work together on real problems.

The department has asked itself some important questions. How best should they measure student success in research? How can they ensure students are being prepared for graduate work? How can the department continue to succeed in research with limited external funding ability? Should we as a department seek ACS certification? How can we increase the number of majors in chemistry without impacting other departments negatively? This introspection is good, and it is clear to me that the department has discussed these questions together for a while. The answers to these questions are not simple, and will require ongoing conversations within the department and across the university. I hope that this report helps the department to see outside of itself a little bit and begin to answer their questions.

The most important question the department has is one that I share: How can the department continue to offer a viable chemistry curriculum without a physical chemist? This is an exceptionally important question, but the answer to this question is quite simple: they can not. It should be of the highest priority that the department be able to replace their recent retirement in physical chemistry so that the department can continue to offer its suite of courses and continue to graduate students.

I address the additional questions in the External Review Template that was provided. I want to conclude by restating my strong positive view of the Point Loma Chemistry Department. I wish them the best as they continue through the final stages of this review process and begin to address and work with the questions and answers they have gained through it. Of course, I am available to address any questions or concerns the department of administration has regarding my report.

Sincerely,



Adam Johnson
Professor of Chemistry
Harvey Mudd College

PLNU Program Review

External Reviewer Report Template

Rev 12-4-15

Instructions:

Thank you for agreeing to be an external reviewer for the PLNU Program Review process. We are grateful for your engagement with us and look forward to your feedback and insights. We are including the department's/school's entire self-study document in order to give you context. While we appreciate your feedback on the entire self-study, we especially look forward to your feedback on the specific program that you have agreed to review. The Dean and Chair of the academic unit will be your main points of contact and will arrange opportunity for you to interact with them and/or other departmental personnel as appropriate. This will allow you a chance to ask questions or seek clarification prior to the completion of your report. We have created the following external reviewer template for your report in an attempt to give you some guidance in terms of what type of feedback we are hoping to get. The text boxes are there for your convenience, but if they get in the way or create formatting issues, feel free to delete them and put your text in their place. This is a new process for us so we have created a space at the end to provide any feedback on the process that can help us create a better instrument in the future.

Thank you again for your help with our program review at PLNU,

Kerry Fulcher, Provost

Point Loma Nazarene University

Department Level Analysis

A) Introduction

B) Alignment with Mission

Please review and evaluate the academic unit's response to the questions regarding mission alignment of their unit with the university mission from both an academic and Christian faith perspective. Are there any suggestions for how they might better articulate and demonstrate their alignment to the university mission and purpose?

The mission of the college, as I gleaned from the review document, is to Teach, Shape, and Send. Teach: The program seeks to educate students in chemistry, not just to learn about chemistry, but to do chemistry. The program focuses on fundamentals, allowing students to pursue a variety of options post-graduation. The summer research program is an important aspect of teaching students how to do chemistry; the two-year commitment to the program allows for more time for students to grow. Shape: The close one-on-one interactions of students with faculty as researchers, TAs, and graders, fosters a long-term relationship. I heard from students during my visit and saw first-hand in the classroom the one-on-one interactions and how valued they are by the students. Send: the program produces students who are highly successful as evidenced by their success in post-graduate education in graduate school, allied health professions, and the workforce. Students reported feeling very well prepared for their future education or career choices. The department meets and aligns with the stated mission.

C) Quality, Qualifications and Productivity of Department Faculty

Based on all the evidence and responses provided in the program review report, provide a summary analysis of the qualifications of faculty associated with the program. Identify the degree to which scholarly production aligns with the expectations of the degree level of the program offered (undergraduate, master's) at this type of institution. Are there any strengths or distinctives that should be noted? Are there any gaps or weaknesses that should be noted?

The faculty of chemistry all have Ph. D. degrees in their disciplines. The chemistry department is also relatively young, with most faculty having been at PLNU for less than 10 years. This means that they may not be as experienced teacher-scholars, but it also means that the department is vibrant and full of energy. However, I heard from more than half of the faculty telling me about their innovative teaching strategies to promote student learning. These strategies include small class sizes when possible, and a variety of teaching methods (lecture, discussion, small group work) in both lecture and laboratory. This commitment to undergraduate education is a significant strength.

With the retirement of the department's physical chemist, the program will be deficient in its ability to offer the breadth of the major required for students, and for ACS certification. This is a serious shortcoming of the department, and it was discussed at length in several of the meetings I had during my visit. The department is quite concerned about its ability to offer courses in physical chemistry in the short term, as no one currently in residence is qualified to teach that material at the collegiate level required. Without a physical chemist on the permanent faculty, I question the ability of the department to maintain a viable program that will serve its majors and allow them to continue their post-baccalaureate education, or frankly, even complete their baccalaureate education.

The department reports using adjunct faculty for laboratory sections when demand is high. In general, the adjunct and part-time faculty are reported as doing a good job, though quality of instruction appears to be uneven across sections sometimes. The department seeks to minimize use of adjunct faculty but obviously this ideal can not always be met.

Review and comment on the scholarship of the faculty. Identify the degree to which scholarly production aligns with the expectations of the degree level of the program offered (undergraduate, master's) at this type of institution. Where appropriate, suggest improvements that may be necessary to increase the quality and/or quantity of scholarship produced by the faculty in this program.

The publication rate listed in the self-study is quite high for a teaching-heavy institution; 35 publications in the past 5 years for a department with 7 members. The only way to increase scholarship would be to reduce teaching commitment. This is a balancing act that every faculty member and every department does, within the confines of their home program. I can not, however, make a recommendation as to whether PLNU should make efforts to increase scholarship, as that is a conversation that must be held internally. All faculty are active in scholarship with students. There appears to have been substantial effort (and success) in seeking external funding for research and instrumentation.

D) Progress on Recommendations from Previous Program Review

Review the narrative supplied for this section. Discuss whether it provided a good accounting and rationale for what changes have or have not been made based on the previous program review and/or any circumstances that have arisen since? Where appropriate, identify any insights or questions that you might have stemming from this narrative.

The last program review was in the mid 1990's, and at that time, reviewers noted a deficiency in inorganic chemistry, and a lack of retention after the introductory course. Minor adjustments were made to the curriculum, and an inorganic chemist was hired to round out the department. The department is responsive to data driven needs.

The department changed from a BA to a BS degree within the last decade, to better match the designation to the degree offered by PLNU Chemistry. A variety of course restructurings were also reported in order to better align the program with the ACS guidelines. The ACS is the principal accrediting body for chemistry programs, and to have an ACS approved program requires course offerings in both lecture and laboratory across all the major disciplines of chemistry. Restructuring was done in both the analytical and organic sequences. The department reports a "lean curriculum," and the restructuring that took place did not add units to the major.

E) General Education and Service Classes

Identify any program response to GE or service classes that may be associated with this program. Review and discuss the quality of the program's responses to the questions in this section of the self-study. Identify any insights or suggestions that program might consider based on your knowledge of courses like these at other institutions.

The department has begun to assess "GELO 1e: Quantitative reasoning." Some courses met the criteria for success, but others did not. Longitudinal data is needed. Certainly, quantitative reasoning is a major component of chemistry education. The department reports using best practices to help achieve these goals. Department members have attended events on chemical education, (ACS, PKAL, etc.) and use pedagogical methods such as flipped classroom, clickers, and team learning. No one teaching modality is perfect for all students, so using a variety of methods in different courses is beneficial and standard practice.

The department only has a single chemistry course that is specifically designed to meet the GE requirement, the non-majors "Chemistry and Society" lecture and lab course (3+1). However, general chemistry, organic chemistry, and biological chemistry courses serve a number of students in chemistry and biology, and these courses also fulfill the GE requirement as part of the regular curriculum designed to prepare the students for majoring in these fields.

These latter courses are classified as "service courses" by the department, as they are required by pre-nursing, Kinesiology and pre-health majors. The department feels that it is having difficulty keeping up with the demand for this course. Representatives from Nursing and Kinesiology, the major beneficiaries of service courses in chemistry, spoke extremely highly of their relationship with the chemistry department, and reported that chemistry is very responsive to needs and demands of the outside students vis a vis scheduling, and allowing growth in the service course.

F) Program Level Analysis

1. Trend and Financial Analysis

Based on data and responses provided by the program, summarize and evaluate the effectiveness of the program's recruitment and matriculation efforts as it relates to enrollment. Are there any suggestions or insights that you might have that can help to increase the demand for the program and/or improve the enrollment yield?

CHEM:
There is a general trend upwards in inquiries, applicants, and admits to the program. The selection rate for chemistry seems to be similar though perhaps a bit less selective than the PLNU selection rate. The yield (number of matriculates) is low, though perhaps a bit higher than the PLNU yield rate. These two trends taken together suggest that strong students are applying to PLNU chemistry, but they are being wooed by other strong programs in the San Diego area. The assessment by the department reaches the same conclusions. The department expects continued fluctuations in yield, as their numbers will reflect the opportunities available to incoming students both at PLNU and other institutions. Addition of the new science building, as reported by the self-study, should help recruit students.

The department has a small but relatively consistent number of majors year-over-year. Due to problems transferring from other majors to chemistry, based on prerequisites, they do not expect significant recruitment to occur at PLNU once students matriculate. This is a problem faced by many chemistry programs; the major is very linear and sequenced, and missing a prerequisite could add a year to the program.

The department and I discussed the feasibility of recruiting at local (San Diego and/or Los Angeles area) high schools, especially religious schools. We also discussed having high school teachers participate for several weeks of summer research in order to advertise PLNU's program and hopefully build recruiting lines to those schools. The takeaway was that a relatively minor outlay of time and money could result in a significant upturn in student interest in chemistry.

BIO-CHEM:
The only major difference with this program is the relatively larger number of students interested in the Bio-Chem major. One issue, reflected in the report and shared with me during the visit, is that biology has proposed limiting enrollment in its major, while chemistry does not wish there to be limits. Chemistry has unmet capacity and they are interested in growing their program.

Based on data and responses provided by the program, summarize and evaluate the program's role in GE and Service functions and identify any opportunities or challenges from this that could have positive or negative impacts on the program itself.

CHEM and BIO-CHEM:
The department recognizes that the relatively high numbers of students in the GE courses (CHE101, 103, 152 and PSC110) is at least somewhat due to the fact that these courses are required for their major (chemistry, biology, nursing, kinesiology, for the most part). The courses are not populated mostly with students seeking the GE requirement, though those students exist as well. Certainly, as enrollments in biology, kinesiology and nursing have risen over the years, this has impacted chemistry. While chemistry is a net importer of majors from other disciplines, that number is small and it was reported to be difficult for students to transfer in to chemistry from other majors after the first year. Chemistry is a very linear discipline at most institutions of which I am aware, and it is generally difficult to take courses out of sequence, so this would be a relatively common observation.

Based on data and responses provided by the program, summarize and evaluate the efficiency of the program based on its overall and course enrollment trends along with the external benchmarking use of the cost per student credit hour data (Delaware). Are there any

suggestions or insights that you might have that can help to increase the efficiency of the program without having a negative impact on quality?

CHEM and BIO-CHEM:
Having never seen data like this before, it is relatively difficult for me to evaluate beyond what the department reports: “chemistry education may be more expensive than other PLNU programs but compared to similar programs elsewhere we are delivering good value at a comparable cost to other schools.” With a substantial lab requirement, and the large number of lab sections needed to maintain student safety, science, including chemistry will always be relatively more expensive than other courses of study.

2. Findings from Assessment

After reviewing the program’s responses to their assessment findings, do you think the program is effectively using their assessment activities and data? Are there suggestions that you might make to improve their assessment plan or insights from their data that you might offer in addition to their analysis? Discuss the quality of their analysis and identify elements of their analysis that you think could be strengthened.

CHEM and BIO-CHEM:
Although the department began the process of revising programmatic learning outcomes within the last year or so, the department has kept longitudinal data with regard to its prior outcomes and students have met those standards historically. One deficiency reported previously was the relative lack of preparation in inorganic chemistry. However, the inorganic curriculum was recently revised with the goal of remediating this observation. This shows a clear interest and ability of the department to collect, and more importantly, respond to assessment data. In a meeting with faculty, it was reported to me that most graduate school attendees from recent years have been in the field of inorganic chemistry (or at least inorganic is overrepresented). This supports a successful revision of the inorganic chemistry curriculum.

3. Curriculum Analysis

After reviewing the program’s curricular analysis, student learning outcomes (SLOs), and curricular map, characterize the quality and appropriateness of the program’s curriculum for meeting the learning outcomes expected of students within this discipline. Identify any possible changes to the curriculum or to the SLOs that would result in an improved program.

CHEM:
The chemistry curriculum, the listing of the courses available within the department made available to me, is consistent with a high-quality program. As is typical at many institutions, PLNU chemistry offers year-long courses in general, organic, analytical/instrumental, and physical chemistry, along with semester long courses in biochemistry and inorganic chemistry, all with associated laboratory courses. The department also offers advanced courses (bioinorganic, for example) that are not regularly seen at the undergraduate level.

BIO-CHEM:
While relatively unique in its "double major" nature, my own department also has a joint major in chemistry and biology with a similar footprint and impact (though smaller number of majors). We do not hold our joint major graduates to the ACS-CPT guidelines (though some choose to meet that by taking a few extra courses). We similarly struggle with the concept that no student could obtain all the knowledge required for a true double major. Our measure of success is student acceptance into graduate programs or employment, and the department at PLNU uses a similar metric to evaluate its success.

After reviewing the program's curricular analysis through a guild or comparator lens, summarize and discuss the quality of their analysis and comparison and offer any suggestions or insights that might be helpful for the program to consider regarding their curriculum content and structure.

CHEM:
The ACS-CPT (American Chemical Society Committee for Professional Training) regularly updates its guidelines for ACS approved programs in chemistry. These guidelines include not only course content, but also recommendations on material delivery, instrumentation requirements, and library holdings. Importantly, the ACS requires that 4 of the 5 foundational courses (analytical, biochemistry, inorganic, organic, and physical) be offered annually, with the remaining being offered at least every other year. In addition, 4 of the 5 courses must be offered as in-depth courses at least annually; an in-depth course is one that has a foundational course as a prerequisite. Historically, the department has been able to meet (or very closely meet) these requirements. The department has proposed (and I believe completed) to convert the physical and inorganic curriculum to 3 unit semester long courses in order to address the largest deficiencies in the curriculum with regards to the CPT guidelines.

However, with the retirement of the physical chemist, and no replacement on the horizon, the department will not be able to continue to offer a curriculum that meets the ACS requirements.

BIO-CHEM:
The department held up the BioCore and the ACS-CPT as standards to measure their curriculum against, recognizing that no single major could meet all the requirements of two separate majors. Not being familiar with the BioCore, I must simply accept the departments analysis. Certainly the major appears to strongly prepare students in biology. The BIO-CHEM major requires 4 foundational courses and has as options in more advanced courses. The choice by the department to require bioinorganic chemistry instead of inorganic chemistry for the joint majors is both clear and appropriate for the population of students it serves. There are a few minor sequencing issues mentioned by the department that can easily be addressed with consistent advising and communication.

After reviewing the program's curricular analysis through an employability lens, summarize and discuss the quality of their analysis and narrative and offer any suggestions or insights that

might be helpful for the program to consider regarding their curriculum content and structure as a preparation for future employment.

CHEM and BIO-CHEM:
I was not familiar with the "Burning Glass Skills Data" before undertaking this review. I found it a very useful analysis of the skills generally required of chemistry majors post-graduation. The department emphasizes communication, (oral and written), problem solving, and organizational skills in most of its courses. Some courses (presumably laboratory components) emphasize detail/planning and quality assurance. The department's commitment to developing students through summer research and teaching assistantships is also noted.

After reviewing the program's curricular analysis through a pedagogy lens, summarize and discuss the quality of their analysis and narrative and offer any suggestions or insights that might be helpful for the program to consider regarding the delivery of their curriculum in ways to enhance the student learning experience.

CHEM and BIO-CHEM:
After reading the department's review, and more importantly, meeting with individuals and groups of faculty during my visit, I am very impressed with the departments commitment to trying new pedagogical tools in the classroom. This is not only well-established and –documented practice in both chemistry and physics, but also a strong mandate from the ACS-CPT for an approved program. The faculty in chemistry have demonstrated a commitment to and willingness to engage in new or revised pedagogies, such as clickers, flipped classrooms, and group work in a large lecture class. Faculty have attended presentations on best teaching practices, and have given talks at conferences that relate local use of these practices at PLNU. I heard several faculty members describe in some detail the approaches they or others are taking in their courses. I witnessed a real willingness to exchange ideas and practices in the team-taught general chemistry sequence.

Additional notes on BIO-CHEM:
It is interesting to note that at least 2 or 3 members of the biology department have education degrees, and as such one would expect the courses in that department to be aligned more closely with modern practices in undergraduate education. However, there appears to be strong interest and support in the chemistry department for these innovations, and I hope that the two departments discuss pedagogy in the joint major as part of a broader conversation on campus about teaching. Several faculty mentioned informal faculty gatherings where pedagogy is discussed on campus. This open sharing of ideas is wonderful and I hope it continues and is supported by the institution.

4. Potential Impact of National Trends

After reviewing the program's discussion of possible impacts from national trends, discuss the quality of their response and identify if there are trends in the discipline that the self-study has missed or not adequately addressed based on your expertise and opinion.

CHEM and BIO-CHEM:
Speaking with both faculty and students during my visit helped to clarify my view of student preparation in chemistry at PLNU. It seems that a large portion of the students go on in allied health professions, and are quite successful in gaining interviews and acceptances to these programs. Other students reported interest in graduate school or joining the workforce. While gaining ACS certification would go a long way towards an external validation of the PLNU curriculum, past successes of students is a good indicator of the strength of the program. A strength of the program is the 2-year commitment to doing research in the department that is met by students who apply to and are accepted by the departments summer research program. There is no better way to learn chemistry than to do it, and students spoke very highly of their experiences doing research during the summer.

5. Quality Markers

After reviewing the program's discussion of its quality markers and the questions posed in this section of the self-study, discuss the quality of their response to these questions and identify any particular strengths and/or weaknesses that you might see in this section of the self-study. Please offer any suggestions or insights that might be helpful for the program to consider relating to these quality markers.

CHEM and BIO-CHEM:
Students in chemistry are retained and graduate at or above the PLNU averages. The department attributes this to the relatively small class size which allows students to make a genuine connection to faculty, as well as the intensive research experience and teaching assistant experience they can achieve in the department. Students buy in to the program and are happy and successful. I view the summer research experience at PLNU to be a strong indicator of success. Four of the five students I met had done 1 or 2 years of summer work, and all four strongly encouraged the sophomore student in their group to apply for the program. Students see a real value in doing research. In my experience, graduate admissions committees look to research experience as the number one indicator of interest and success in graduate school.

6. Infrastructure and Staffing

After reviewing the program's discussion of its infrastructure and staffing, discuss the quality of their analysis and reflection in this important area and offer any suggestions or insights that you might suggest they consider.

CHEM and BIO-CHEM:
The new science building (Sator Hall) is impressive. It was very clearly designed to be (and also appears to be) a highly functional teaching and research capable building with open laboratory floor plan, sufficient faculty research space, and an impressive amount of research instrumentation. PLNU has a larger suite of instrumentation for use in the teaching labs than Harvey Mudd College. I saw two teaching laboratories actively in use, and was very impressed with the facilities. I also saw two classrooms, and the use of furniture that allows for flexible use of the room is very important for modern pedagogical needs. The department (faculty and students alike) were unanimous in their appreciation for the infrastructure.

Additional notes for CHEM:
Although I did not see the 400 MHz spectrometer, that instrument (or a similar high-field instrument) is specifically called out by the ACS-CPT as being a necessary requirement for modern chemistry, of which I wholeheartedly agree. High-field NMR is the bread and butter of synthetic chemistry, as well as some aspects of analytical and physical chemistry. The department indicated a desire for a tunable probe and other modifications to the instrument which would significantly increase the usability of the instrument for research needs.

The department suggests a need for X-ray and LC-MS instrumentation. Certainly there are many undergraduate departments that do not have these instruments, though the specific research needs of the faculty at PLNU (Maloney and Beauvais) do suggest that these two instruments would be extremely valuable.

I agree with the department's assessment of staffing. If the department cannot replace the physical chemist who recently retired, I do not see them being able to have a viable program; they will not be able to deliver the curriculum required to graduate majors in chemistry. The department is quite concerned about the future of the program in both the short and long term. It is not clear who will be able to teach the newly restructured physical chemistry curriculum in the near future. The department does not want to hire an adjunct faculty member to develop such an important foundational piece of the curriculum, since development of a course would require significant buy-in of the faculty member who by definition would not have that ability to be deeply devoted to the department. However, without a physical chemistry on the faculty, no one in residence has the expertise to develop the new course.

Additional notes for BIO-CHEM:
I did not have as much contact with the biology department so cannot comment well on their facilities needs. I imagine that instrumentation and supply funding is of similar importance and concern to biology.

7. Challenges and Opportunities

Do you feel the report adequately identified the challenges and opportunities that they face based on your understanding of the discipline? Why or why not. Are there other challenges or opportunities that you see based on your review of the self-study and your understanding of the discipline in today's higher education context?

CHEM and BIO-CHEM:
I heard from both students and faculty that one of the major challenges of the department in the near term is the size of the major. While chemistry does not appear to wish to grow significantly, there is a critical mass of students required to maintain viability, and I got the impression that the number of majors was close to or slightly below the minimum required to sustain that critical mass. Unfortunately, I do not have good recommendations to solve this problem; my own department suffers similarly with a low number of majors and we have not figured out how to address this problem. Interestingly, this is not a national trend, as there are several programs of which I am closely aware that are bursting at the seams with chemistry majors. Chemistry feels some pressure from biology, as there is a general sense that biology does not wish to grow further, but increasing recruitment of chemistry would likely also increase the size of biology. Even growth in the joint major in chemistry and biology would potentially affect biology adversely. During my discussion with admissions, this topic came up, though the admissions officer did not share this same sense of conflict in recruitment. That being said, it is clear from the biology self study that they do feel to be at essentially maximum capacity, and further growth in chemistry that also impacts biology needs to be avoided if possible.

The department identified several other challenges, including funding for research and instrumentation. The largest expense in modern instrumentation is not usually purchasing the instrument itself, but maintaining it (supplies, replacement of parts, etc.). The NSF and other funding agencies generally assume that the institution will bear the long-term maintenance and supply costs of these instruments which truly are required to carry out impactful research. With funding rates at the NSF at historical lows (less than 8-10% in most programs in chemistry), maintaining a research enterprise is falling more and more to institutions rather than single PI grants. That being said, the department has a strong history of applying for research grants. This is a significant time (and intellectual) commitment and should be recognized or rewarded by the institution if possible.

I talked briefly with the department about establishing short-term to long-term collaborations with local and non-local industrial or academic partners to further the impact and opportunity for research by PLNU chemistry students. These seem to be collaborations based mostly with contacts made at meetings, so continuing to encourage attendance of student and faculty at ACS meetings is going to remain important.

Finally, and most importantly, as has been mentioned previously, the department needs to be able to hire a physical chemist. Lacking this hire, I do not feel that the program is viable going forward.

8. Recommendations for Program Improvement

Do you feel the recommendations being made for this program are supported by the analysis and evidence provided in the self-study document and narrative? Discuss why or why not. Are there other recommendations or suggestions that you would make that the academic unit should consider? If so, please give a brief rationale for why?

I read the department's self-study carefully but tried to not form any strong opinions about the program until after the site visit. At the site visit, I felt that most or all of the opinions expressed by the faculty, staff, and student participants was directly indicated in the self-study. While the self-study addressed both Chemistry and the joint program in Biology and chemistry, the major themes that came through really were broadly programmatic and not specific to one or the other major. The department has a strong history (and student interest) in the more biological side of chemistry, but the recent increase in the inorganic and physical curricula seems to set the stage for increased recruitment and retention in chemistry. However, the two majors are quite closely related and the major themes and needs expressed touch on both majors essentially equally.

The department has been proactive at keeping its curriculum modern and based on the ACS-CPT guidelines, even though the department is not required to do so. The department has explored and used modern pedagogy in the classroom, has improved its suite of instrumentation, and has adjusted its curriculum to meet these guidelines. The needs of the department are well-stated and data driven, not based on a selfish drive for more resources. In addition, the department has done a thorough and complete analysis, and I see no other obvious places where additional resources are needed.

G) External Reviewer Feedback on PLNU Program Review Process:

We recognize that there are many ways to approach a program review. We would value your feedback on our process so that that we can continue to make it better and more helpful to the programs undergoing review. Are there areas that were confusing or sections that you felt were unhelpful? Are there areas that you were not asked about where you feel you could have provided useful information? Is there anything about the process that you would recommend we change or consider changing that could make it better?

The only thing that I see to be missing from this process is some sort of introductory narrative prepared by the department or chair. I would have appreciated a 3-5 page cover letter that outlined the department, its history, its successes, its challenges, and its requests, in a more narrative format than one that is so rigidly constrained by the common format that seems to be used for all external reviews. However, I did appreciate the common format as a document for delivering the data and analysis of that data for me as a reviewer.

In reviews I have been a part of previously, the reviews have always been a team of at least three, but even having a second person participating in the review would have allowed for a more thorough discussion of ideas. I do somewhat worry that this review is very much one person's opinion, that could be biased according to my own personal views. That being said, I understand the expense and logistical coordination required to bring more than one person to campus, and as such, I have tried to write this review as a detached outside observer as much as possible.

Response to External Program Review for Chemistry BS

1. Introduction

We appreciated the thorough review of the Chemistry programs by Dr. Adam Johnson and we would like to respond to his review in the following document. It is important to notice that beyond the very positive comments about the scholarship of teaching, scholarship of discovery, and well-equipped facilities, our deep care for our students' success was apparent, which is one of the main goals of the Chemistry department.

2. Scholarship of Teaching

As mentioned by the reviewer, the Chemistry department's curriculum is purposefully lean and efficient. It has always been designed to align closely with the ACS-CPT guidelines and we hope to become ACS certified in the near future. Many of our GE courses serve different departments and we are pleased to see that our efforts to offer high quality GE courses meet their needs and are recognized by our colleagues. Our recent APC proposal to offer a new GE course, Chemistry in Our Everyday Lives (CHE102), was approved. We look forward to reaching out to the broader student population and demonstrating the importance of chemistry in their lives in a fun and interactive way. In recent years, the Chemistry department has increased its use of modern pedagogical tools to enhance student engagement and student learning. Teaching is our highest priority in the Chemistry department and it is very encouraging to hear positive reports from the students. The reviewer was particularly impressed with the collaborative way in which the general chemistry sequence is being delivered. We desire to keep pursuing excellence in teaching through conferences, book discussions, engaging laboratories, and participation in the science FLC.

3. Scholarship of Discovery

The new science building has allowed our department to offer high quality laboratory and research experiences for our students. Not only are the labs fully equipped with state of the art instruments, our research projects offer a broad set of topics for our students to choose from which prepares them for their careers after PLNU. In order to continue offering high quality laboratory and research experiences, we will need to replace our current outdated 400 MHz NMR. We have used this refurbished instrument extensively in the last 2 years and it has become a central part of our laboratory courses and summer research program. We hope to secure the necessary funds to purchase a new 400 MHz NMR in the near future. Two additional instruments, a powder X-ray diffractometer and LC-MS, are also highly desired and funding for these instruments will be sought by chemistry faculty.

4. Physical Chemistry

Physical Chemistry - arguably the most fundamental sub-category of chemistry - is an essential element of any undergraduate chemistry curriculum. With the retirement of Dr. Ken Martin, we were at risk of losing a key element of our curriculum, a concern reflected in the program review by Dr. Adam Johnson. Fortunately, with the recent approval to hire a physical chemist, we've received an especially strong set of applications and are confident that we will be able to find someone with great teaching skills and a strong research agenda who will allow us to continue to offer a vibrant, viable chemistry curriculum.

5. Conclusion

Overall, the review from Dr. Adam Johnson was very positive and with the hiring of a new physical chemist we are confident that we will address his main concern. The Chemistry department will continue to have ongoing discussions around different strategies to increase the number of chemistry majors.