Thomas Harriot College of Arts and Sciences
Department of Chemistry
Self-Study: 2010-2017

Executive Summary

The Department of Chemistry has completed a self-study of the department's BA, BS, and MS programs, including the teaching, research and service components. For this self-study, we considered the programs in the context of the mission and strategic goals of the department, the Harriot College of Arts and Sciences, and the University. We are committed to the University's mission of student success, regional transformation and serving the public, and the department's high quality instructional, research and service activities are a critical and on-going part of that mission.

Our graduates' rigorous preparation and technical skills have resulted in strong placement rates into graduate programs, professional schools, and local industry. Multimillion-dollar local pharmaceutical industries rely on our programs for their workforce needs. We play a central role in efforts to expand the pipeline of K-12 STEM educators for eastern North Carolina. Further, the department's engagement in interdisciplinary research makes it a valuable resource in supporting the University's overall research mission.

The department's strong research performance relative to other MS programs' research productivity and increasing levels of external funding, along with high teaching demands, merits further investment in the department. Launching of a stand-alone PhD program has been proposed.

a. Overall quality of each degree/certificate

BA and **BS Chemistry**

The BA degree in Chemistry provides excellent grounding in chemistry principles, including specially focused 3000-level coursework. The BS degree in Chemistry offers in-depth coverage of all major areas of chemistry, featuring challenging advanced coursework for our majors. Students who earn a BA or BS in Chemistry are equipped with skills that enhance their marketability to a wide variety of employers in technology and science, and are well-prepared to enter graduate school in chemistry or professional school such as medical, dental, or pharmacy school. Our BS degree is certified by the American Chemical Society, the largest professional scientific organization in the world.

Our assessment results on research methodology and subject knowledge have shown modest gains over the seven-year self-study period. The steady increase in majors demonstrates student confidence in our preparation, advising, and job placement rates; diversity among our majors is also improving. Student survey results are positive, as the vast majority (an average of nearly 90%) report that they are satisfied or very satisfied overall with the program. Our data driven approach to addressing DFW rates has worked well, most notably in the general chemistry courses, although further progress is needed in addressing variation between sections of the same course.

MS Chemistry
The MS degree in Chemistry consists of an interdisciplinary core curriculum, additional coursework in the chosen concentration, then several options including a research based thesis track, a non-thesis track, and a Professional Science Masters. Students who earn a MS in Chemistry are well equipped with skills that enhance their marketability to a wide variety of both regional and national pharmaceutical industry employers, and are well-prepared for further study in chemistry or professional school such as medical, dental, or pharmacy school.

Our assessment results suggest that a recent curriculum revision appears to have had a positive influence, and while the students have still not consistently met all the criteria for success, average scores on the rubrics in the areas of concern have improved. In particular, we continue to make progress on the oral presentation skills.

The degree completion rate has remained consistent and high; the average 3-year graduation rate is 86% and the 5-year graduation rate is essentially the same. The time-to-degree has dropped from an average of 2.5 years to almost 2 years. The MS program graduates have a near 100% job placement or admission to a graduate/professional program. Enrollment growth has been slightly up as additional research funding has supported more students.

b. Strengths and weaknesses of the department

Teaching
The Department of Chemistry at ECU is clearly among the most efficient in the university and likely nationally in terms of student credit hour generation per faculty member, with fewer faculty members and Graduate Teaching Assistants (GTA) per student than institutionally identified peers. During the self-study period, four faculty members have received the Board of Governors Distinguished Professor for Teaching and one the Alumni Association Award for Outstanding Teaching. Anne Spuches was named the inaugural Provost's Faculty Fellow for Teaching. Several of our faculty are recognized campus-wide for their outstanding teaching and have led workshops through the Office of Faculty Excellence. Three faculty were selected for BB&T Active Learning & Leadership program and one as a BB&T Faculty Leadership Fellow; both programs foster leadership development in the classroom.

The recent hire of Joi Walker as part of the STEM Collaborative for Research in Education (STEM CoRE) has provided both expertise in course redesign and assessment and a boost via funded educational research (see below). She has led an overhaul of the general chemistry laboratory sequence with the adoption of the Argument-Driven Inquiry (ADI) approach.

We have found that the incorporation of more problem-based learning in the classroom has resulted in lower DFW (grades of D, F and withdrawal) rates in those sections. Additional support in terms of appropriate classroom space, learning assistants and graduate assistants are necessary to expand these offerings if section enrollments remain high. However, it is anticipated that these investments would quickly translate to savings in terms of increased student success and lowered course repeat rates. We look forward to providing the university with promising initial results from the burgeoning Learning Assistant program.

Research
Publication (average 23.4 per year over self-study period) and presentation (average 13.6 per year) numbers, while showing some variation year-to-year, have demonstrated small upward trends. This trend is reflected in grant submissions (average $3.6 million/year) and awards (average $325 thousand/year), although 2017-2018 is looking very good with $1.09 million already awarded, including the department's first ever NIH R01 grant.

Publications are appearing at almost exactly the median rate as that of our in-state aspirational peers (UNC-Greensboro and UNC-Charlotte, both of whom have small PhD programs) and institutional peers (2.6 pubs/graduate student vs. 2.6 pubs per graduate student). The department is focused on increasing research expenditures; however, the department grant data reflects the difficulty of producing competitive grant applications without the manpower in the labs, instrumentation, and scientific staff to produce the needed preliminary results.

A major highlight of the last seven years was the recognition of Associate Professor Shouquan Huo with the ECU Five Year Research Award in 2015-2016. Associate Professor Allison Danell and Associate Professor Colin Burns were both named members of the National Academy of Inventors and Associate Professor Anthony Kennedy was a NC Biotechnology Center "NC Innovation to Impact" Finalist.

Service
Our faculty have served important leadership roles campus-wide, including memberships on workgroups and taskforces, Faculty Senate committees and administrative roles. One of the faculty members served as Chair of the Faculty. Faculty members have reviewed over 250 articles and served as ad hoc and panel reviewers for the NSF, NIH, and others. Several faculty members have served as Chair, Chair-Elect and Councilors for the ACS Local Section. Regional service includes organizing Science Olympiad events, judging science fairs, and activities with *A Time for Science* and the Scouts.

Regional Transformation
In 2013-2014, the department received a Golden Leaf grant bringing more than $1.1 million to the department and university to fund the creation of the Pharmaceutical Development and Manufacturing Center of Excellence. This center is an outgrowth of the strong, ongoing relationship the department has built with regional industry, providing analytical services for both internal and external stakeholders and continuing education for their employees.

c. Major findings
The department has successfully maintained instructional quality in an era of declining instructional support and increasing enrollments through utilization of undergraduate teaching assistants and exemplary data-driven scheduling. Additional instructional resources (undergraduate learning assistants and graduate teaching assistants) would allow the department to implement more team-based learning into our lecture courses, which would reduce DFW rates and improve student success and engagement. While research productivity has not met College and University expectations or the aspirations of the department, the department has been matching the median number of publications per graduate student of our peer institutions, and

despite ranking last among those institutional peer institutions in graduate teaching assistantships and scientific staff, the department has improved research funding over the self-study period. The department believes additional investment in research and instructional infrastructure is merited and will be rewarded with improved student success and research productivity.

d. Significant actions or changes planned

In summary, the most significant actions planned in this self-study are provided below:

- Apply for a PhD program in Chemistry with a concomitant increase in the number of graduate teaching assistantships required to improve publication rates and funded research grants.
- Advocate for upgraded lecture space for team-based learning and additional undergraduate learning assistants, personnel, graduate students, and research space support for the STEM CoRE group to expand their programming.
- The department plans to continue to incorporate team problem-based learning, Course-based Undergraduate Research Experiences, and related pedagogical approaches into our lectures and labs. We have established that these approaches improve student success as measured via DFW rates and engagement in the material, and on-going research is exploring the impact of these approaches on the peer leaders as well.
- The department is exploring offering hybrid courses (blends of online and face-to-face) for our core and selected upper division graduate classes, and scheduling to minimize trips to campus that interfere with work, so that more employed people might return to school here to get their MS.
- Expand internship and co-op opportunities for both undergraduate and graduate students.
- Apply for a NSF S-STEM grant designed to expand the MS program and expand the reach and access to the program further out into the region.
- Continue to actively seek external resources in support of research programs.
- Addition of upgraded NMR capabilities and additional mass spectrometry and other analytical capabilities to the Pharmaceutical Development Center are critical for both internal researchers and external stakeholders. Personnel needs will include technicians and graduate research assistants to help run routine samples and maintain the instrumentation.

Full Report

1a. Program Purpose: BA Chemistry/BS Chemistry

1.1a Program Purpose

The BA degree in Chemistry provides excellent grounding in chemistry principles, including specially focused 3000-level coursework. Students who earn a BA in Chemistry have a broad education in the chemical sciences, and are equipped with skills that enhance their marketability to a wide variety of scientific companies, and are well-prepared to enter fields such as medicine, dentistry, pharmacy, and forensics. This flexible 4-year plan leaves room for exploring other interests and is a popular major to pair with other science majors.

The BS degree in Chemistry offers in-depth coverage of all major areas of chemistry, featuring challenging advanced coursework for our majors. Students who earn a BS in Chemistry are equipped with skills that enhance their marketability to a wide variety of employers in technology and science, and are well-prepared to enter graduate school in chemistry or professional school such as medical, dental, or pharmacy school. Our BS degree is certified by the American Chemical Society, the largest professional scientific organization in the world.

These two degrees capture a much larger student population than either program would alone. Students with advanced math skills, as evidenced by ACT/SAT scores and/or AP credit for Calculus, are well-suited to begin the highly sequenced ACS-certified BS Chemistry program as freshmen. The BS Chemistry degree requires three semesters of traditional Calculus (MATH 2171, 2172, and 2173; Calculus I, II, and III) and calculus-based Physics (PHYS 2350 and 2360; University Physics I and II). However, students who may not have been well-prepared in high school mathematics, and may need to begin college mathematics at the College Algebra (not even the Pre-Calculus) level could be less likely to major in Chemistry if the BA degree were not available to them. The BA Chemistry degree requires only two semesters at the survey level for calculus (MATH 2121 and 2122; Calculus for the Life Sciences I and II) and algebra-based Physics (PHYS 1250 and 1260; General Physics I and II). Because ECU serves a large number of students with average, but not advanced, math skills, we believe it is important to facilitate their engagement in Chemistry with the BA degree. The requirement of at least 4 (sometimes 5) semesters of chemistry coursework by several other life and allied health sciences majors, such as the BS Biology degree, which also require the condensed survey of life-sciences calculus and algebra-based physics, allow us to recruit additional students to the BA Chemistry major upon their exposure to chemistry.

1.2a Program Alignment

These two programs' purpose align with the University's mission and strategic initiatives as follows:

- Commitment: Maximize Student Success
    - Our strong and ongoing undergraduate research program is perfectly aligned with the university's commitment to expanding undergraduate research.
- Commitment: Serve the Public
    - As a major provider of coursework required for the nursing, health education and promotion, exercise physiology, and pre-medical and pre-dental students, we are

well aligned with the University's commitment to expanding the number of high quality health professionals.

- Commitment: Lead Regional Transformation
    - Several multi-million dollar international companies (Mayne; Patheon, now Thermo Fisher) rely heavily on our graduates for their workforces.
    - As mentioned above, our lower division service courses are critical components of preparing a workforce for STEM and healthcare professions.
    - Our hiring of Assistant Professor Joi Walker as part of the STEM Education Cluster aligns with addressing the critical need for K-12 STEM educators.

1.3a Features

- The BA in Chemistry is a very common double major with the BS in Biology and other similar majors, as it is only three additional courses (with labs). This double major offers a desirable option for pre-professional school applicants by providing a skill set that makes them very employable regionally, and in some cases, leads to a MS in Chemistry.
- The department has multiple faculty advised student groups, including the CHEM Club (which is an ACS Affiliate), pre-Pharmacy and Pre-Dental groups.
- Our pharmaceutically-focused coursework at the undergraduate (Pharmaceutical Industry Skills Laboratory: Good Manufacturing Practices) and graduate (Current Good Manufacturing Practices) has grown from 8-10 students per annum to nearly 40 per annum, and our local industries have provided strong support for the course. Typical feedback from the employers is that the course saves approximately six months of training and makes our graduates quite attractive as potential employees.
- We have a strong and expanding internship program, providing much needed experience for our students in a non-academic environment.
- The Department provides research support for our undergraduates through competitive Chemistry Undergraduate Research Experience awards, supported via the financial return to the department of a portion of the cost of the undergraduate lab manuals. We have expanded this level of support from approximately $10,000 per year to ca. $20,000 per year. Tying this type of support to a requirement that students apply for Undergraduate Research and Creative Activity Awards (URCA, campus-wide competition involving proposed research) and present at Research and Creative Activities Week (RCAW) has resulted in an average of six URCA awards and eight presentations at RCAW per year since 2014. In addition, ten Honors theses have been prepared under the guidance of Chemistry Department faculty since 2014.
- We were the first in the university to create an Undergraduate Teaching Assistantship program in 1998, obtained partial funding for the program from Metrics, Inc. in 2003, and are currently funded, in part, by Mayne Pharma (who provides $20,000 per year to support the students in the program). Students spend the first semester shadowing experienced faculty mentors, meet every Friday with the instructor of CHEM 2301, which provides the pedagogical underpinnings for the program, then transition into teaching their own section under the supervision (and jointly with) a faculty member or Southern Association of Colleges and Schools (SACS) credentialed GTA.

- We have a newly launched Undergraduate Learning Assistant program, with financial support from the Provost. These learning assistants work with faculty members to facilitate group work in large lecture courses, providing both important support for students in the course and an enriching experience for themselves.

1.4a External Factors

State allocations for higher education in NC have been flat or declining over the period of this self-study, although there has been some support for enrollment growth funding. This level of support has been the primary contributor to the shrinking of the department (the department peaked at 31 faculty members in 2008) and the slow rebound. Institutional support has expanded, both in terms of new hires and support for the Pharmaceutical Development Center.

There will be increasing opportunities for our graduates here in eastern NC, including those at local and regional pharmaceutical and biotechnology companies (which is already robust, with nearly 7000 employees at companies east of I-95; the recent acquisition of Patheon by Thermo Fisher will likely expand demand). In addition, the recent designation of NC 264 as a future interstate will likely spur more growth in this region. Nationally, the US Department of Labor (**Bureau of Labor Statistics, Occupational Outlook Handbook, 2016-2017 Edition**) projects average growth (6% over the next 10 years). Quoted here is the pertinent section:

"Employment of chemists is projected to grow 6 percent as they continue to be needed in scientific research and development (R&D) and to monitor the quality of products and processes. In pharmaceutical and medicine manufacturing, chemists will be increasingly needed to develop nanotechnology for medicinal uses. And in basic chemical manufacturing, employers will call upon chemists to use knowledge of green chemistry to improve environmental safety in the workplace and community."

1b. Program Purpose: MS Chemistry

1.1b Program Purpose

The MS degree in Chemistry consists of an interdisciplinary core curriculum, additional coursework in the chosen concentration, then several options including a research based thesis track, a non-thesis track, and a Professional Science Masters. Students who earn a MS in Chemistry are well equipped with skills that enhance their marketability to a wide variety of both regional and national pharmaceutical industry employers, and are well-prepared for further study in chemistry or professional school such as medical, dental, or pharmacy school.

1.2b Program Alignment

The program's purpose aligns with the University's mission and strategic initiatives as follows:

- Commitment: Maximize Student Success
    - Our recent curriculum revision, in which five, very traditional courses (analytical, biochemistry, inorganic, organic and physical chemistry), were combined into three interdisciplinary courses, is designed to broaden our students' preparation and understanding of the multidisciplinary field they are entering.

- Commitment: Serve the Public
    - Multiple department faculty have cross disciplinary collaborations with faculty in the medical school aimed at treatments for skin cancer, understanding contributing factors for obesity, and the preservation of donated blood cells.
- Commitment: Lead Regional Transformation
    - Our research driven MS program, the synthetic and analytical skills of our graduates, and the graduate level Current Good Manufacturing Practices Class and Professional Science Masters (PSM) track help provide skilled employees for the local pharmaceutical industry.
    - The PSM requires an internship, and other students from the MS program also have participated in this important opportunity.

1.3b Features

- There have been 129 graduate student co-authors on research publications from the department over the period of the self-study.
- As mentioned above, our pharmaceutically-focused coursework at the undergraduate (Pharmaceutical Industry Skills Laboratory: Good Manufacturing Practices) and graduate (Current Good Manufacturing Practices) has grown from 8-10 students per annum to nearly 40 per annum (the majority of the MS students take this course), and our local industries have provided strong support for the course. Typical feedback from the employers is that the course saves approximately six months of training and makes our graduates more attractive as potential employees.
- We have a strong and expanding internship program, providing much needed experience for our students in a non-academic environment.
- The department has added a Professional Science Masters track within the MS degree. This track, which mandates an internship and includes several graduate level business school courses, is designed for career advancement of in-place employees or those anticipating employment at regional industries.

1.4b External Factors

As mentioned above in 1.4a, the state allocation has been reduced (operating budget, faculty positions) or flat (Graduate Teaching Assistantships) over the length of this self-study. While there has been a rebound in terms of faculty positions allocated to the department, this does not reduce the impact of the low number of funded GTA positions.

Also, as mentioned previously, the Bureau of Labor Statistics (BLS) has predicted continued strong growth in job prospects for chemistry graduates, particularly those with the Good Manufacturing Practices (GMP) training and/or internships locally.

"Chemists who have laboratory experience outside of a classroom environment, such as through a cooperative program or internship, are likely to meet with better employment prospects after graduation. Chemists and materials scientists with advanced degrees, particularly those with a Ph.D. and work experience, are expected to have better opportunities."

In addition, the 2015 American Chemical Society ChemCensus (taken by the Society every five years) has revealed a greying of the workforce. Since 1990, the percentage of chemists in the workforce aged 50 years of age or older has gone from 27.9% of the workforce to 49.3%. As these older chemists retire, there will be enhanced demand for new employees.

2a. Enrollment, Degrees, and Student Success: BA Chemistry/BS Chemistry
All raw data and charts are available in Appendix A.

Enrollment and Degrees Analysis

2.1a Enrollment Trends

BA Chemistry
Enrollment in the BA Chemistry major decreased from 2011 to 2013 but rebounded by 2015 (note increases after 2015 are inflated due to inclusion of intended majors). Average part-time enrollment over the last seven years is about 7%, with a maximum of 13% in 2014. The percentage of BA Chemistry majors who are women has been at least 50% over the last seven years, but as of Fall 2017 is actually more representative of the make-up of the university in terms of gender with 64% female students. The percentage of minority students pursuing the BA Chemistry major increased from 2011 to 2015 such that half of the students were from under-represented groups, but then tapered off again to 39% minority students as of Fall 2017. Most students are of traditional college age over the entire review period, where at least 95% of the students from 2011 to 2018 were under age 24.

While weighted high school GPA has not deviated significantly for BA Chemistry majors, certain measures of college entrance exam scores are of concern. For example, from 2011-2017, SAT scores for the 50th and 75th percentiles of BA Chemistry majors have decreased from 1110 to 1080 and 1220 to 1180, respectively. It is not known how best to interpret this decrease in light of SAT redesign in 2016. For example, a student's MSAT score of 540 in 2015 would likely be 570 in 2016 (see "Score Converter" at https://www.collegeboard.org). Thus, the decrease in SAT scores may be even more dramatic than indicated. ACT scores for the 50th and 75th percentiles have not shifted dramatically, although it does appear the lowest 25th percentile has decreased during the 7-year period, from 23 to as low as 20, and sitting at 21 for Fall 2017.

BS Chemistry
Enrollment in the BS Chemistry major increased over 40% from Fall 2011 to Spring 2015. It appears to continue to grow, although data are convoluted due to the inclusion of intended majors with declared majors as of Fall 2015. That said, the enrollment has increased when accounting for intended and declared majors, from 127 in Fall 2015, to 140 in Fall 2016 and 148 in Fall 2017. Like the BA Chemistry major enrollment, part-time students account for no more than about 10% of students (less than 7% on average over the review period). The department has enjoyed an increase in female BS Chemistry majors, also. Only about 1/3 of BS Chemistry majors were females near the beginning of the 7-year period under review, but have consistently accounted for about half of BS Chemistry majors since Fall 2013. The percentage of minority students in the BS Chemistry major has increased, also, with more than one third of BS Chemistry majors associated with minority groups in the last two years. BS Chemistry majors

average slightly older than BA Chemistry majors, with more than 15% of majors aged 24 or older in 2015.

Weighted high school GPA increased slightly over the review period, but as in the college entrance exam scores described above for BA Chemistry majors, these scores decreased for BS Chemistry majors, also. From Spring 2011 to Spring 2015, the mean composite SAT score for BS Chemistry majors was 1150, but dropped dramatically to 1102 for the last two years of the review period. If post-2016 scores are normalized higher, then this drop is even more significant. ACT scores follow a similar trend, from a mean of 25 from Spring 2011 to Spring 2015, to 23 from Fall 2015 to Fall 2017. The lowest 25th percentile dipped as low as 18 in Spring 2017 (38th percentile for national test takers, see http://www.act.org/content/dam/act/unsecured/documents/MultipleChoiceStemComposite2017-18.pdf).

2.2a Degrees Conferred

BA Chemistry
The number of BA Chemistry degrees conferred has remained steady, between 50 and 60, over the 7-year review period. About half of students earning BA Chemistry degrees have been women from 2011-2017, and there has been a modest increase in the percentage of minority students earning BA Chemistry degrees in the same time period.

BS Chemistry
The number of BS Chemistry degrees conferred has increased significantly from 10 degrees in 2010-2011 to as high as 21 in 2014-2015. In the years when more than 15 students have earned degrees (this has occurred every year since the 2014-2015 year), 55% of degree earners were female BS Chemistry majors. Up to 38% of degree earners were minority students earning BS Chemistry degrees.

2.4a Student Demand and Enrollment Management
Both undergraduate degrees offered by the Department of Chemistry are primed for further growth and expansion. Degree earners are qualified for jobs in STEM, healthcare, and other technologically advanced fields, or to pursue graduate/professional education. Given the myriad job opportunities in these popular fields, demand has increased and should continue to increase for chemistry degrees from ECU. We have expanded the pharmaceutical skills laboratory curriculum to increase throughput and attract pre-pharmacy and other students to the major, and engaged in aggressive marketing to pre-health profession students. We have also advertised detailed double major plans with complementary fields like Biology, Physics, Nutrition Science, Public Health Studies, and Science Education.

Enrollment management has been a significant focus in our department during the last seven years, requiring careful monitoring in Banner and taking appropriate action to condense under-enrolled sections or advise students who have not met prerequisites. The department uses five-year enrollment trends to calculate anticipated enrollments (including growth factor), and success rates in the first of two-semester sequences to predict enrollment in the subsequent courses.

Student Success

2.5a DFW Rates and Trends

BA and BS Chemistry majors take the same 1000- and 2000-level courses in Chemistry. In addition, the vast majority of students taking 1000- and 2000-level classes in Chemistry are not intended or declared Chemistry majors, as we serve a number of majors across the university. For the 2-semester sequence of chemistry courses taught to mainly intended nursing majors (CHEM 1120, 1130), in the first course, the DFW rate is 25-35% in the fall semesters when students are still on track for a four-year program, but increases for students taking the course in the spring. (These students typically have gotten 'off-track' on their four-year plan.) In the second course, students have already succeeded in the first course and perform generally better in the second semester course, with DFW rates below 20% in the last 4 years. In the traditional General Chemistry sequence (CHEM 1150, 1160, offered to science majors), DFW rates tend to be about 35% for the first semester course, and generally a bit less than that for the second semester course.

The two-semester Organic Chemistry sequence (CHEM 2750, 2760) displayed a DFW rate between 30-40% in the first semester course over the last three years, but the rate for the second-semester course has varied much more widely over the same period. As with the Nursing Chemistry sequence, there appears to be poorer performance from groups enrolled in the course outside of the expected fall-spring sequencing. That is, one of the highest DFW rates observed over the last 7 years occurred in Organic Chemistry II taught in Fall, 2015 (most four-year plans would target spring of a student's sophomore year for taking Organic Chemistry II, indicating the student may have fallen behind on their four-year plan and may not be as well-prepared). The other course taught at the 2000-level is Quantitative and Instrumental Analysis, which on average had a 28% DFW rate over the three-year period, but the range was from 18% to 37%. Chemistry courses are taught exclusively face-to-face except for one general education, non-major course (CHEM 1020), so no comparison of face-to-face and online courses is presented. The DFW rates for General Chemistry I and II are the most consistent of our 1000- and 2000-level classes; we attribute this to department's stringent enrollment requirements which our faculty have identified as statistically significant markers for subsequent success in General Chemistry I. These requirements are based on math capabilities, with Math SAT scores of 570 or above (540 pre-2016) correlating with earning Cs or better in CHEM 1150. Advancement to Organic Chemistry requires Cs or better in General Chemistry. In addition to data-driven prerequisite implementation in the last seven years, the department provided leadership and is participating in the STEM CoRE faculty research group established in 2015 to improve science education at ECU. The use of early alerts as well as 'forgiveness' opportunities in courses at the 1000- and 2000-level are encouraged among the Chemistry faculty, as well as consistent grading scales and course materials across sections.

2.6a Job Placement

Job placement rates are strong based on ECU Chemistry's close ties to regional industry. Students also enjoy success via admission to graduate and professional programs. The faculty are supportive in writing letters of recommendation and acting as professional references. It is difficult to quantify the rates of success, but our most recent graduating class can be used as an example. Of the 69 graduates in 2016-2017, 14 entered graduate programs in STEM, and 11 are

working in industry at companies such as Mayne Pharma, Potash Corp Aurora, Pfizer, and Catalent Pharmaceuticals. Three entered professional programs, and another seven reported they are taking a gap year to subsequently apply to professional programs. Eight are still seeking employment according to LinkedIn profiles. The Director of Undergraduate Studies frequently reaches out to students via platforms like LinkedIn, alumni emails, and Facebook, including the 27 graduates unaccounted for from the 2016-2017 graduating class, to ensure they are enjoying success.

2.8a Actions Taken

The Department of Chemistry has taken numerous actions to improve student success. We have engaged in a variety of peer-led learning activities including tutors via Project HEART, expansion of undergraduate teaching assistants in 2000-level laboratories, and newly formed Learning Assistant programs. We have partnered with other science departments and the College of Education to hire science educators who have been very successful in securing research funding, and who are developing and implementing these best practices for instructional effectiveness in the sciences. We are leading curricular and pedagogical science education investigations to increase early interest and success in the sciences. Faculty advising records are reviewed semesterly to ensure students are on track to graduate and have access to needed coursework, and faculty facilitate professional development opportunities such as internships and other contact with industry and government representatives such as scientists from Patheon and the FBI.

Action Plans

2.9a Actions Planned

The department plans to continue to incorporate team-based learning, problem-based learning, argument-driven inquiry (ADI) and related pedagogical approaches into our lectures and labs. We have established that these approaches improve student success as measured via DFW rates and engagement in the material, and on-going research is exploring the impact of these approaches on the peer leaders as well. Appropriate lecture space and additional undergraduate learning assistants are immediate needs, and additional graduate student and research space support as the STEM CoRE group expands their discipline based educational research efforts and leadership of these efforts.

2b. Enrollment, Degrees and Student Success: MS Chemistry

All raw data and charts are available in Appendix A.

Enrollment and Degrees Analysis

2.1b Enrollment Trends

Enrollment

The MS program enrollment has displayed an overall growth trend from Spring 2011 to Fall 2017, increasing from a total of 16 to 20 with an average of 19. It should be noted that the small size of the program, where the enrollment range is 13-24, leads to high variability in the data; a single student can represent between 4 to 8% of the total enrollment. On average, 78% of students are enrolled full-time. The part-time students can be placed into two categories: 1)

students who work full-time while enrolled and 2) students who leave for employment after completing all degree requirements except the thesis. The latter change their enrollment status from full- to part-time. There is no overall enrollment trend in the data for the two categories of part-time students.

Diversity
The overall student diversity can be summarized as male (avg = 58%), white (avg = 85%), and between the ages of 19-24 (avg = 71%). The gender balance has fluctuated greatly, but the female enrollment has only equaled or exceeded 50% during 4 terms covered by the date range of this study. In terms of race and ethnicity, the number of Asian students decreased from Spring 2011 to 2014 and then increased. The program had no students identifying as Black/African American or Hispanic until Fall 2015. The overall age profile of the students has trended steadily towards a larger proportion being 24 or younger.

Characteristics of Incoming Students
The GPA and test scores of the incoming students has remained very steady. The average incoming student has a GPA of 3.30 (stdev = 0.12), a quantitative GRE score of 153 (stdev = 2), a verbal GRE score of 151 (stdev = 2), and Writing GRE score of 4 (stdev = 0.2). In terms of percentile scores, the incoming students rank approximately in the 50%tile, 40%tile, and 60%tile respectively. The variation in all these scores is low demonstrating consistency over time in the academic scores of incoming students.

The number of applications shows considerable variability with no definitive trend, with a high of 37 for 2016-2017 and a low of 11 for 2017-2018. However, the selectivity (admitted/applied) reveals a distinct trend with the selectivity rate increasing; the average of the rates for the past three years is 88%. The average yield rate (enrolled/admitted) is 62%; excluding the data for the single lowest year brings the average to 75% (stdev = 9).

2.2b Degrees Conferred
The number of degrees conferred each year is consistent with an average of 7 (stdev = 2). This number is strongly correlated with the number of available assistantships to support students in the program.

2.3b Completion Rates
The degree completion rate has remained consistent and high; the average 3-year graduation rate is 86% and the 5-year graduation rate is essentially the same. The time-to-degree has dropped from an average of 2.5 years to almost 2 years. The creation of the non-thesis option and the streamlining of course offerings has improved the time-to-degree. The flexibility the department offers in terms of 3- and 4-semester plans for obtaining the MS Chemistry degree has had an unintended outcome; students may drift off track and the department has not been aggressive in advising students to set and meet a targeted graduation date. This negatively impacts productivity and resources. We are going to continue working toward improving that with a more structured approach (see section 2.9b).

2.4b Program Size

- As discussed above in Section 1.4b, BLS and demographic trends, along with expansion of the pharmaceutical industry east of I-95, predicts continued growth in demand for our MS graduates.
- Increased federal research funding will enable us to continue expanding program via Graduate Research Assistantships.
- Alignment with the strategic plan of expanding research based degrees (Section 1.2) merits further support and expansion of this program.
- Growth of the PSM, GMP offering, and internship program is necessary to expand base of trained students for regional industry.
- The department has recently requested inclusion in the university academic planning process that will lead to the creation of stand-alone PhD program, these MS students will provide the initial base of research productivity necessary to make faculty and students competitive for external support. While the PhD program is a critical component of growing research productivity, the MS will remain key in the near future for our relationship with local industry and serving the economic needs of eastern NC, and merits modest expansion to continue to support local employers. Sacrificing the MS program to populate a PhD program will not address the instructional and research needs discussed in this self-study, and our regional industry consistently values and needs the MS graduates.
- Alignment with the strategic plan commitment to preparation of STEM trained educators in eastern NC merits expansion of this program as well to support local community colleges and in-place high school science teachers.

Student Success

2.5b DFW Rates in 1000 and 2000 level courses

Not Applicable.

2.6b Job Placement

Near 100% job placement or admission to a graduate/professional program. This outcome meets faculty expectations.

2.7b Licensure Pass Rate

Not Applicable.

2.8b Actions Taken

As discussed above, creation of the Professional Sciences Masters track, a non-thesis track, and the curriculum revision to reduce formal coursework while increasing interdisciplinary learning were all designed to improve student success and align with regional needs. The department has made additional research connections to other departments, particularly those in Pharmacology and Toxicology and other Brody School of Medicine basic sciences to increase interdisciplinary experiences and research for the students in the MS program.

Action Plans

2.9b Actions Planned

The department is considering offering hybrid courses (blends of online and face-to-face) for our core and selected upper division graduate classes, and scheduling to minimize trips to campus that interfere with work, so that more employed people might return to school here to get their master's. The department intends to apply for a NSF S-STEM grant designed to expand the MS program and expand the reach and access to the program further out into the region. In addition, we plan to encourage more of our graduate students to apply for federal fellowships. We also plan to alter the structure of the program to tie key products (e.g. thesis proposal, seminar, oral defense) to specific courses, which should result in shorter time to degree and higher quality student products.

3a. Curriculum, Learning Outcomes and Student Satisfaction: BA and BS in Chemistry

Curriculum Analysis

The link to degree requirements as published in the Catalog are listed below. See Appendix B for an updated curriculum map from TracDat that illustrates alignment of student learning outcomes to courses in the curriculum.

BA CHEM: http://catalog.ecu.edu/preview_program.php?catoid=12&poid=2783&returnto=909

BS CHEM: http://catalog.ecu.edu/preview_program.php?catoid=12&poid=2810&returnto=909

3.1a Curriculum Map and Course Sequences

Consistent with the vast majority of chemistry undergraduate programs, the sequences laid out in the curriculum map reflect the introduction of fundamental concepts (bonding, acidity, thermodynamics and kinetics, research methodology, etc.) beginning in General Chemistry and the labs (CHEM 1150, 1151, 1160, 1161). Various aspects of those concepts are reinforced as appropriate in Organic Chemistry (2750, 2753, 2760, 2763) and Quantitative Analysis (for example, bonding and acidity) while new concepts such as reaction mechanisms and spectroscopy are also introduced. Further reinforcement and mastery (as defined as mastery of a concept at the undergraduate level of understanding) occur in the upper division courses in Biological (CHEM 2770), Inorganic (CHEM 3450, 3451 then optionally 4550 for BS majors) and Physical Chemistry (CHEM 3850, 3851 for BA and CHEM 3950, 3951, 3960 and 3961 for BS majors). Many of our majors also reinforce and master specific skills (dependent on research project and advisor) in the three undergraduate research classes (CHEM 4515, 4516, 4517).

3.2a Curriculum

Primary responsibility for the annual program assessment lies with the Chair of the Department, the Assessment Coordinator, and the Undergraduate Program Committee. In addition, the Chair of the Department and the Director of Undergraduate Studies are responsible for ensuring that the curriculum for the BS aligns and meets the American Chemical Society certification standards.

Several department faculty have led the incorporation of additional pedagogical innovations around team based learning and argument driven inquiry into lecture courses, and Assistant

Professor Joi Walker (as part of the STEM CoRE) has led the revamp of the CHEM 1151 and 1161 labs.

Student Learning Outcomes Assessment

3.3a Identified Strengths and Weaknesses in Student Learning Outcomes

The university modified assessment procedures and some outcomes were updated two years ago, so some of this discussion will reflect relatively incomplete data. The current approach is to assess (as reflected in the curriculum map and chart in Appendix B) subject knowledge in the five major disciplines of chemistry (analytical, biochemistry, inorganic, organic and physical) and research methodology. Prior outcomes included general subject knowledge, successful collaboration, and global interdependence (supplanted by the new outcomes) and research methodology (means of assessment changed from questions on the American Chemical Society end of term general chemistry exam to the CHEM 1151/1161 lab practicals).

Our graduates consistently did not meet the criteria for success in the assessments in the General Chemistry (CHEM 1150, based on scores on ten questions on the exam) of **research methodology** prior to the transition to the Argument-Driven Inquiry approach in the General Chemistry labs. This can at least partly be attributed to using a proxy Means of Assessment (performance on an exam in the lecture course) for skills and content being taught in the laboratory. In addition, as the ADI approach is established in the literature to more directly address the desired outcome, we anticipate that improvement will result as the laboratories are modified in response to assessment results. In the single year of data obtained since the revision, the students in CHEM 1151 did meet the criteria for success, while those in 1161 did not. Ongoing efforts will address the identified deficiencies.

In the **general subject knowledge** assessment prior to the revision, assessed using the ACS General Chemistry Exam in CHEM 1150, the students did not meet the criterion for success. This last year, we assessed our students using the ACS DUCK (Diagnostic exam for Undergraduate Chemical Knowledge) exam for their subject knowledge in **inorganic chemistry** and via the written final lab report in quantitative analysis to assess their knowledge of **analytical chemistry**. Students in both courses met the criterion for success.

As mentioned above, the American Chemical Society's Committee on Professional Training offers guidelines for curricular design, laboratory interactions, and meaningful assessment. These are reviewed annually via a straightforward reporting mechanism to the professional society, but at a deeper level every five years. In 2013, important criticism regarding the use of multiple choice questions and the repetition of questions on midterm and final exams in our lower division courses was received. While the exams cited in our 2013 recertification represented only a fraction of the assessments performed by our faculty, they brought to our attention these important issues as an undesirable perception that should be addressed across the board. The department chair has encouraged multiple format testing and allotted graduate student resources for grading assistance. The creation of the STEM CoRE in 2015, and their special events such as seminars and lunch and learn series, has provided important settings for re-evaluating assessment, and frequent comparison of exams and outcomes among professors teaching different sections of the same course assist in the creation and deployment of rigorous and creative exams. For example, the majority of the eight faculty

teaching General Chemistry courses in Fall 2017 (which was not necessarily cited as courses with exams that lacked rigor, but does represent a large number of students taught) include open-ended and free response questions on exams. We anticipate the inclusion of these and other thoughtful assessments as part of our 2018 certification by the ACS so that the improvement in our high-quality program is reflected.

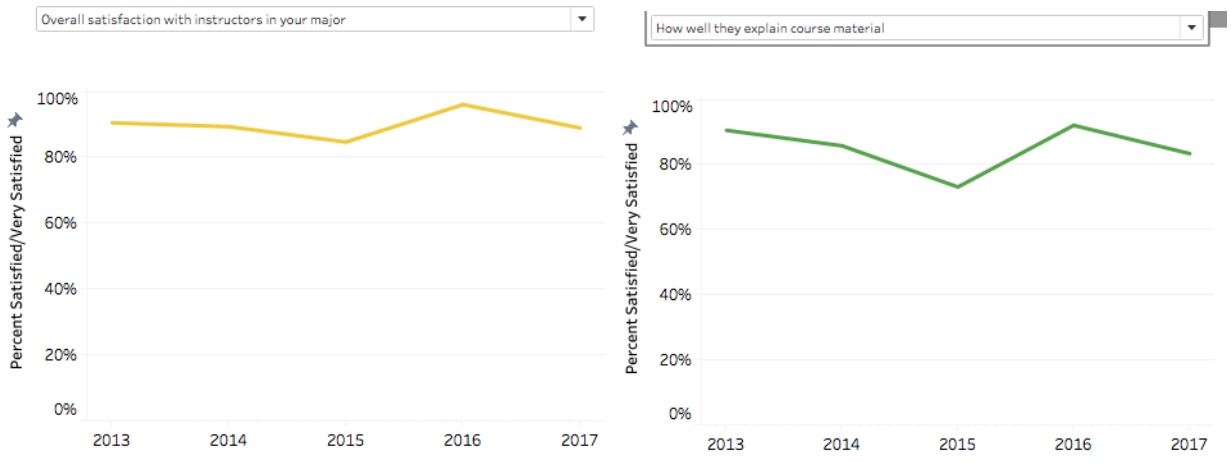
3.4a Differences in student outcomes in face-to-face and online programs
We have no online programs at the undergraduate level

3.5a Decisions Made and Changes Instituted Based on Assessment
Lack of progress made by the students in the assessments of subject knowledge and research methodology prompted the department to reconsider the means of assessment to ensure that we are assessing the skills we are attempting to improve (Dr. Walker's expertise in assessment is an invaluable piece of this change). We have also made the change in the undergraduate General Chemistry lab classes to incorporate the ADI approach. Other changes include curriculum revisions including both CHEM 3450 and 4550 in the BS sequence to improve inorganic subject knowledge and course based undergraduate research experiences (CURE) in instrumental analysis (coming to Organic Chemistry II lab and Quantitative Analysis this upcoming year as well).

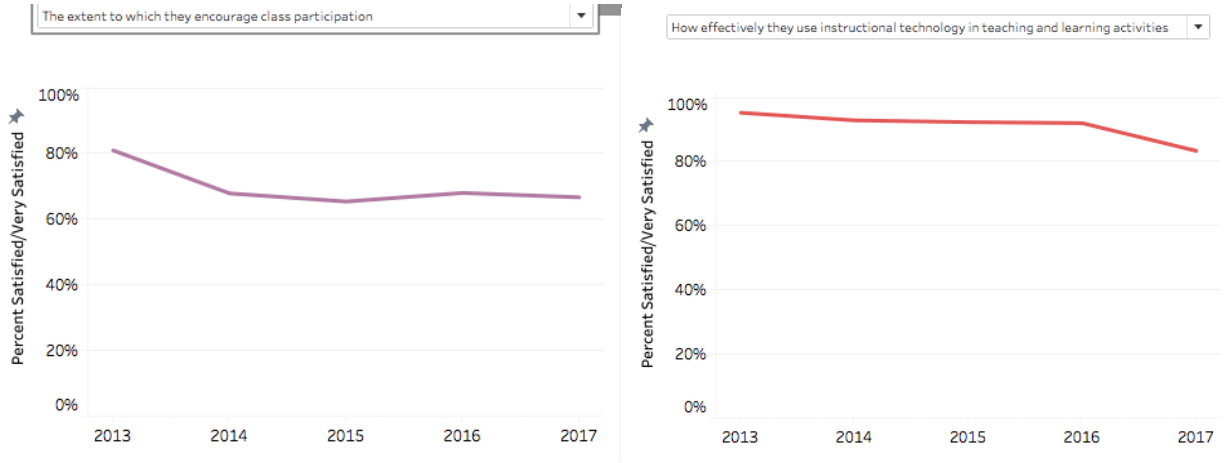
3.6a Effectiveness of the Changes
Feedback and assessment results strongly support the move to the ADI labs, and the CURE labs have received positive feedback.

Student Satisfaction
3.7a Student Satisfaction
Based on the five years of data (2012-2017) available to us via the Graduating Student Survey, which has a 49% response rate, we can see the following trends:

Overall satisfaction with the department's instructors has remained essentially flat, with an average of 89.7% of the graduates giving ratings of satisfied or very satisfied. Ratings for communication of the course materials is similarly high and relatively consistent.

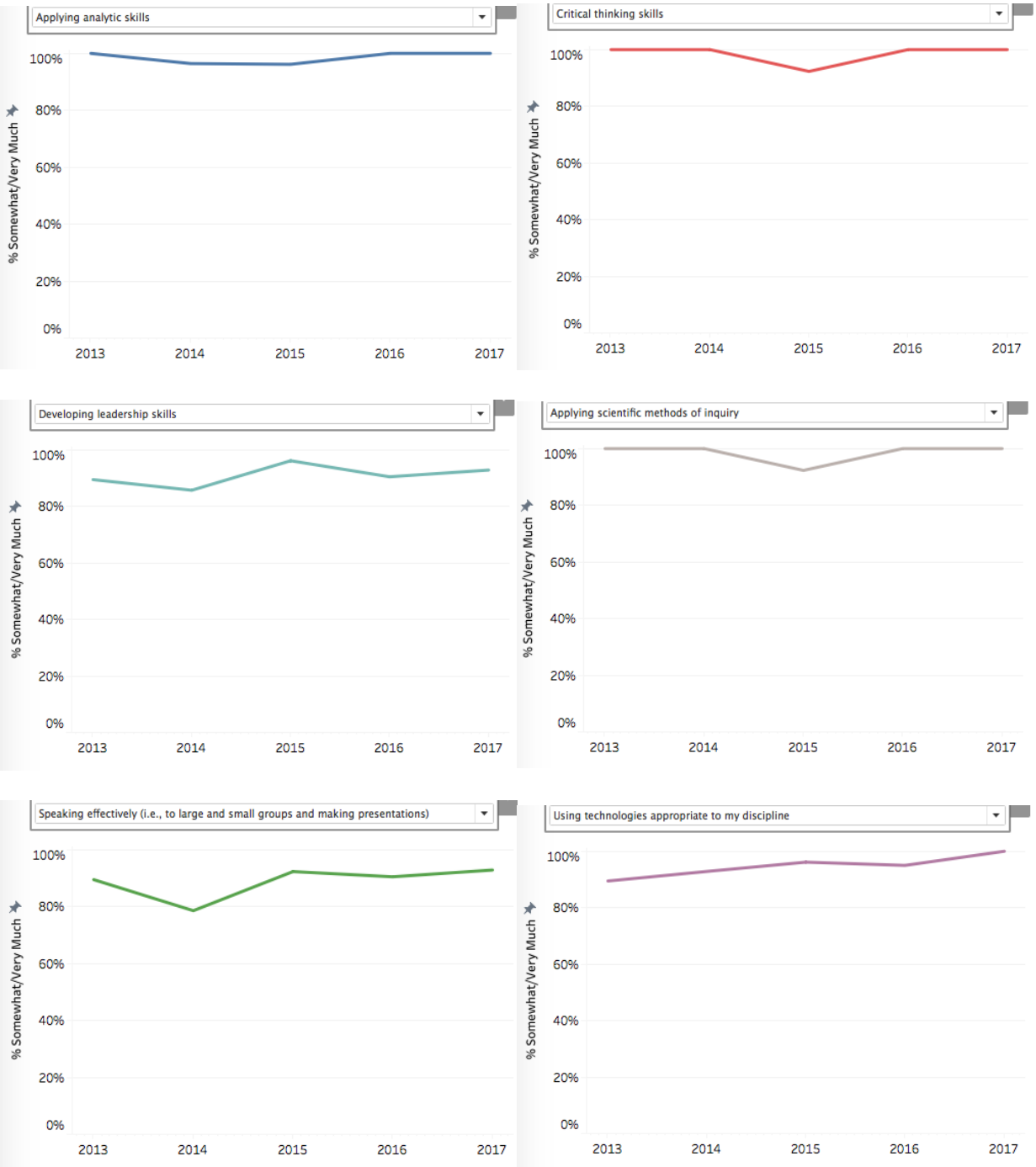


There are slight downward trends in reported satisfaction with the instructors' encouragement of class participation, which may reflect either larger class sizes and/or potentially students who are not in flipped classrooms discerning that the conventional lecture doesn't afford the same opportunities for class participation. Clearly, further investigation is merited. Likewise, the small and recent dip in satisfaction of classroom technology use may be an outlier, but merits monitoring.



3.8a Graduate Evaluation of Skills Gained

Our graduates give the department high marks (percentage ranking their skills as somewhat or very much improved is shown in the charts below) on their experience and mastery of new skills. There are no clearly discernable trends, although the slight upward trend in leadership skills and speaking effectively skills may reflect our students experiences as undergraduate teaching assistants and the additional incorporation of student presentations in many of our upper division courses. Likewise, the small upward trend in technology utilization skills may reflect the incorporation of new analytical instrumentation and the related training in CHEM 2251, 4351, and 4522.



3.9a Employer Feedback

While we do not formally survey our local employers, we have multiple employers represented on our departmental Advisory Council. They provide positive feedback on many aspects; any negative experiences reported we investigate if it is an individual issue or something requiring some fine tuning in our course materials.

3.10a Improving Student Satisfaction

The department has, under the leadership of Dr. Allison Danell, continued to ensure that student advising by faculty in the department is consistent and correct. We utilize the Sharepoint web portal to keep accurate advising notes and records, use student data to guide advising, and carefully monitor progress. The department has a peer evaluation process in which every faculty member is regularly evaluated by two colleagues on not just lecture delivery, but quizzes, exams, and other content to ensure best practices.

Action Plans

3.11a Actions Planned: Pedagogical Changes in Next Seven Years

- Expand ADI approach to Organic Labs.
- Expand Course based Undergraduate Research Experiences to additional upper division labs.
- Incorporate Learning Assistants into more lecture courses as funding allows to facilitate more team based learning approaches and group work.

3.12a Actions Planned to Improve Student Education Experience

- Expand our internship and Co-Op opportunities.
- Expansion of offerings of lower enrollment lecture courses utilizing pedagogies other than the traditional lecture, as UTA, ULA and GTA support allow.

3.13a Additional Resources Needed

- Upgraded instructional space appropriate for problem-based learning.
- Additional support for learning assistants and graduate teaching assistants to support teaching activities and student success.

3b. Curriculum, Learning Outcomes and Student Satisfaction: MS in Chemistry

Curriculum Analysis

The link to degree requirements as published in the Catalog is listed below. See Appendix C for an updated curriculum map from TracDat that illustrates alignment of student learning outcomes to courses in the curriculum.

http://catalog.ecu.edu/preview_program.php?catoid=13&poid=3061&returnto=1020

3.1b Curriculum Map and Course Sequences

Students in the MS program are required to take two of three core courses, CHEM 6210, CHEM 6220, and CHEM 6230, in which, building upon their undergraduate knowledge, their subject knowledge of the broader field is reinforced and expanded. They also take two electives, at least one of which must be in their selected area. The primary reinforcement and mastery of their chosen sub-discipline occurs in their research (i.e. CHEM 650x, Research) and the defense of their major products (i.e. research proposal, major research paper or thesis). Reflecting this flexibility of curriculum sequence and the variation in research programs, assessments are carried out in the two required seminars (CHEM 6103) and the proposal and thesis defense.

3.2b Curriculum

Primary responsibility for the annual program assessment and leadership of curriculum changes lies with the Chair of the Department, the Assessment Coordinator, and the Graduate Program Committee.

Student Learning Outcomes Assessment

3.3b Identified Strengths and Weaknesses in Student Learning Outcomes

The MS program assesses students in communication skills, both oral and written, mastery of concepts, research skills in literature and laboratory, analysis and instrumentation (see rubrics for the proposal and thesis defense in Appendix C). Our students typically meet the criteria for success in laboratory skills, instrumentation, and research skills in literature (i.e. finding and citing sources). The criteria are less often met for mastery of concepts and analysis (based on rubric scores rating ability to answer questions during seminars and defense). Communication skills ratings have varied, with strengths in quality of visuals and organization, but some deficiencies in delivery and ability to answer questions.

3.4b Differences in student outcomes in face-to-face and online programs

We have no online programs at the graduate level

3.5b Decisions Made and Changes Instituted Based on Assessment

As discussed above, the recent curriculum revision to condense five core classes (of which the students were required to take three) into three interdisciplinary core courses (two required) was designed to improve mastery of concepts across the entire field of chemistry. Various strategies have been attempted to address communication skills (additional practice sessions, scaffolded approach to building a seminar).

3.6b Effectiveness of the Changes

The curriculum revision appears to have had a positive influence, as while the students have still not consistently met the criterion for success on mastery of concepts, analysis, delivery, and ability to answer question scoring, average scores on the rubrics have improved. The best approach for the communication skills has been the scaffolded approach, in which a five-week sequence designed to incorporate multiple levels of peer feedback and two practice seminars was implemented.

Student Satisfaction

While we have reasonable response rates for the Graduate Student Exit Survey (average 49.7%), the small number of responses over the last five years (9) makes analysis of any trends difficult and not particularly meaningful.

3.7b Graduate Student Satisfaction with Program

As discussed above, the number of responses is small, but very positive. The data is summarized in this table:

Satisfaction Ratings:	Somewhat and Very Satisifed	Neither Satisfied or Dissatisfied
Academic Experience	100%	0%
Quality of Instruction	100%	0%
Overall Experience	100%	0%

3.8b Graduate Evaluation of Skills Gained

The vast majority of students rated their gain in skill and content positively, as summarized below.

Contribution to:	Somewhat and Very Much	Not at All or Very Little
Communication Skills	89%	11%
Knowledge of Field	89%	11%
Leadership Skills	78%	22%
Personal Development	89%	11%
Problem Solving	100%	0%
Technical Skills	100%	0%

3.9b Employer Feedback

As mentioned above for the BA and BS graduates, while we do not formally survey our local employers, we have multiple employers represented on our departmental Advisory Council. They provide positive feedback on many aspects, any negative experiences reported we investigate if it is an individual issue or something requiring some fine tuning in our course materials.

3.10b Improving Student Satisfaction

The department's increase in stipend in 2015 was partially in response to student concerns over ability of stipend, once tuition and fees were paid, to provide a level of support required to live in Greenville.

Action Plans

3.11b Actions Planned: Pedagogical Changes in Next Seven Years

We also plan to alter the structure of the program to tie key products (e.g. thesis proposal, seminar, oral defense) to specific courses, which should result in shorter time to degree and higher quality student products.

3.12b Actions Planned to Improve Student Education Experience

- In-state tuition waivers would alleviate significant financial burden on the students and make the offers we make more competitive with in-state peers.

3.13b Additional Resources Needed

- In-state tuition waivers to be more competitive with in-state peers.

4. Strength of Faculty: Teaching, Research and Scholarship

Faculty Resources

4.1 Faculty Profile

For 2017-2018, we have 19 Full-Time Faculty members tenured or tenure track, and 8 Full-Time Fixed Term Faculty members. In addition, in both semesters of 2017-2018 we will also have 3 Part-Time Fixed Term Faculty members teaching one course each per semester. These data are summarized in the table below. Faculty biosketches are available in Appendix D.

Rank/Title	Number	Tenure Status	Full/Part Time	Highest Degree	Demographics	
					Male/Female	Race/Ethnicity
Professor	4	Tenured	Full	PhD	4 Males	2 White, 1 Hispanic, 1 Asian
Assoc. Professor	12	Tenured	Full	PhD	9 Males, 3 Females	9 White, 3 Asian
Assist. Professor	3	Untenured	Full	PhD	2 Males, 1 Female	3 White
Teaching Assist. Professor	7	Not Eligible	Full	PhD	6 Males, 1 Female	4 White, 1 Hispanic, 2 Asian
	1		Part	PhD	1 Male	White
Instructor	1		Full	MS	1 Female	White
	2		Part	MS	1 Male, 1 Female	2 White

4.2 Faculty Resources

The Department of Chemistry at ECU is clearly among the most efficient in the university and likely nationally in terms of student credit hour generation per faculty member, as the department is significantly below the institutionally identified peers in the amount of instructional resources provided by the university, as summarized in the table below. The department was the first in the

university to launch a very successful Undergraduate Teaching Assistant program, and in a typical semester the UTA's teach (under the supervision of a SACS credentialed instructor) between 20 and 25 sections of laboratories. This has allowed the department to keep lecture sizes to between 120-250 students, relatively manageable by the faculty without support for grading, recitation sections, and other sources of faculty assistance provided by GTA's.

Per 10K students	Tenure Track Faculty	Total Faculty	Staff	Scientific Staff	Graduate Teaching Assistants
Peer Median	9.36	10.97	3.65	1.60	13.61
ECU	6.36	9.19	2.47	0.72	5.94
% of Median	68%	84%	68%	44%	44%
Rank	19/19	16/19	17/19	19/19	19/19

The current distribution of teaching specializations is adequate for covering the departmental needs, indeed, the department has not concerned itself with teaching specialization for the last few hires, preferring to concentrate on building research expertise. The impending retirement of two senior members of the Physical Chemistry division may require hiring for that specific teaching need.

4.3 Faculty Recruiting and Retention: Diverse Faculty

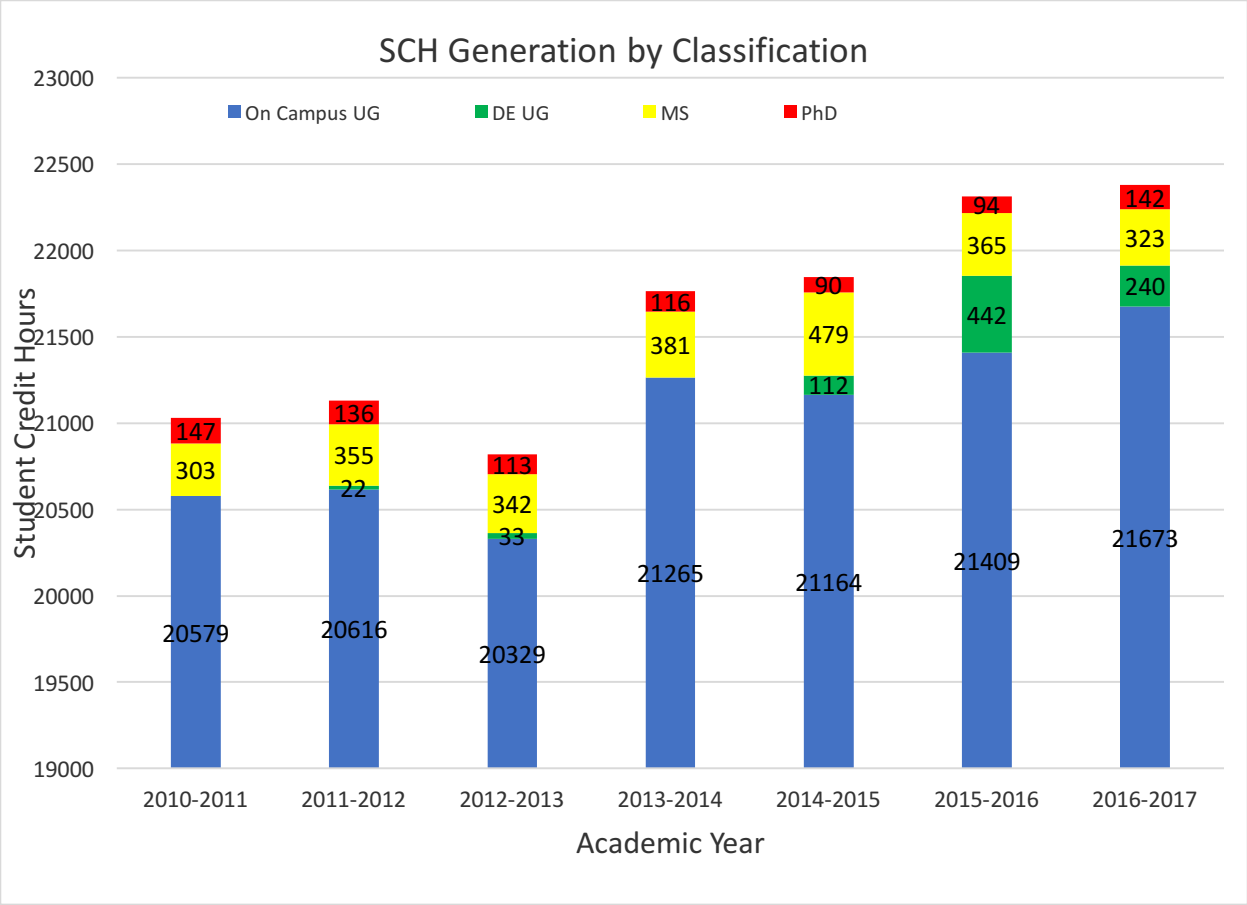
The department has hired three tenure-track, six full-time fixed term, and two scientific staff faculty members. Working closely with the Office of Equity and Diversity, the department has advertised through multiple avenues, many of which are targeted at improving the number of members of under-represented groups in the pool. We have made diversity in the pool of on-campus interview invitees a priority as well. These efforts have been relatively successful, although diversity will have to continue to be a focus. One of the three Assistant Professor hires was female, the other two are male. Among the fixed-term faculty, three of the hires are female (although two have since departed) and three are male (one of whom has since departed). One of the FT male hires is of Asian descent. The scientific staff (through the Pharmaceutical Development Center) consist of one male and one female.

While the department has made progress on diversifying the faculty, particularly at the Assistant/Associate Professor rank (the department had gone several years without a female faculty member on the tenure track before the hire of Yumin Li in 2004), diversity in the Professor rank is a particular concern, with all four Professors currently in the department being male (three white and one of Asian descent). Priority must be given to appropriate support and mentoring to ensure that the female faculty members currently holding the rank of Associate Professor progress towards the Professor rank, as this is likely to become a retention issue along with the lack of representation in the highest rank.

Analysis of Teaching

4.4 Program Instructional Trends

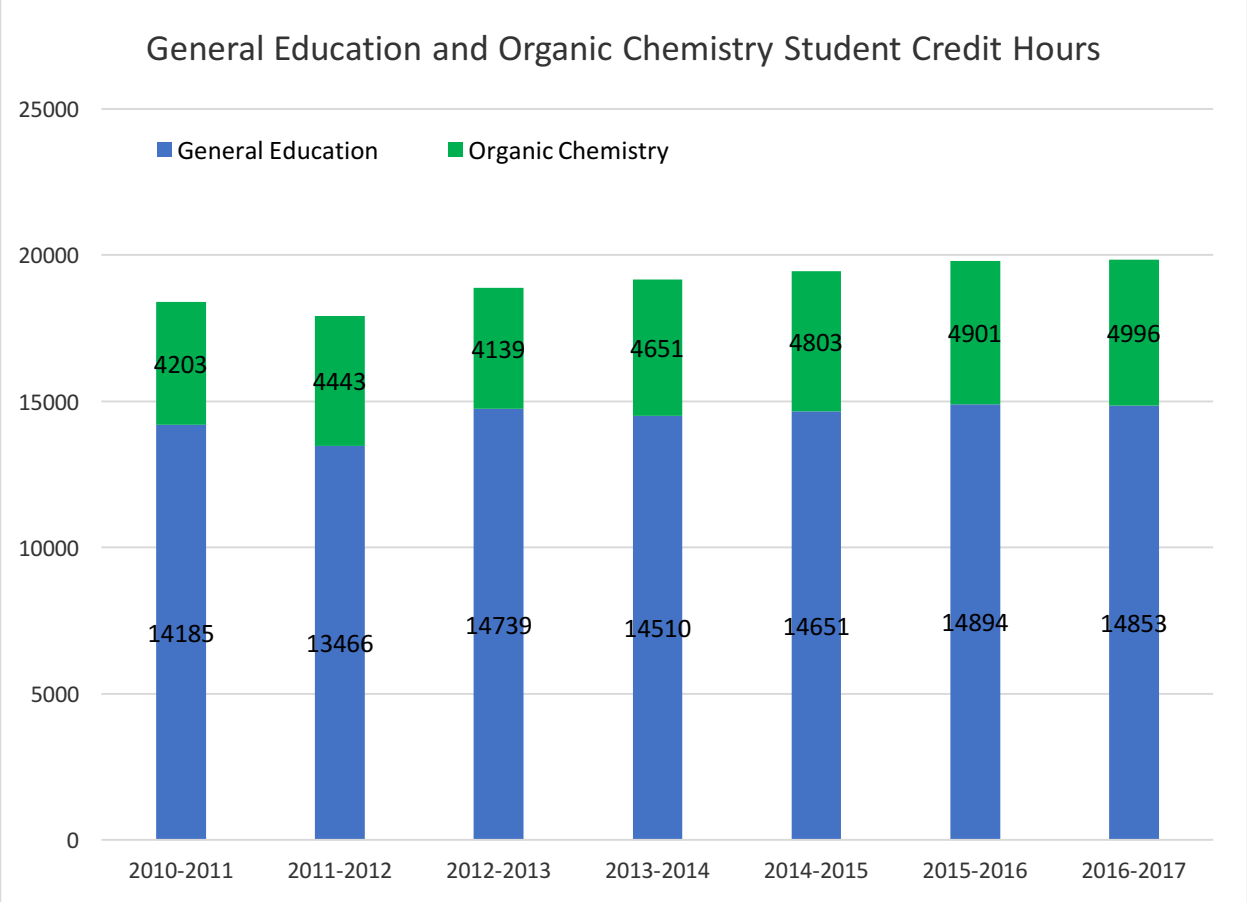
As can be seen in the first figure below, the overall trend in student credit hour (SCH) production has been trending upwards.[1] The vast majority of SCH generation occurs at the undergraduate level, almost entirely face to face. The only courses we teach online are CHEM 1020 (the foundations course for non-majors) and occasionally an online version of CHEM 1130 (general, organic, biochemistry for nursing majors) during the summer. At the graduate level, the majority of the SCH generation is from the MS students, with a small number of PhD students from the Interdisciplinary PhD in Biological Sciences (note that some of our MS students also take the 7000 level PhD courses, so that number reflects a blend of MS and PhD students).



As one would expect for a department with ca. 320 undergraduate majors and 20-25 graduate students, the largest SCH production comes from the general education (CHEM 1020), nursing chemistry (CHEM 1120 and 1130) and general chemistry I and II (CHEM 1150 and 1160), all of which fulfill the natural sciences foundation requirement, and organic chemistry (CHEM 2750 and 2760). As an institution with a medical school, dental school, and allied health programs,

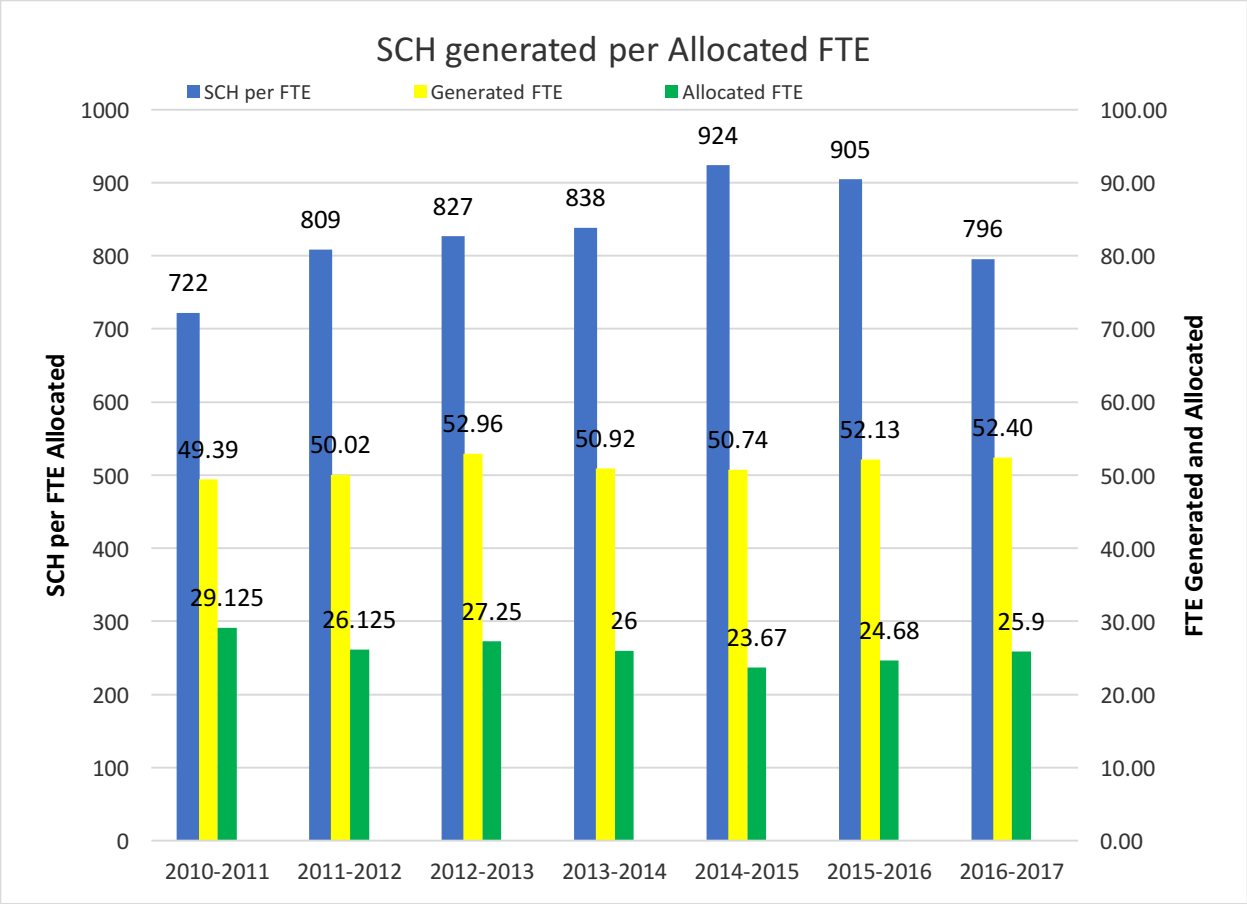
[1] For this section, all SCH and FTE Derived data may be found in the Academic Program Profiles: Student Credit Hours and Generated FTE (https://performance.ecu.edu/portal/?itemId=da462de1-86b8-e511-ba87-005056890024)

pre-professional class enrollment is a major driver of SCH generation, and this is illustrated below. For example, in 2016-2017, these courses accounted for 93% of the SCH generation in the department.



As shown in the following plot, SCH production per allocated faculty FTE[2] has trended upwards from 2010-2015 (as both SCH production has gone upwards and FTE's allocated has slightly declined), a trend that has reversed with new faculty allocated to the department starting in 2015. Further allocations of graduate assistantships would greatly facilitate maintenance of this high level of productivity while improving student success. In particular, as discussed above, we have found that our flipped classes (regardless of method) have had lower DFW rates, additional support in terms of appropriate classroom space, learning assistants and graduate assistants are necessary to expand these offerings if section enrollments remain high.

[2] Data derived from Productivity Matrix (where available), Delaware Report, and departmental teaching schedules.



4.5 Teaching Load

Based on Delaware Study data, teaching loads for tenured and tenure-track faculty:

	Fall 2010	Fall 2011	Fall 2012	Fall 2013	Fall 2014	Fall 2015	Fall 2016
Delaware Study	4.0	4.0	5.0	4.8	5.5	4.6	Not yet available
Actual Sections Assigned[a]	1.6	2.4	2.2	2.3	2.5	2.2	2.1

[a] Not including those sections in which a faculty member supervised a GTA or UTA; including the single course/semester assigned to the Chair

Per the UNC Code, the teaching load for a faculty member at ECU is expected to average 5 courses/AY. As fixed term faculty members teach as many as 8 courses/AY, there is some release time that is allocated to faculty for duties including Chair of the department, the two Directors of Undergraduate and Graduate Studies, and lab coordination. The department has had unbalanced teaching loads for tenured/tenure track faculty since 2006, in which research productivity merits fewer courses assigned per year, while faculty who are less productive in terms of research publications and grants will teach more than 5 courses/AY. In addition, as we started hiring new Assistant Professors in 2015 (with no new tenure track hires since 2008), the

lower loads given to these three new faculty members to facilitate the development of their research agendas are reflected in a lower average across the department.

4.6 Graduate Teaching Assistants

	AY10-11	AY 11-12	AY 12-13	AY 13-14	AY 14-15	AY 15-16	AY 16-17
GTA's provided	20	20	20	18.5	17.5	18.5	17.5
Sections taught as IOR	37	45	51	34	49	47	40

Graduate teaching assistantships are provided by the Graduate School, and consist of a stipend, and for MS students, a limited number of out-of-state tuition waivers. The MS students pay the in-state tuition and fees. The department also has a limited number of GTA positions associated with the interdisciplinary PhD in Biological Sciences, these students receive a stipend, in- and out-of-state tuition waivers, and health insurance. The allocation of funds from the Graduate School in 2010-2011 was sufficient to fund 16 MS students and 4 PhD students. The decrease in 13-14 reflects the need to increase MS stipends to be competitive with our in-state peers. We have also allocated some of these funds over the last few years to support graduate research assistants for the new tenure-track faculty members.

Graduate teaching assistants generally serve as primary instructors for one or two laboratory sections per semester. Those with lower loads reflect assignment to other duties including laboratory prep, instrument room support, and related needs. All GTA's serve as proctors, some semesters we can offer grading assistance to one or two faculty members with large sections.

4.7 Major Achievements and Department Support for Teaching

Over that last seven years, numerous department faculty have been recognized for their strong teaching abilities. Highlights include:

- Four faculty members have received the Board of Governors Distinguished Professor for Teaching: Anne Spuches (2014), Keith Holmes (2013), Rosa Alvarez-Bell (2012), and Subodh Dutta (2011).
- One Faculty Member has received the Alumni Association Award for Outstanding Teaching: Subodh Dutta (2012).
- Anne Spuches was named the inaugural Provost's Fellow for Teaching.
- One faculty member has received a Faculty Senate Teaching Grant.
- Rosa Bell received grants from the UNC General Administration and the BB&T Leadership Center to facilitate and carry out research on Problem-Based Learning in introductory chemistry classes.
- Joi Walker is the Principal Investigator on nearly $1 million in NSF grants for research on the Argument-Driven Inquiry model of instruction in general chemistry labs and

Course embedded Undergraduate Research Experiences in Organic and Quantitative Analysis.

The department's undergraduate program committee has coordinated the general chemistry courses for most of the self-study period, with an eye towards sharing best practices, consistent feedback to the students and the selection of texts and ancillary materials. Informal mentoring by experienced instructors is expected and the department has a well-established peer review process in which all the faculty are required to participate. Laboratory course instructors are required to attend training sessions regularly. Several of our faculty are recognized campus-wide for their outstanding teaching and have led workshops through the Office of Faculty Excellence. Three faculty were selected for BB&T Active Learning & Leadership program and one as a BB&T Faculty Leadership Fellow; both programs foster leadership development in the classroom.

Analysis of Research, Scholarship and Creative Activities

4.8 Major Achievements

A major highlight of the last seven years was the recognition of Associate Professor Shouquan Huo with the ECU Five Year Research Award in 2015-2016, recognizing his research publications and grant activity. Associate Professor Toby Allen received the 2016 Distinguished Master's Graduate Faculty Mentor Award for his outstanding work as a research mentor. Associate Professor Anne Spuches was named the 2014 Sigma Xi Helms Award recipient in recognition of a single, high impact publication, which also led to her invitation to "The Inorganic Chemistry of Neurobiology, Immunology and Bioenergy: New Faces" Symposium at the national meeting in San Francisco.

Associate Professor Allison Danell was named an inaugural member of the ECU Commercialization Hub and she and Associate Professor Colin Burns were both named members of the National Academy of Inventors for their collaboration with Associate Professor Rukiyah van Dross-Anderson in Pharmacology and Toxicology that led to a patent for a skin cancer treatment. In a similar vein, Associate Professor Anthony Kennedy was a NC Biotechnology Center "NC Innovation to Impact" Finalist.

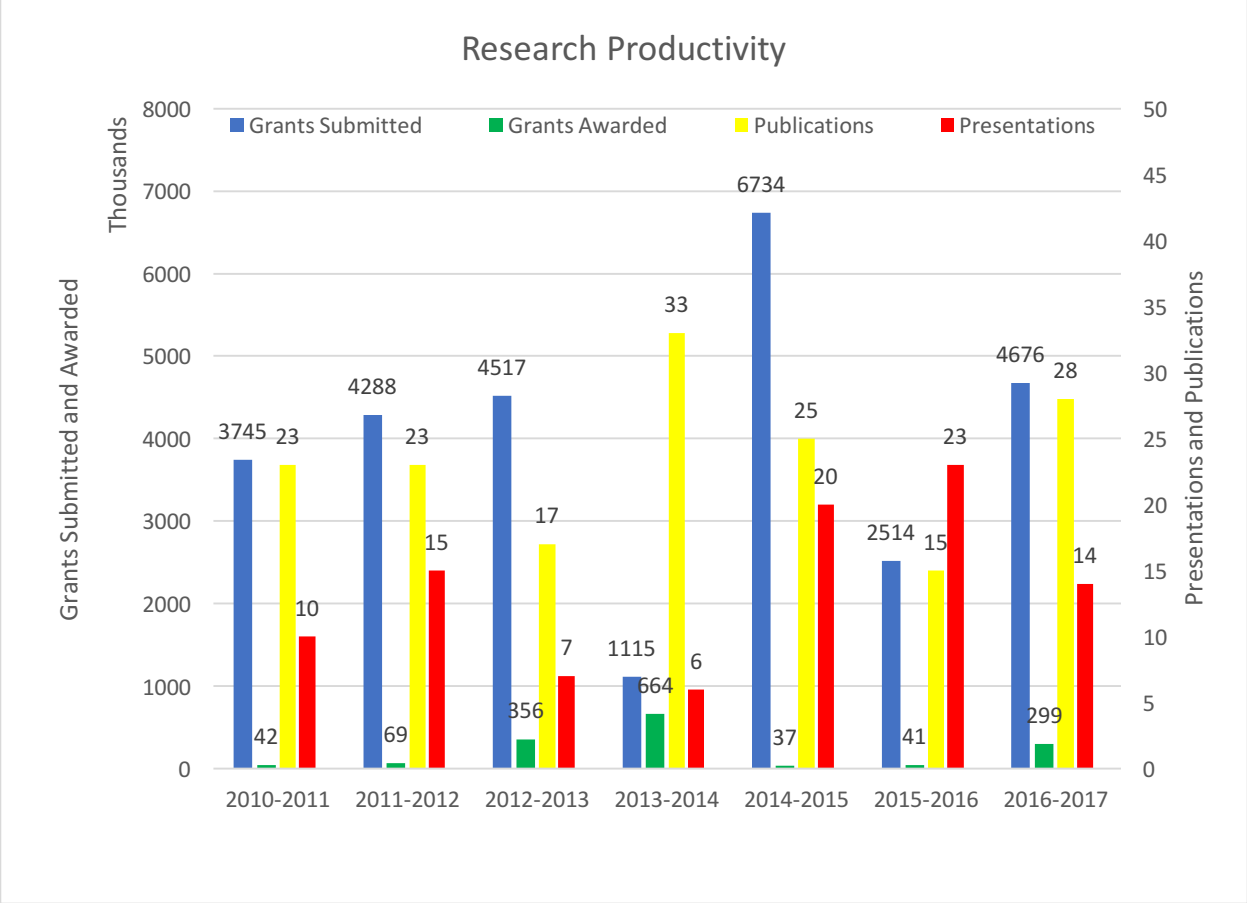
4.9 The Department of Chemistry's research productivity is summarized in the plot and table[3] below. Publication (average 23.4 per year over self-study period) and Presentation (average 13.6 per year) numbers, while showing some variation year-to-year, have demonstrated small upward trends. This trend is also reflected in grant submissions (average $3.6 million/year) and awards (average $325 thousand/year), although 2017-2018 is looking very good with $1.09 million already awarded, including the department's first ever NIH R01 grant.

As seen in the table, publications are appearing at almost exactly the median rate as that of our in-state aspirational peers (UNC-Greensboro and UNC-Charlotte, both of whom have small PhD programs in their departments) and institutional peers (2.6 pubs/graduate student vs. 2.6 pubs per graduate student). Publications per faculty member are near the top end of our actual peers (i.e.

[3] Data for the plot is derived from the ECU Performance Portal, data in the table from Academic Analytics, University Factbooks and Websites, and the American Chemical Society Directory of Graduate Studies.

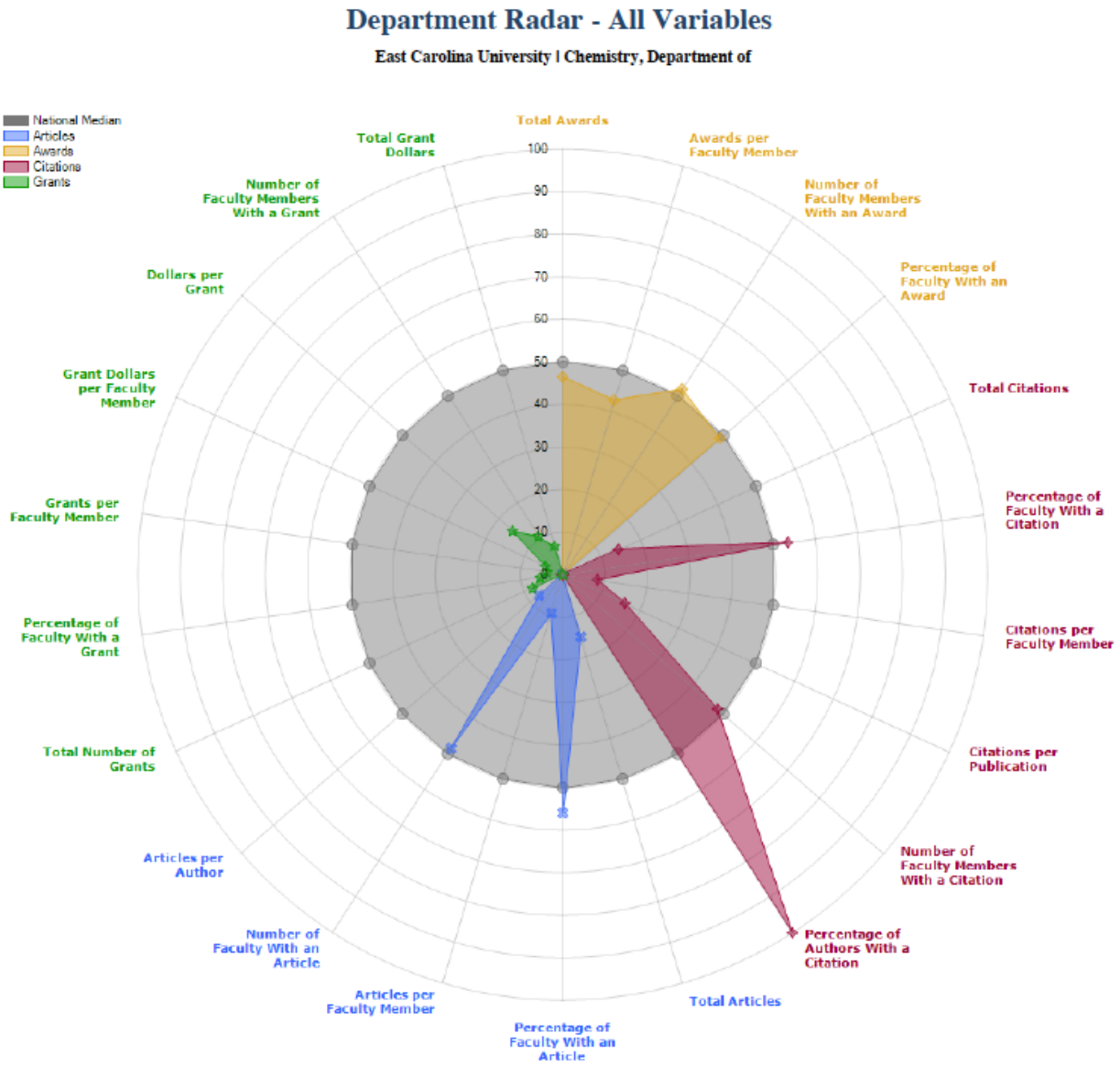
the three non-PhD granting programs), but the other fifteen institutional peers all have higher publication rates as would be expected with their PhD programs.

Grant application numbers and the total amount requested are rebounding from lows in 2013-2014, likely caused by the surge in instructional load following the recession. The success rate has also improved recently, but is still below expectations. Improving research publication rates and the amount of preliminary results will no doubt improve the competitiveness of the department's grant applications.



	Tenure Track Faculty (Per 10K students)	PhD Grads (2105-2016)	Sci. Staff	GTA/TT Faculty member	3 Year Pubs/TT Faculty Member	Pubs/Grad Student	3 Year Ave Grant$ per Faculty Member (thousands)
Median Non-PhD Institutional Peers	7.5	0	2	2.1	3.2	1.3	Not Available
Median Institutional Peer	9.5	7	3	2.8	8.9	2.6	118
Median Aspirational Institutional Peer	10.8	21	5	3.9	16.5	3.5	233
ECU	6.4	0	2	1.3	3.9	2.6	19
UNC-Charlotte	8.6	5	4	1.9	4.6	2.0	77
UNC Greensboro	9.3	5	4	2.8	11.8	3.6	162

The radar plot below, which shows the data of the 241 PhD granting institutions in Academic Analytics in comparison with data from our department reflects the labor force issues. Our faculty produce high quality publications (reflected in the number of faculty with publications and the number with cited work matching or exceeding the national median) but the number we can produce is low without adequate graduate student support. The grant data reflects the same issue, it is extremely difficult to produce competitive grant applications without manpower in the labs, instrumentation, and scientific staff to produce the needed preliminary results.



4.10 Departmental Support

Out of a departmental operating budget of $236K, last year we spent ca. $61K for materials and supplies, almost $14K for travel, and nearly $86K on instrument maintenance and related items. It is an expectation that all faculty will seek matching funds, college and university travel and research grants to assistant in extending the departmental support as far as practicable.

All new faculty receive startup funds, the department has contributed to each of those startup packages.

Analysis of Service and Outreach activities

4.11 Major Service and Outreach Activities

Our faculty serve many leadership roles campus-wide, including:

- Numerous roles on Faculty Senate Committees including Grievance, Research and Creative Activities, Faculty Awards, Teaching Grants, Governance, Admissions and Retention, Athletics, and Curriculum. One of the faculty members served as Vice-Chair and Chair of the Faculty.
- As members and leaders of the Chancellors Committee on the Status of Women, the Quality Enhancement Plan, Project Heart, Student Conduct, Health Professions, Finish in Four, Predictive Analytics and many others.
- Playing critical roles in economic development via the Pharmaceutical Development Center, ECU Patent Committee, and the Innovation Hub.

Professional Service Activities include:

- Over 250 articles reviewed over the last seven years for leading journals in the field.
- Serving as ad hoc and panel reviewers for the NSF, NIH, American Chemical Society, Alzheimer's Association, American Heart Association, and others including the Swiss National Science Foundation.
- Organizing symposia at the American Society of Mass Spectrometry, American Schools of Oriental Research Annual Meeting, International C. Elegans meeting, Cottrell Scholars Consortium, International Conference on Green Chemistry and Technology, and Gordon Research Conferences.
- Several faculty members have served as Chair, Chair-Elect and Councilors for the ACS Local Section.
- Multiple faculty have served as outside reviewers for tenure and promotion decisions at other universities.

Community Service Activities include:

- Judges at Local and Regional Science Fairs.
- Judges and organizers for the Research and Creative Activities week here at ECU.
- Organizing the local Science Olympiad and activities at A Time for Science.
- Outreach activities with numerous local K-12 schools, local community colleges, Boy Scouts of America and Girl Scouts of America.

Action Plans:

4.12 Action Plans

In order to support the teaching, research, and service activities of the faculty, the department plans to:

- Continue to advocate for upgraded instructional space appropriate for team based learning.
- Continue to advocate for additional support for learning assistants and graduate teaching assistants to support teaching activities and student success.

- Continue to actively seek external resources in support of research programs.
- Apply for the NSF S-STEM grant to expand the graduate program.
- Apply for a PhD program in Chemistry with a concomitant increase in the number of graduate teaching assistantships at the PhD level required to improve publication rates and funded research grants.

Resources Needed:

- Graduate teaching assistantships required to expand the MS program, participation in the Interdisciplinary PhD and eventually launch a stand-alone PhD. This will lower teaching loads on research active faculty, provide more research productivity by the graduate students, and provide more time for student success activities and external service. While launching a PhD program will slightly increase the number of MS graduates (this is a common off-ramp for students that don't successfully pass candidacy), simply allocating MS lines to support new PhD students will reduce the instructional capacity (approx. 2 MS student lines are required to fund one PhD) and close off a vital employee pipeline for local industry.
- Additional support for learning assistants in lecture classes.
- Additional instructional space appropriate for flipped classes (Note this is a campus-wide issue).

5. Regional Transformation – Economic Development/Public Service

5.1 Major Activities

In 2013-2014, Associate Professor and Interim Chair Allison Danell was the PI on a Golden Leaf grant application bringing more than $1.1 million to the department and university to fund the creation of the Pharmaceutical Development and Manufacturing Center of Excellence. This center is an outgrowth of the strong, ongoing relationship the department has built with regional industry, including the creation and on-going support of the GMP class mentioned previously.

The mission of the center is:

> The Pharmaceutical Development Center is a laboratory-based education and training center providing research and innovation expertise to internal and external constituents. With a focus on workforce and professional development, the center offers opportunities for students to receive industry-specific training to shorten new workers' time to productivity, and welcomes incumbent workers seeking career progression opportunities in areas such as regulatory affairs and clinical trials. The modern laboratory instrumentation and scientific expertise of our personnel fuel innovation and enhance the competitiveness of our collaborators in industry and academic research and development activities. We strive to impact the region through economic, educational, and innovative development in the pharmaceutical sciences sector.

Dr. Jack Pender (who also teaches the GMP class) was hired as Director, Pharmaceutical Training and Services and Dr. Kim Kew was brought in as Director of Mass Spectrometry Services. These two staff provide support, training and consulting experience to both internal and external constituencies.

In 2014-2015, the Department also participated in the cluster hire of four faculty members in Chemistry, Biology, Physics and Education (Joi Walker was the hire in Chemistry) to form the STEMCoRE (STEM Collaborative for Research in Education). The mission of this group is to improve student success in introductory science courses in the foundation curriculum, prepare more qualified teachers to serve in K-12 public education, increase the production of science and science education majors, and increase cross-disciplinary research in the teaching and learning of science to promote regional transformation in eastern North Carolina.

Assistant Professor Joi Walker is off to a tremendous start, with funded research from the NSF totaling ca. $1 million, and she has led the revamp of our undergraduate labs to the ADI model discussed above.

5.2 Action Plans and Resource Needs

The department is fully committed to expansion of both of these critical components of regional economic development and transformation. Addition of upgraded NMR capabilities and additional mass spectrometry and other analytical capabilities are critical for both internal and external stakeholders. Personnel needs will include technicians and graduate research assistants to help run routine samples and maintain the instrumentation. Much of these costs should be offset with development of grant and external revenue streams.

The STEM CoRE initiative will need additional learning assistant support to help expand its methodology to large lecture classes, and at some point, an additional coordinator (likely a fixed term faculty member) for that program. Expansion of the pipeline of K-12 and community college STEM educators will result, and additional GTA positions will likely be necessary to support the expansion and carry out the research agenda of the faculty in the core.

6. Resources

6.1 Adequacy of Resources

Our primary source of operating funding is the state fund allocation, which is transferred to us via the College. We receive an additional allocation from the Research, Economic Development, and Engagement division to support maintenance contracts and related costs for the departmental equipment. The current operating budget is stretched quite thin by the enrollment increases, which are generally not supported by an additional allocation for purchase of lab supplies (each additional lab section costs over $2000/semester). However, the department, through efficiencies instituted over the last seven years, has been able to maintain support for faculty instructional needs while still being able to support most faculty research needs. Allocation of Foundation's funds (i.e. the undergraduate research support funds, Mayne Undergraduate Teaching Assistant funds, general use fund) have allowed us to support additional research and instructional needs.

As discussed above, state personnel funding (faculty lines, scientific staff, and particularly GTA's) is well short of our institutional peers.

6.2 Projected Space Needs

- Additional lab and office space for any new hires; the department is currently occupying all the allocated office and laboratory space in the Science and Technology Building. The eventual move of the Biochemistry (of the Biology Department) faculty to the new Life Sciences Building should help address this issue and presents an opportunity for additional researchers in support of the PhD program.
- Appropriate space for a high field NMR, once obtained. This vital piece of core instrumentation will require a dedicated staff and space (possibly on the Health Sciences campus). A high field NMR should be on the ground floor with the appropriate shielding.
- Additional dedicated space for other analytical instrumentation (and the support staff) as it is purchased. As above, the department is currently at capacity in the allocated instrumental space of the Science and Technology Building
- As mentioned above, the university needs additional, appropriate space for team-based learning.

7. Other Operational or Programmatic Outcomes

7.1 Other Assessed Outcomes

The department has no formally assessed outcomes over the last seven years.

Operations of the department have been significantly impacted by two factors. The first, a series of significant state budget cuts starting the 2008-2009 academic year, reduced the state operating budget for the department by almost $70K, reduced the number of staff from seven to five, and reduced the allocated permanent FTE from 31 to a floor of 23 FTE. Some recovery has occurred on both fronts, due to allocation of new positions, both tenure-track and fixed-term. The department, as discussed above, is back up to 27 full time faculty members. The additional resources from the division of Research, Economic Development and Engagement for instrument support have provided significant relief and freed operating funds for other uses.

The second factor has been significant turnover in leadership and staff. Professor Rickey Hicks left the department at the end of 2012 to become a Dean at Georgia Regents University (Now Augusta). Associate Professor Allison Danell very ably ran the department on an interim basis until Associate Professor Andrew Morehead became Chair in 2015. Professors Hicks and Danell did an admirable job of finding efficiencies that allowed continued operation of the Department, and Professor Danell (in addition to the stellar work addressed elsewhere launching the Pharmaceutical Development Center) did an exemplary job addressing instructional efficiency in terms of scheduling courses and utilizing faculty resources. Still, two leadership transitions in one and a half years are challenging for any department.

Front office staff turnover has been a real issue. Since 2010, the department has had four lead administrators, four purchasing and travel staffers, and three student support specialists. Competitive salaries for SHRA staff would be of significant value in retaining good support staff.

7.2 Action Plans

The department does not anticipate a Chair transition in the near future, but putting potential candidates in leadership roles (Directors of Graduate and Undergraduate Studies, Chairs of Executive, Undergraduate, and Graduate Program Committees) is an important part of succession planning.

SHRA staff morale is currently good, primarily due to hard work by the lead administrator and good rapport among the staff. Retention of these good staff requires concerted efforts by the administration to use market rate adjustments, reclassifications, and raises and bonuses to reward good work.