Review of the Chemistry Major at Fitchburg State University, Spring, 2022 May 9th, 2022
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Preface: I have been asked to review the current status of the Chemistry Major at Fitchburg State University (FSU). I was provided with a copy of the Chemistry Program Review (2013-2021) by the Department of Biology and Chemistry and subsequently was able to visit FSU (April 26, 2022) to meet with faculty, administrators, support staff and students to discuss their evaluations and aspirations for the program and to tour the new science facilities. I have incorporated the information obtained during my visit as well as the written documentation provided into this evaluation. My overall opinion is that the program serves the needs of the students well, but suffers from a distinct under-enrollment. An evaluation of the program and potential points to consider to assist in moving the program forward are included below. If I may be of further assistance or clarify any comments, please do not hesitate to contact me.

Chemistry Programs Offered:
The Dept. offers several 'flavors' of the major and a minor which are tailored to serve the needs of a wide variety of students and their goals upon leaving FSU.

B.S. in Chemistry:

Although the Dept. indicates that their major is not an approved American Chemical Society (ACS) certified major, it is important to note that the program most certainly could be. All the formal coursework required by the ACS is already part of the major (both in chemistry and in ancillary fields). The only potential sticking point would be the required laboratory hours (400 hours beyond introductory chemistry). At most institutions, this latter requirement can only be met by a student who participates in at least a semester of directed research (~140 hours over a semester), or an equivalent summer internship (at FSU or outside). Given the population that FSU serves, there does not appear to be a need to seek ACS certification as that is of greatest importance for students intending to pursue Ph.D. study after graduation and, as the department has shown, those students who do desire to progress on to graduate study are able to do so without difficulty.

B.S. in Chemistry with Concentration in Biochemistry

This newer option for chemistry majors is an excellent addition to the Dept.'s offerings. Most institutions at present are experiencing a significantly higher enrollment of students in biochemistry than traditional chemistry. At my own institution, we average 4-5 biochemistry majors for each chemistry major. There are many more jobs available at present, and I anticipate that presently there will be even more as a result of the worldwide increase in both biochemistry research and the related vaccine/drug production. In my estimation, the program has suffered severely from unfortunate timing; Covid. The program was introduced just prior to the pandemic which has affected all levels of education, but perhaps the collegiate level most with decreases in enrollments. This is beginning to ease with the lifting of many restrictions across the country, but Covid is certainly with us now for the long-run and I do not see a decline in the increased number of jobs available in the near future. Taking advantage of this program will require special efforts in both marketing and recruitment (*vide infra*).

B.S. in Chemistry with Initial Teacher Licensure

The dearth of qualified middle and high school STEM teachers has been a problem for decades and continues to be so. The incorporation of a program in collaboration with the Education Dept. to provide the necessary background for licensure fills a clear need.

Minor in Chemistry

The requirements fall very much in line with other programs in the state for a minor. From my conversations with both students and faculty, this is clearly a popular program, especially for biology majors, and provides a gateway for many students to obtain jobs as laboratory technicians upon graduation (or before).

Graduate Level Courses

The Dept. currently offers a variety of graduate level courses intended for in-service teachers to aid them in completing an M.Ed. to transition from initial licensure to professional licensure. This program has been suspended due to low enrollments and faculty are currently teaching only those courses needed to allow current students to complete their degrees. I view this as unfortunate given the real need for STEM teachers, but the low numbers of initial licensure teachers makes this a necessary reality. I hope that this trend will reverse itself at which time the administration should reconsider the program, but until that time this does not appear to be a good investment of faculty time. The recent surge in retirements of public school teachers as a result of the problems associated with teaching during the Covid era may create sufficient need to reinstitute the program, but that remains to be seen.

General observations

It is important to note that several of the courses offer by chemistry faculty in the department serve not only those students enrolled in the various chemistry major and minor options, but also are service courses to other majors, most notably the biology major and Exercise and Sport Sciences, and in particular students enrolled in the health sciences track in the biology major.

The Dept. seems to have responded well to the University's revised general education requirements and it is an important recognition by the Administration that so many courses meet various categories in the new rubric.

Some of the students with whom I spoke were concerned about the scheduling of classes, both in terms of times/days and the fact that some courses were only offered in the spring or the fall. However, they were not able to suggest a way that the schedules could be modified in a realistic fashion that would allow for any significant improvement. I do not view the scheduling as a problem that is any greater/worse than at any other institution; it is simply not possible to accommodate all students' situations.

Faculty:

It is clear that the faculty are well trained, and distributed by areas of expertise, to fulfill the roles required of them. They have the necessary backgrounds to cover all the fundamental areas of chemistry and the expertise in specific sub-fields to offer a variety of advanced and special topics courses to fulfill both the needs and interests of their students. In addition, many faculty spend a great deal of time, both formally and informally, in outreach efforts both to broaden science education in the

greater Fitchburg areas and to assist in attracting students to FSU. This includes presentations in the area and collaborative work with faculty at area Community Colleges.

The dedication of the faculty to their work is clear, in part from my discussions with them but more importantly from my conversations with current students. Students were varied in their concerns on many topics (chiefly related to class scheduling and the efficacy of tutors), but were absolutely unanimous in the praise for the faculty and in particular, the faculty's dedication to helping students to be successful in every way possible.

Support staff:

The Dept. appears to be well staffed with laboratory managers and administrative/secretarial staff for its needs. However, I must note that through conversations with both faculty and students, this is due, in large part, to the extensive dedication of those staff to their duties and beyond.

Facilities:

The addition of the Antonucci Science Complex has provided up-to-date and sufficient space for the laboratory teaching needs of the department. The equipment is, in general, of good quality (but needs to be updated on a regular basis as in all departments) and of sufficient quantity and capability for the general research needs of the department as well. I also note that the faculty have made good use of the broader academic community, developing collaborations with area schools when instrumentation needs for research could not be met at FSU. Faculty research space is available, but in my opinion is insufficient for some needs, particularly if it becomes feasible to increase the number of students undertaking undergraduate research (*vide infra*, Recommendations).

Problems:

It appears that the most important concerns for the department are already well recognized. I put them into two categories: student preparation and recruitment/enrollment.

Preparation

As is true at the vast majority of schools in the area and around the country, students entering college are poorly prepared for analytically rigorous fields of study; their math skills are poor. In highly quantitative disciplines such as chemistry, physics, computer science … this leads to poor student success and poor retention. This further filters into recruitment issues as these fields are considered "too hard" by the majority of students, in part rightly so because of their poor preparation. It is an unfortunate reality in our country that the phrase "oh, I'm just not good at math" is accepted as a reason that student preparation is not held to the same standard as many other areas of study. The loss of the SAT requirement for admission, to my surprise, does not appear to have made the problem worse, based on my conversations with the faculty.

The department recognizes this problem in their students and has instituted many programs to assist in both bringing the students up to speed while at the same time helping them make realistic career decisions. The requirement that students much complete General Chemistry successfully after two attempts to continue in the program prevents students from wasting their time and money in an area which they cannot pursue effectively. The use of qualifying exams for a student to enter general chemistry is another measure that will assist in student success by ensuring that students are properly prepared before entering the program. However, as with most institutions, such measures are not

sufficient. Although introductory chemistry requires only elementary school arithmetic and high school freshman algebra, many students are still unable to perform at the necessary level. The faculty provide additional assistance to students and the University has a tutoring office which provides tutors on a broad basis. However, it appears at FSU as elsewhere, broad-based tutors are very hit or miss with respect to their effectiveness. Students indicated that they had highly variable experiences with the University tutors and, in some cases, this resulted in advanced students wanting to serve as tutors to provide a level of service that they had desired for themselves. For tutoring in highly quantitative areas to be effective, tutors must be specifically qualified and to be the most effective, should be directly involved in the class itself (*vide infra*, Recommendations).

Preparation for more advanced courses does not appear to be a problem, indicating that the course sequence is well designed to provide each student with the skills they need to be successful at the next level. Further, it appears that preparation in transfer students from Community Colleges (a significant source of both majors and minors) is appropriate as these students do not have greater problems than students beginning at FSU in their freshman year.

Enrollment/recruitment

The other major problem for the department is in recruiting students to the major. Chemistry majors must begin the program in the spring of their first year if they are to be able to complete all the requirements and graduate on time. This means that, effectively, they have to be chemistry or biology majors when they arrive (the only two majors that would require introductory chemistry in the freshman year). This means that the University must have an effective advertising program so that potential students are aware of the program, its requirements and benefits, and believe it will be appropriate for them. For the STEM fields, this requires developing a rapport with the marketing and admissions staffs so that they can be educated in what it takes to be a successful chemistry major and what students need to do to prepare themselves well. In my experience, the staff in these departments are rarely people educated in the sciences and therefore, they cannot (and cannot be expected to) present the necessary material or field questions knowledgably on their own. There has been a significant turnover in both the admissions and marketing offices in recent years which exacerbates this problem. I am told that the recent restructuring by FSU in admissions and retention has introduced two new area heads who are expected to be long-term. This will certainly provide significant help with respect to the problems.

Recommendations:

Although having few majors at present (but many minors), the program shows great promise and is well designed to serve the needs of the greater Fitchburg area and beyond. Several points should be considered for possible future action.

1) Recruitment/enrollment/alumni

The Dept. needs to work with the new Admissions staff to provide them with the background that they need to effectively advertise the program to prospective students. Among other things, this requires that FSU work to develop a stable admissions staff. Educating the Admissions staff to the specific programs available through the Biology and Chemistry Department, and the chemistry majors in particular, is a time-consuming task - on both ends - and cannot work if it has to be done again and again, year after year. It also requires the support of the Admissions directors to ensure that the staff

are willing to receive and employ the necessary information from the Chemistry faculty. In my own experience (not at FSU) this is very hit-or-miss and based on the Director recognizing the benefit of enhanced recruitment in a small program. Yes, the Chemistry program is small, but it could triple its number of majors (not course enrollments) without requiring additional faculty, a net revenue gain to the University. This must be coupled with efforts by the Marketing staff to develop - in close collaboration with the department - the necessary brochures/web pages/FAQ's … to assist Admissions in this effort. The University's/Dept.'s articulation agreements with Lake Erie College of Osteopathic Medicine and Husson College (Pharm. D. program) are two examples of information that must be made clear to prospective students (and their parents) early in the college search.

The B.S. in Chemistry with Biochemistry Concentration must also be promoted much more strongly. As indicated above, at most schools with both a Chem and a Biochem program, the biochemists outnumber the chemists heavily; at present, FSU has one student in the Biochem program. As also indicated above, this is in part due to the very unfortunate timing of the new program and the Covid pandemic. However, it also has to be very clearly marketed. Ideally, having a separate major in Biochemistry (with the current requirements) might be most effective, but getting a new major approved is a lengthy process and not likely to occur within the needed timeframe to have the most effect. As such, developing separate marketing materials and approach by Admissions to really emphasize the B.S. in chemistry with concentration in BIOCHEMISTRY is crucial. Many approaches are possible including the simple truth - it is more efficient to run one major with two tracks than to have two separate majors/faculty/… to assuage concerns that the biochemistry program is not a 'real' program simply because it doesn't have its own department or major.

Although a very small cadre at this point in time, it is very important to tap into your alumni. I realize that every University is aware of this, but many are unaware of a general observation that STEM alumni tend to be much more strongly tied to their home departments than to the University as a whole. Thus, they are more likely to provide time or funds to support those departments than they are a general fund. Recent alumni are not likely to be in a position to help financially, but bring back those working in the sciences to speak to current students (all four years) to talk about their experiences: what kinds of jobs are available, what things made them prepared for the jobs they have, what do upperclassmen need to do to secure jobs, … Students respond better to 'peers' (those who were sitting in the same desks they are currently) than generic 'career presentations.' Your alumni may also be able to help financially indirectly. Those working in industry may be aware of new instrument purchases by their companies. What's happening to the old instrument? Most instrument replacement programs in industry are on a much shorter time-frame than in academia and companies would rather donate the old instrument to a school (for the tax deduction) than to just scrap it. Faculty in the sciences, and in particular here chemistry because of the small numbers, are likely to know where their students went after graduation, what they are doing, … to be able to support these kinds of efforts.

2) Tutoring

The math problem is with us to stay until significant inroads into preparation before college, and a change in the public's attitude that 'it's ok to be bad a math' changes. Embedded tutors, those who are dedicated to a course and participate in the course, are much more effective in STEM fields than generic tutors. Prior performance in the course and a faculty recommendation should both be requirements in choosing tutors. The tutors should attend the class (so that the students know them and to provide a reminder in the case of faculty who want things done in a particular way), have time to

prepare appropriately and have set hours to work with students. No, it's not inexpensive (I estimate from discussions with the faculty that it would be about $6,000/yr/tutor ($20/hr, 14 weeks, 12 hours/week). Although this is not an insignificant amount of money, it is less that the tuition of one student and if it improves recruitment (through advertising the program) and retention (through increased student success), it will be very cost effective.

3) Research

It was very clear from my conversations with the students and faculty that research opportunities and participation need to be increased; students wanted it but were very mixed on its availability. It was interesting to see a very distinct dichotomy among the students between those who believed that information about research and research opportunities was presented and readily available, and those who thought it was a black box. From my observations, the difference was largely based on who was paying attention (possibly unfair, but I can't think of a simpler term). The students who felt they were well informed commented on bulletin boards around the department that highlighted programs (both on and off campus) and sessions where faculty gave short presentations on their areas of interest and invited students to speak with them if they wanted more details (I believe the students were referring to the "Science Symposium", but none of them used that term). Only upperclassmen commented on this. I understand that although this was common, it has not been done with the same regularity during Covid, but that the department intends to reinstate the program in the fall. Okay, we know who reads bulletin boards and there's nothing we can do about that. Getting back to the faculty presentations will be very important and they have to be well advertised. I could not tell from my conversations with the students, but my general impression is that the presentations were things that happened very early in their time at FSU (when they are still trying to figure out where the bathrooms are kept) and not emphasized later. Even if that's not correct, if that is the impression that students have then more needs to be done. Also, current transfer students (all in the Age of Covid) were basically unaware of most research opportunities. The Dept. may have had an introductory program for transfers pre-Covid and plans to get back to it as soon as it is practical, but if not, one should be developed. Students learn heaps about how things really work from upperclassmen, but you cannot rely on that form of communication.

Obviously, as with so many things, this will require time, money and space. Current research space is adequate for current student involvement but may need to be enlarged if there is a significant increase in participation. Money is necessary for materials, but more importantly for student support for summer research projects. Here is a place where alumni can be tapped by establishing an endowment fund, specifically to support student summer research in the Department. It will not grow quickly until there are more alumni, but if you can plant the seed, it will grow steadily.