

**Program Review of the Department of Chemistry
at
Weber State University**

by

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A. Review Activities

The authors of this report reviewed the Chemistry Department at the Weber State University (WSU) on March 22, 2013. During the on-site visit the external reviewers met with faculty and staff of the Chemistry Department, a group of eight students, the chair of Chemistry, and had briefing and debriefing interviews with the Chair of the Department and separately with the Dean of the College of Science. We toured the departmental facilities, including research labs, the stockroom, central stores, classrooms, and the teaching labs. At the end of the review day the team brainstormed a list of strengths and weaknesses that are listed in the Appendix.

Prior to the review, the department completed a self-study that was sent to the external reviewers to help them gain a sense of the major issues to be addressed in the review. The core self-study documents were concise helping the reviewers to gain a sense of places where the department particularly would value some input. Dr. Pugh had been a member of the most recent review team that visited the Department of Chemistry about five years ago.

We have framed most of the report based on issues that emerged from the self-study, that arose during our visit or were explicitly provided by the Dean of the College of Science.

B. Major Findings Regarding Questions Posed by the Dean

1. Curriculum: Is the curriculum appropriate compared to current national trends and ACS guidelines? Is the curriculum agile and able to change as workforce needs change.

Strengths: (a) The department's BS degree in chemistry is certified by the Committee on Professional Training (CPT) of the American Chemical Society (ACS). The ACS certification means that students who complete the degree have taken courses in the major areas of chemistry and also means that the faculty are qualified, the proportion of lecture and laboratory experience is appropriate, that library holdings meet at least minimum standards and that chemistry content meets guidelines. The value of ACS accreditation cannot be over-estimated as it is an assurance of quality to employers and to graduate schools. **We strongly recommend the BS curriculum undergo a significant revision in order that WSU maintain this accreditation by the ACS.**

(b) The two-year Chemical Technicians Program leads to an Associates degree in Applied Science or to a Certification of Skill Proficiency. This program produces technicians for chemical industry or provides students seeking the BS degree in chemistry with skills that help secure employment during the summer or the academic year.

Weaknesses: (a) Neither the overall structure of the curriculum nor the pedagogy employed to deliver the curriculum in lecture and laboratory courses is distinctive.

(b) The curriculum is prescriptive, very large, does not satisfy current guidelines by CPT of ACS, and appears to be focused on analytical at the expense of emerging areas of chemistry (e.g. biochemistry, environmental, or materials).

(c) The requirement of simply two semesters of undergraduate research does not provide students with a robust experience and is often too constrained to allow publishable research to be completed.

Opportunities: (a) The prospects of a new science building affords the opportunity to construct classrooms and laboratories conducive to numerous, modern pedagogical approaches (melding of lecture and laboratory, group-work to build team skills, research-based laboratory experiences, etc.).

(b) The curriculum must be revised to satisfy the new CPT-ACS guidelines and this could introduce modern pedagogical techniques into classes and laboratories and could lead to an effective undergraduate research program. In addition, if the curriculum is streamlined then faculty heavily involved in mentoring undergraduates in research may be able to have their teaching load reflect those obligations. This could lead to differential teaching loads that depend on specific faculty responsibilities.

Threats: Faculty respond to the reward system. Currently, the greatest financial reward is development of online courses at the expense of revising the curriculum, adopting and implementing modern pedagogical approaches in classes or laboratories, or engaging students in undergraduate research.

Recommendations:

(a) The ACS Certified degree option should be substantially revised to satisfy the CPT guidelines. For example, Principles of Chemistry (5 hrs) could be the Introductory Course (note that CPT specifies a single course) followed by five 4-credit hour Foundation Courses covering the five sub-disciplines (total of 20 hrs). These first six courses will take typically 3 years and several would be designated as 3000 level courses. If each course is 15 weeks in length and has a 3 contact hour laboratory then these laboratory courses together provide 225 laboratory contact hours of the required 400 hours. Finally, the equivalent of 12 credit hours of In-Depth Course work is to be required and this needs to provide an additional 175 contact hours of laboratory work. The In-Depth experience could be three 4-credit hour courses with associated laboratory(s). Or, a rigorous undergraduate research experience can satisfy up to one-third of the 12-credit hour requirement and can easily complete the required 400 laboratory hours. The TOTAL of required chemistry credit hours is $5 + 20 + 12 = 37$ hours. Together with 10 hrs. of physics and 8 hrs. of calculus the ACS approved chemistry degree must be at least 56 credit hours. The In-Depth courses can be packaged to provide students with several optional “degree tracks”. We strongly recommend that initially two degree tracks be offered, one in chemistry and one in biochemistry. The department might consider changing its name to the Department of Chemistry and Biochemistry as a recruitment tool and as a mark of distinction within Utah. Students would need to select sufficient number of 3000-level courses in other departments, and/or in chemistry to satisfy the requirement of 40 credit hours at the 3000 level.

If one curricular track is Biochemistry we suggest that the department market this program to students interested in the pre-health professions. Because the department

generally places a relatively small number of its chemistry graduates in medical or other health professional schools we believe this is an undervalued area with considerable growth potential. The department is encouraged to build up these very modest successes and expand its contribution to advising of students interested in health related careers. National statistics show that chemistry and biochemistry majors have a higher success rate (typically 45-50%) for admission to medical schools than majors in other science disciplines (typically biology, microbiology, etc. are 35-40%). Additionally, changes to the Medical School Admissions Test (MCAT) are increasing the emphasis on biochemistry starting in 2015. The presence of a BS biochemistry track with a Foundation of Biochemistry course will likely attract many students to the new major who would be new science majors not just shifted over from biology. We think the faculty should market the department as a great option for students interested in the pre-health professions. The department might want to develop a 4-year curricular plan for chemistry majors seeking admission to professional schools and place a poster in the hallway marketing this opportunity, celebrating successes of recent students, and citing the national data mentioned above. This poster should also mention that a chemistry or biochemistry major is a great backup option in case a student does not get admitted or chooses not to attend health professional school.

During restructuring of the curriculum the opportunity exists to modify the undergraduate research program to match the CPT language of a “vigorous research program” leading to “original research culminating in a comprehensive written report... that allows students to participate directly in the **process of science.**” More information about the process of science will be given in section 4 on pedagogy. The experience at most institutions is that two semesters of research is rarely a rigorous experience that is satisfying to both the student and the faculty mentor. However, we only recommend ramping up the research requirement if a method is designed to provide faculty with teaching load credit for mentoring research students. Finally, we note that a substantial research experience could become a “distinctive” for the department compared to other undergraduate chemistry programs in the local geographic area.

If the department is unable to design an effective undergraduate research program for WSU, or during the transition/implementation of a substantial undergraduate research program the chemistry faculty should assist interested students in securing REU or internships experiences at external sites.

2. Facilities: Are facilities adequate for current national trends? For preparing the chemists and chemical technicians of tomorrow? For engaging students in undergraduate research? For engaging faculty in research? For attracting new faculty?”

Strengths:

- (a) Chromatography Instrumentation in Dr. Walker’s lab and the 90 MHz FT-NMR in teaching space with a large screen display suitable for instructing groups of students.
- (b) The Chemical Technology Center.
- (c) Centralized stockroom for multiple STEM departments.

Weakness:

- (a) Fragile and old facility to support current research programs.
- (b) Outdated and unmaintained instrumentation (chromatography, spectroscopy, etc.) for supporting undergraduate teaching and research. While the amount of instrumentations appears to be significant, the fact that most of the instrumentation is donated and not purchased new, requires a significant amount of up keep for it to be useful. This continual maintenance results in additional (unaccounted) workload for faculty.
- (c) Graduates who enter industry encounter modern instrumentation that is foreign to them because instruments in many of the instructional laboratories are several generations out-of-date.

Opportunities:

- (a) The likelihood of a new science facility.
- (b) Creation of a central instrumentation facility in the new structure and dedicated laboratories for research.
- (c) Creation of student and faculty meeting areas, conference and meet and greet areas in a conducive interactive environment.
- (d) The philosophy of a common stockroom for all STEM departments should be applied to the hiring of a common instrument/equipment maintenance person for the STEM departments.

Threats:

- (a) Aging faculty that has a comfort zone and may be unwilling to adapt and to initiate change.
- (b) Aging instrumentation and technical tools of communication.

Recommendations: (a) The facility and instrumentation should be upgraded and faculty need to have input during the design process of the new building. The classrooms and laboratories need to incorporate as much flexibility as possible to allow for use of modern teaching methods as well as pedagogical approaches not yet envisioned.

(b) In the longer term, the faculty as a group should put together a 3- to 5-year strategic plan for key tactics that would result in a well-defined undergraduate research program, including workload issues that would benefit from the newly constructed science building.

3. Faculty: Is there an appropriate breadth and depth among the faculty specialties? How could this be improved given where we are and who we are?

Strengths: (a) Faculty and Staff: Every student that was interviewed commented that members of the faculty and staff in the chemistry department at WSU were friendly, helpful,

and approachable. Students appreciated the fact that members of the faculty and staff were always available and helpful in answering student questions. Almost all of the students interviewed felt that there was a family atmosphere within the chemistry department.

(b) All full-time faculty members of the chemistry department held Ph.D. degrees and all five major specialty areas of chemistry (organic, inorganic, analytical, biochemistry and physical chemistry) were represented.

Weaknesses: (a) Faculty Load: The loss of a full-time faculty position along with the increase in student credit hours (SCH) has increased the loads that faculty teach. During the review many of the faculty disclosed that they teach 15 to 16 contact hours per week which is 3 to 4 hours over the recommended 12 contact hours per week (set by ACS-CPT certification). In addition to the heavy teaching loads some faculty are carrying additional loads teaching on-line chemistry courses. The additional loads that faculty carry to cover courses decrease the amount of time faculty spend to develop curriculum and undergraduate research programs that provide students opportunities to perform undergraduate research.

(b) Courses Faculty Teach: During the review process two faculty members of the chemistry department mentioned that they desired to teach courses within their field of expertise but they were not given the opportunity. One faculty was hired under a job description that did not include courses within their field of expertise. The other faculty member was not allowed to teach a course in his/her field of expertise because another faculty member with more seniority “owned” that course and would not allow any other faculty to teach that course. This limits members of the faculty the ability to stay current and excited in their field of expertise and thus weakens the department in both their educational goals and ability to maintain an undergraduate research program.

(c) Grant Proposals by Faculty for External Funding: The faculty do not have a track record of success with traditional funding agencies (NSF, NIH, PRF, RC, etc.) that could provide instrumentation and/or support for faculty and undergraduates engaged in research projects.

Opportunities: (a) ACS-CPT Certification: With the change in the ACS-CPT certification the members of the chemistry faculty at Weber State University have the opportunity to change their curriculum in the classes and laboratories and to incorporate research methodologies into their traditional labs (from general chemistry to the advanced labs).

(b) New Faculty and New Facilities: With the proposal for a new chemistry building and new hires the chemistry department has the opportunity to design a new building and recruit new faculty that will build upon the undergraduate chemistry education and research program at Weber State University.

Threats: (a) Overload and Online Financial Incentives: Many members of the chemistry faculty at Weber State University carry overload and online courses to supplement their income. This creates a conflict for faculty to teach courses for additional pay or perform

undergraduate research for less compensation. This conflict will ultimately be the demise of establishing an undergraduate research program.

(b) New Hires Teaching Courses in Area of Expertise: New faculty hired at Weber State University should be allowed to teach courses in their areas of expertise. This allows the faculty to stay current in their fields and promotes opportunities for faculty to establish undergraduate research programs. The strength of the chemistry degree offered at Weber State University is dependent upon the faculty and their ability to stay current in their field of expertise.

Recommendations: (a) Short Term: At least one and possibly two new faculty hires are needed to meet the demands of the teaching loads in the chemistry department at WSU. One new hire should be in the field of analytical, biochemistry or bio-analytical chemistry and the other hire could be a term appointment: either a laboratory instructor or a teaching postdoc to decrease the contact hours for the full-time faculty. This will allow the department chair of chemistry to grant leaves for the full-time faculty to develop/revise curriculum required by ACS-CPT certification, author grant proposals, or use a sabbatical to update research skills. This will also decrease the teaching load for the chemistry faculty so they will have the time to develop research projects to improve their undergraduate research program. We believe that leaves or sabbaticals should only be awarded if the activity is directly related to research with undergraduates. In the future this position could be converted to tenure-track with expertise in Chemical Education Research or another area of need.

(b) Short Term: A university or college policy should be implemented that allows any faculty teaching at Weber State University the ability to teach courses in their field of expertise. With a policy in place the department chair can easily generate a rotation where any faculty qualified to teach a course will have that opportunity to do so if they desire.

(c) Long Term: To attract qualified new faculty to WSU the amount of start-up funding should be increased to compete with other comparative undergraduate universities.

4. Pedagogy: Are pedagogical methods appropriate?

Strengths:

(a) Faculty very student centered – Most seem to have an open door policy towards helping students, they are dedicated and passionate about teaching their courses. They are family friendly creating a “home” atmosphere for those who work and learn in this environment

(b) Recent growth and diversity of students in the major.

(c) Some faculty are using active, guided inquiry, student centered pedagogical approaches in their classes

Weakness:

- (a) Current facility does not support collaborative/team building learning environment for students because the laboratories tend to have long benches rather than tables that are more conducive for group interactions.
- (b) Heavy overload teaching schedules, little Undergraduate Research (UGR) load credit, and lack of available funding for summer UGR.
- (c) Lack of funding in the Chemistry budget to hire adjuncts that could teach additional sections when there is a need for additional adjuncts.
- (d) The pervasiveness of heavily overload teaching schedules has led to the perception that faculty are unable to take sabbaticals, or course release time to increase research productivity, or consider curriculum changes that would benefit the program

Opportunities:

- (a) Increase visibility/activity of student ACS club (create community for students)
- (b) Increase availability/opportunities to secure external research/sponsorship dollars for funding undergraduate research.
- (c) Create research and innovation award system for students and faculty to encourage and reward the behavior.
- (d) Hire temporary/contract based teaching post-docs or faculty “instructors” so that tenure-track faculty can have some time to effectively mentor undergraduate research (program requirement) during the school year.
- (e) Incorporate research methodologies as part of curriculum in traditional labs.
- (f) Provide more direction and mentorship of student presentation and publication of their data and conclusions from undergraduate research experiences.
- (g) Encourage intellectual collaboration with other departments at Weber state, at other Universities and with industry. This may increase research funding and collaborations fostering more research productivity for faculty and students.

Threats:

- (a) Lack of incentives to faculty to promote undergraduate research and curriculum changes.

Recommendations: (a) **Create an environment that encourages the implementation of active, collaborative, student-centered teaching methods.** In order for faculty to explore the use of a variety of effective pedagogical methods in their courses, they must have time to

research and plan how to implement these approaches. Faculty should pursue ongoing professional development opportunities to support a successful chemistry program that is modern, relevant and provides a transformative learning experience for students. This should be validated through the tenure and promotion process as part of faculty workload.

(b) **Provide a meaningful research experience for undergraduates.** A more structured plan for mentoring and assessing student research required for chemistry majors needs to be developed and implemented. Faculty should be sufficiently compensated for the associated workload responsibilities to train, direct and supervise research students. A more concerted effort to incorporate opportunities for research experience throughout the undergraduate curriculum should be examined. Competitive startup funds should be offered to new faculty hires and increase support of faculty willing to offer summer research experiences.

(c) **Diversify faculty workload responsibilities.** In view of the current department makeup with faculty in a variety of different stages in their careers, a more holistic approach to faculty work as a department should be thoughtfully considered. Teaching assignments should be driven by faculty strengths and program goals (articulated by individual faculty and the department as a whole) rather than seniority and overload compensation rates.

SUMMARY RECOMMENDATIONS. We will end with a summary of our most critical recommendations. Engaging key faculty in development and implementation of a 3- to 5-year strategic plan may be a first step to addressing these recommendations.

1. Major revision of the curriculum as outlined by the CPT guidelines for the ACS certified degree(s) incorporating modern pedagogical methods (student-centered learning) in the newly designed courses. The addition of a biochemistry track should be considered.
2. Two new faculty hires are needed to teach the curriculum and to allow time for other faculty to develop curriculum, to take sabbaticals related to upgrading research skills, and to develop undergraduate research programs. One faculty hire should be tenure-track in biochemistry, bio-analytical or closely related field and the second position should initially be a term appointment with broad capabilities. Faculty should consider submitting ROA (Research Opportunity Awards) research proposals to NSF to aid in recapturing/upgrading research skills.
3. A major change is needed in policies concerning overload, online course and undergraduate research load/support to reshape the faculty incentive program.
4. A new building and upgrade of instrumentation holding along with a new hire for instrument maintenance for all STEM departments is needed.
5. Start-up funds for new hires and work-load compensation for engaging undergraduates in research needs to be competitive with other undergraduate universities to attract qualified applicants in the new hire process and reward those faculty who are accomplishing undergraduate research.

APPENDIX:
SWOT Analysis on Weber State University- Chemistry Department:

Strengths:

- (a) Faculty very student centered – Most seem to have an open door policy towards helping students, they are dedicated and passionate about teaching their courses. They are family friendly creating a “home” atmosphere for those who work & learn in this environment
- (b) Recent growth and diversity of students in the major
- (c) 2 Yr. Associates degree in Chemical Technology – augments the “community college” mission of Weber State
- (d) Very attractive to local students due to lower tuition and commuter friendly campus

Weakness:

- (d) Facility does not support collaborative work environment for students. It is not welcoming to visitors. It is not a building that would attract outsiders.
- (e) Outdated and unmaintained analytical instrumentation (chromatography, spectroscopy) for supporting undergraduate teaching and research. While the amount of instrumentations appears to be significant, the fact that most of the instrumentation is donated and not purchased new, requires a significant amount of up keep for it to be useful. This continual maintenance results in additional (unaccounted) workload for faculty.
- (f) Overall, there appears to be nothing distinctive about the chemistry program in general that would attract majors. It seems that many chemistry majors are converted from other areas due to the strength of their interactions with chemistry faculty.
- (g) No formal plan to maintain long-term contact with chemistry majors to determine their career path (job, graduate school, professional school...). However, graduating seniors are interviewed to collect this information at the point of graduation for Weber State University.
- (h) Lack of communication/awareness of internship opportunities
- (i) Faculty teaching assignments seem to be driven by desires of the senior faculty. There is no formal rotation process for all faculty to teach courses they may desire that align with their area of expertise.
- (j) Twelve hour teaching load requirement is very disproportionate to the number of actual contact hours for faculty. 1.5 hours for a 3 hour lab or 2 hours to supervise twice as many students in lab is an extremely heavy burden in a heavily laboratory

based curriculum such as chemistry. In particular, some faculty (Jr. faculty) may teach more lab than lecture sections which exacerbates the problem.

- (k) Heavy overload teaching schedules, little UGR load credit, lack of available funding for summer UGR, inhibit the supervision of undergraduate research.
- (l) Lack of funding in Chemistry budget to hire adjuncts to teach additional sections due to increased enrollment needs leads to overloaded teaching schedules
- (m) The pervasiveness of overloaded teaching schedules/and limited faculty in certain disciplines to cover upper division courses has resulted in the perception that faculty can't afford to take sabbaticals or course release time to increase research productivity and/or consider curriculum changes that would benefit the program

Opportunities:

- (e) Improvement of facility based on new renovation / construction plan.
- (f) Upgrade of existing analytical instrumentation with a maintenance plan.
- (g) Creation of a central instrumentation facility in the new structure for the whole faculty (involves interaction of students within science faculty).
- (h) Creation of student and faculty meeting areas, conference and meet and greet areas in a conducive interactive environment,
- (i) Revision of the ACS-CPT curriculum
- (j) Increase visibility/activity of student ACS club (create community for students)
- (k) Enable availability of external research / sponsorship dollars for funding undergraduate research.
- (l) Awareness of availability of undergraduate internship programs.
- (m) Hire temporary/contract based teaching post-docs or faculty "instructors" so that tenure-track faculty can have some time to effectively mentor undergraduate research (program requirement) during the school year
- (n) Create creativity and research award system for students and faculty to encourage and reward the behavior.
- (o) Incorporate research methodologies as part of curriculum in traditional labs.
- (p) Enable presentation and publication of the data and conclusions from undergraduate research.
- (q) Encourage intellectual collaboration between the Chemistry Department at WSU with external departments at WSU and other universities and industry. This may help to bring in research dollars and collaborative research opportunities for faculty and students.

Threats:

- (c) Aging faculty that has a comfort zone and challenges to adapt and influence change
- (d) Aging instrumentation and technical tools of communication
- (e) Financial incentives that encourage online teaching leading to work overload
- (f) New hires need to be allowed to teach in the area of expertise
- (g) Startup for new hires
- (h) Lack of incentives for faculty to promote undergraduate research

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