2008-2009 Yearly Program Assessment report for
the Department of Chemistry Undergraduate Program.

I. Program's Mission: To be known as one of the top programs in the nation by integrating teaching with research experience. This vision statement was created in August 2009 at a departmental strategic planning retreat.

The university mission statement says a university goal is delivering "high quality undergraduate … education appropriate for the state and the region." It also states that university goals include: "enhanc[ing] the quality of health care in the region" and "promot[ing] economic development through research, collaboration, and technological innovations." Our program seeks to provide a high quality education for both our major and non-major students. This is our singular goal as educators. With the high concentration of chemical industry and health care delivers in the local area, achieving our vision would make our graduates more attractive to graduate and professional schools, which will directly and indirectly contribute to the university mission.

II. Program's Student Learning Outcomes

A. Learning Outcomes/Data Collection.

Students will

i) possess core foundational information (knowledge) in the discipline;
ii) be able to perform laboratory tasks competently;
iii) be able to apply information (knowledge) in problem solving.

In chemistry, research represents the most common application of problem solving and the best application of laboratory skills.

III. Assessment Activities

The Department has historically used four tools to assess its programs, see A - D below. However, if the need arises for us to take a more detailed look at specific issues related to the performance of the Department, a detailed study of the problem is undertaken and the results are presented to the faculty. Such a study appears as point E. In this reporting period we underwent an external review, and those results along with our response to them will be detailed in the next year's report.

A. *Final Exams in Principles of Chemistry I*

The Department of Chemistry is committed to improve student success in our courses. Because our largest attrition rates occur within the first courses students take in chemistry, we are tabulating final exam scores in Chemistry 211 and 212. While not a true standardized exam, the final in these courses is departmental and undergoes relatively few changes over the years. We believe its addition will aid the Department in monitoring student progress through the curricula.

We are including data from the CHM 211 final exams for the past 5 years. Complete final exam data from Fall 2004 to present are presented in Table 1.

Table 1 CHM 211 Final Exam Scores

Score	Fall 2004	Fall 2005	Fall 2006	Fall 2007	Fall 2008
90%+	3.4*	4.4	4.5	7.3	3.0
80	6.8	20.8	18.3	19.9	9.0
70	14.4	27.8	22.8	25.3	15.7
60	31.3	19.0	20.3	20.3	19.8
0- 59	44.1	30.8	37.1	27.2	52.6
N	236	321	197	246	268
Mean	60	70	65	68	57

*Percentage of students in this range.

The final exam averages were fairly constant through the previous 4 years, the first 3 of which used the same final exam. It is possible that the 2008 dip arose because it was a new final exam. There was also a sizable increase in the number of students taking the final exam. It is possible that if the additional students collectively did poorly, it could have a negative impact on the collective success of the students. Despite this, we believe that student success can be improved over past rates. Possible methods of improving student success, including a new CHM 111 course (see Part III.E.) and the use of required on-line homework.

B. *Standardized American Chemical Society (ACS) Exam in Organic Chemistry*.
The Department of Chemistry uses this mathematically objective method of evaluating the progress of its students as they matriculate through our program. At the end of their second semester of organic chemistry (typically the Spring semester of the sophomore year) a national exam written by the ACS is given. We plan to use this tool in conjunction with the Principles of Chemistry I Scores (Section A, above) to further investigate and improve retention through this critical portion of our curricula.

Of the 134 students taking the final exam in CHM 356 during the 2008-2009 academic year, 42% made above the 50^{th} percentile, 6% were above the 90^{th} percentile, and 14% above the 75^{th} percentile (Table 2). The trend at the 50^{th} percentile, 42%, is not radically different than what we generally what we have been seeing over 8 years (Table 3). The upward trend of the last few years appears to be waning.

Table 2. ACS National Exam Scores

Year	# Students	50^{th}ile	75%ile	90%ile
2006-7	106	59	14	6
2007-8	115	51	19	9
2008-9	134	58	14	6

Table3. Historical pattern of the 50%ile

Year	Number of Students	50%ile
2001-2	107	43
2002-3	131	34
2003-4	116	39
2004-5	120	45
2005-6	151	53
2006-7	106	59
2007-8	115	51
2008-9	134	58
AVG	N=980	48

C. *Placement of our Graduates*.

We find no other tool as useful in our assessment of the Department as tracking our students in the first 12 months following their graduation. It is difficult to identify the first employment or professional school of every graduating senior once they leave campus, but we generally are able to track 80-90% of them. Table 4 summarizes the results for the previous academic year. The total number of graduates for the year was 36. This number is higher than the average number of graduates over the last 5 years (24). Two years ago we also experienced an apparent growth in the number of majors at 33. At the time we attributed this to the introduction of majors in forensic chemistry and biochemistry. Yet, last year the number of graduates fell to close to our 5 year average, with 22 graduates. This period we have again increased to 36.

Over the last decade or so, we have been able to track about 80% of our graduates, for example last year was typical and we tracked 84%. This year we were only able to track 42% of our graduates. While this is only one year, it is disturbing to us that such a large number of students simply disappear upon graduation. A significant percentage of these are students perform their Capstone experiences out of the Department (e.g. internships, and under the supervision of MUSOM faculty), and they only appear to give their presentation to the Department. Should this trend continue, the Department may have to re-evaluate the how these Capstones are conducted. We were able to track fewer graduates than normal in this reporting period (42%), possibly because economic conditions caused unemployed graduates and those without post-graduate educational placements not to report their current situation.

Table 4	Number of students	Percent of students
Seniors Graduating in 2008-2009	36	100%
Admitted to Ph. D. programs	0	
Admitted to pharmacy, medical, veterinary or law school	7	19%
Admitted to Master's in Forensics	1	3%
Admitted to Other Master's programs	1	3%
Admitted to the Department Chemistry's Master's program	2	6%
Additional Education	2	6%
Industrial employment	2	6%
Attempting Admission to Medical School	0	
High School Teaching	0	
Unknown	21	58%

D. *Student research productivity*. The fourth measure of our success lies in the number of students whose research (e.g. Capstone) is presented to the chemical community. In chemistry, the following methods are standard for dissemination of research: (i) having a research paper published in a peer reviewed national or international journal (ii) presenting a paper at a national meeting of the American Chemical Society or (iii) presenting a paper at a regional or local meeting of the ACS. Because of the natural time lag associated with the publication of research in journals, students from earlier years will be carried over into this year and those from this year will appear in later years.

Table 5.	Number of students
Student co-authors in journal papers	0
Student presenters at national meetings	3
Student presenters at regional meetings	0
Students presenters at local or state meetings	7
Students co-authoring posters/papers at national meeting (not presenting)	3

Note: It is difficult to comply with Board of Trustee Initiative 3 because there is no national standard measure available for students graduating with an undergraduate degree in chemistry. The only quantitative data available is the GPA of the graduate. This value can be normalized using a student's composite ACT score when they enter our program.

The Department believes student presentations and publications to be an important measure of its success. The University requires a Capstone experience from all graduating seniors. It would be easy to develop "busy work" projects for them, however we believe that participating in faculty directed research provides significant benefits to both students and their mentors. Thus, the number of presentations and publications are a measure of the quality of both a student's achievement and the quality of the research in the Department. Furthermore, peer pressure ensures that research which is presented at a meeting of faculty peers be novel and of high quality. The results of the period are presented in Table 5. We are proud to have 10 undergraduate names appearing on technical presentations this year, which is up from 7 last year. When presenting at these, students meet professionals from all over the country, and it also hones their ability to answer technical questions concerning their work, which is an extremely valuable skill when interviewing for employment. Unfortunately no student names appeared on scientific publications during the period.

E. *Results from Tracking the High School Grades of CHM 211 Students*.
The high school chemistry, math, and physics grades of all students who took CHM 211 in the Fall 2005 and Spring 2006 semesters were recorded and investigated to determine if those grades could be used to predict student success. A full report on the results appears in the accompanying file. In short, a series of 6 risk factors are shown as highly predictive of student success or failure. As a result the Department has created a new course CHM 111 that is designed for at-risk students. It currently awaits university curriculum committee approval and two sections will be offered in the Fall 2010 semester. It is briefly described in the attachment under Proposed Curriculum Changes #2.

IV. Overview of changes implemented in your program this past year based on results and planned action specified in last year's report.

We obtained the services of a graduate student from international studies to tabulate the high school grades described in the attachment and Section III.E of this report. We instituted mandatory online homework in the fall 2009 Semester to improve student learning.

V. Specify any changes/modifications made to your program based specifically on data obtained during Assessment Day Activities.

None. The Department of Chemistry does not regard assessment as a one-day-a-year activity. Rather, it gathers data year round and processes it in real time. Major assessments of our courses and programs typically occur over the summer and are presented to the faculty early in the fall semester because to wait until April to consider program changes would delay program improvements for a year. Other assessments, such as graduation and test scores occur at the beginning of the semester following the generation of the data. Thus, changes to our program occur year round on an "as needed" basis.

VI. Assistance Needed with Assessment

None. We need assistance to implement the new policies, courses, and majors arising from assessment.

2009 Assessment of CHM 211

Over the past 4 years, the Department has examined the success of students attempting CHM 211. Our first two studies, compared pass rates as a function of ACT math and English scores. The efficacy of MTH 127 as a remediation tool was also reported. While a strong correlation between pass rates and ACT scores exists and while 127 remediation of students with very low ACT math scores appears to be somewhat successful, the pass rate in CHM 211 is 56% and this raises the question of whether or not it is possible to improve student success in this course without compromising academic standards.

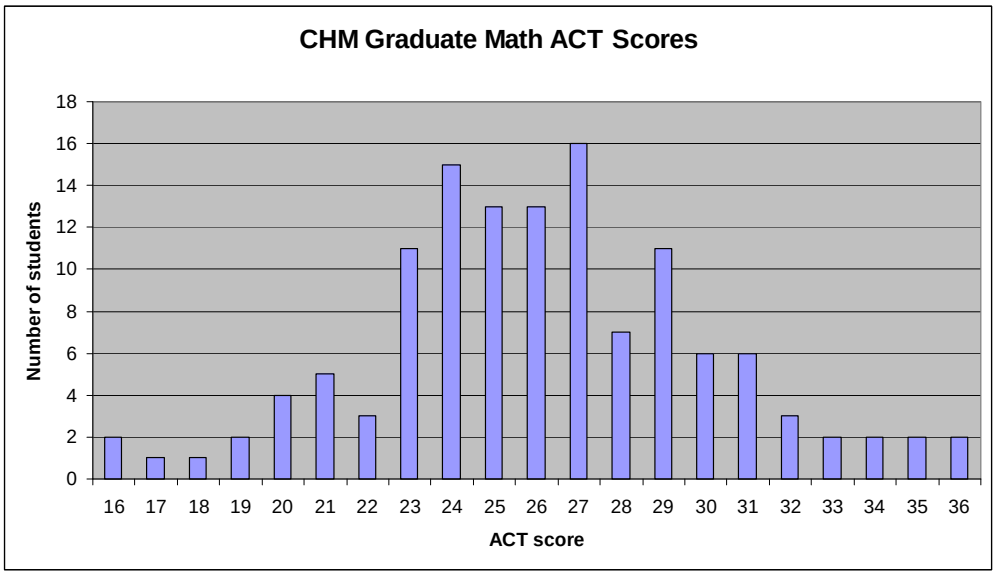
In the fall and spring semesters of 2005-6, 56% of the 508 students enrolled in CHM 211 passed with an "A," "B," or "C" grade. In 2008-9, 56% of the 540 students enrolled in CHM 211 also passed. This pass rate suggests that the entrance requirements to CHM 211: minimum math ACT of 21 or "C" or better in MTH 127, could be improved upon. Towards that end, the Department of Chemistry is reexamining the entry requirements for CHM 211.

In conversations with the College of Science office, it was suggested that students with ACT math scores of 21 and 22 might not be ready to start immediately in CHM 211 and a delay or additional math might improve their chances of success in CHM 211. This lead to a 3 part study that follows. In it, we asked four questions:

1) would raising the ACT math minimum reduced the number of chemistry graduates significantly,
2) was their evidence that having students delay or take additional math would improve their chances of success,
3) were there other, better predictors of failure than ACT math scores, and
4) once low pass rate students ("at-risk") were identified, how will the Department alter its curriculum to improve student success.

<u>Math ACT of Chemistry Graduates</u>

We begin by examining the ACT math scores for all Chemistry graduates for the 5 year period August 2004 – May 2009. During this time there were 134 chemistry graduates (almost 27 per annum). The large majority of our graduates have math ACT scores between 23 and 31 with an average score of 26.0 (26.8 excluding those with remedial coursework). A graph of all students vs. math ACT scores appears below.



A few features from these data warrant comment.

1) The substantial majority of our graduates (86%) entered Marshall with minimum math ACT scores of 23 or CHM 211 transfer credit.
2) A surprisingly large percentage (9%) of our graduates had math ACT scores below 21. All of these students either transferred in their freshman chemistry courses or began taking chemistry late (Spring of their freshman year or later).
3) Eight students (6%) had either ACT scores of 21 or 22, of whom 6 took CHM 211 in their first semester in college. Five of the six students passed. This group required an average of 5.4 years to complete their degrees and had a average cumulative GPA of 2.96. (By comparison, the group with an ACT of 23 or higher had an average GPA of 3.47.)
4) Relatively few transfer students successfully complete a chemistry degree, but those that do have done quite well and are likely to pursue chemistry as a career.

The data suggest that raising the minimum math ACT score for CHM 211 to 23 would have little impact on the number of Chemistry graduates. The numbers of students above 23 would be unaffected. It seems unlikely that the number below 21 would be either as the courses they take will not substantially change. The small number of students with ACT math scores of 21and 22, coupled to the likelihood that some would take remedial work suggests there would a minimal impact on the number of chemistry graduates. In contrast, roughly 15% of all students enrolled in CHM 211 have ACT math scores of 21 or 22. Thus, any change in requirements could have a substantial impact on enrollment and would have a disproportionate impact on non-chemistry majors.

Efficacy of MTH 127 Remediation

The next question is how much raising the ACT math requirement would increase pass rates in CHM 211. Some increase would result from students either choosing not to take chemistry because of the added prerequisite coursework or by not passing it. A more difficult question to answer is the increase that would come from students successfully completing additional coursework.

We begin by looking at the effect MTH 127 and 130 have on CHM 211 pass rates. In the 2005-6 year, we found that students who evaded the math prerequisite passed at a 5% rate versus 31% for those who took MTH 127/130 and made a passing grade. The magnitude of this increase suggests that MTH is having a real, positive effect rather than simply filtering out students incapable of passing it. Still, a 30% pass rate is quite poor and so it may be valuable to provide additional training to these students to improve pass rates (see section 4).

For 2008-9, students entering with ACT math scores of 21 and 22 passed CHM 211 on their first attempt at a 43% rate (33 of 80). The 39 passing students took four pathways into CHM 211. These are shown in the following table.

	ACT 21	ACT 22	% Pass
First semester freshman	6	12	50.0
Freshman with additional math	3	0	33.3
Second year or higher	3	6	44.4
Second year or higher with additional math	5	4	37.5

Two notable features of this data are:

1) Students moving directly into CHM 211 in their first semester have the highest pass rate of all groups. This is lower than the overall pass rate, but reasonable in light of the relationship between pass rate and ACT math scores reported for 2005-6 students.
2) Notably, the two best performing groups have not taken additional math on arrival at Marshall. An examination of the 2005-6 students showed a similar relationship. In that year, first-time students 53% passed without additional math, while only 44% passed after taking MTH 127 or 130.

These points are counterintuitive. That additional math preparation appears to harm students directly contradicts the correlation of pass rates to math ACT scores reported earlier. Sample size could play a role, but it appears unlikely that this alone accounts for the observed student performance. It seems likely that the effect seen here is a self-selection phenomenon. Students who believe their chemistry skills are good enroll immediately and are more successful than those less confident and, as a result, delay entry into chemistry. The additional math might be helping them, but in light of their ACT math scores we cannot know this.

In summary, while the sample sizes are reasonably small, the previous student performance does not support raising the minimum ACT math score to 23 as an effective method of improving pass rates in CHM 211.

Analysis of 211 Pass Rates as a Function of High School Grades

A graduate student went through the high school transcripts of all students enrolled in CHM 211 in the fall 2005 and spring 2006 semesters. She was able to retrieve grades from 339 of 477 students. Presumably many of the missing students were either transfer or returning students. We expect that there were also records that were missed or in other locations.

Grade data were collected on chemistry, physics, and mathematics courses. Notably, chemistry 1, chemistry 2 (we assume AP chemistry), physics 1, and all listed mathematics courses, although only algebra 1, algebra 2, geometry, trigonometry, pre-calculus, and calculus were numerically keyed into our spreadsheet. Grades were A = 4, B = 3, C = 2, D = 1, and F = 0 and where 2 grades were recorded (we assume for 2 semesters), the scores were averaged. Student high schools, state residence, and county (for WV) were also recorded.

Unfortunately, the university does not digitally record high school grade information for students and so the following analysis cannot be used to generate formal prerequisites within Banner. The goal of this analysis is to provide students, student advisors, and associate deans a set of metrics by which they can advise students and to provide students with information with which they can make informed decisions. We will also provide advice to students who wish to pursue CHM 211.

HS Chemistry 1 Analysis

	Pass	Fail	%pass
4.00	116	25	82%
3.00-3.99	51	34	60%
2.00-2.99	**15**	**28**	**35%**
< 2.00	**0**	**10**	**0%**
None	**19**	**33**	**37%**

Number of "C"s in HS Math & Chemistry

	Pass	Fail	%Pass
0	156	48	76%
1	26	30	46%
2	13	27	33%
2 or more	**22**	**57**	**28%**
3 or more	9	30	23%

HS Chemistry 2 Analysis

	Pass	Fail	%pass
4.00	46	5	90%
3.00-3.99	24	6	80%
2.00-2.99	**2**	**12**	**14%**
< 2.00	**0**	**3**	**0%**
None	114	77	60%

Average of Pre-calculus and Calculus

	Pass	Fail	%pass
4.00	72	15	83%
3.00-3.99	48	23	68%
2.00-2.99	10	12	45%
< 2.00	**2**	**10**	**17%**

Average of Algebra I and Algebra II

	Pass	Fail	%pass
3.00 - 4.00	178	78	70%
2.51 - 2.99	3	4	43%
2.5	9	24	27%
2.00 - 2.49	7	21	25%
< 2.00	3	10	23%

composite < 2.51	**26%**

Highlighted in blue are what we deem "risk factors." These are quantifiable measures that are predictive of failure. In addition to the factors listed in the tables on the previous page, ACT math scores below 21 have also been shown to be predictive of student failure and were used in a cross-correlation examination of these risk factors. Not surprisingly, the more risk factors a student has in his/her background, the less likely s/he is to pass CHM 211. One confound to this data is that we look only at students

The effect of these risk factors on student performance cannot be overemphasized as is illustrated in the following table. The data are for students attempting CHM 211 for the first time.

CHM 211 first attempt pass rate as a function of risk factors

	Pass	Fail	%Pass
0	131	7	95%
1	30	47	39%
2	13	25	34%
3 or more	8	34	19%
Overall	182	113	62%

Overall, students having a single risk factor pass CHM 211 at a 39% rate (30 of 77). Those with 2 risk factors pass at a similar 34% rate (13 of 25), while those with three or more pass at an 18% rate (8 of 42). Of the 8, two had a significant protective factor (ACT math 24 and passed CHM 203). Only 2 listed a College of Science major (both BSC, one of who took CHM 203).

Possible Curriculum Changes

Conversations with faculty both within Chemistry, Biological Sciences, IST, and the Dean's office generated several suggestions on how to address the results of this study. They are listed below with advantages and disadvantages and cost of implementation included. A problem we face is that high school grades are not keyed into Banner. As a result all possible solutions can only be recommendations to students, rather than requirements, except where ACT scores fall below 21.

1) *CHM 203 in addition to MTH 127*.
    a. *Pros*: It is the simplest change to implement. One to three additional sections of CHM 203 would meet the demand. Only adding CHM 203 as a pre-requisite for students with low math ACTs scores is needed.
    b. Cons: CHM 203 is not designed for this purpose and contains significant amounts of material from CHM 212. Students in 203 are currently homogeneous in their goals. Adding 211 aspirants would lead to a new tension in the class and would make teaching the course more difficult.
    c. *Cost*: 6-9 additional contact hours annually.
2) *Create a preparatory CHM 1xx course*.
    a. *Pros*: It is relatively easy to implement. As opposed to option 1 the course is targeted to at-risk students. Can be added as a pre-requisite to low ACT score students. Fewer at-risk students in 211 might allow some additional instruction for better prepared students. Few sections needed if students are taught in bulk.
    b. Cons: If CHM 254 provides a historical model, this course will be very underpopulated. Convincing at risk students with ACT scores above 20 to will be very challenging. Large number of smaller sections (25 or fewer students) if significant student-instructor contact is required.
    c. *Cost*: 6-15 additional contact hours annually.
3) *Change CHM 211 to a regular 4 contact hour course*.
    a. Pros: This would provide additional class time on each topic. This could benefit at-risk students disproportionally. Minimal changes in instructor preparation, just more time on topic and working problems.
    b. Cons: There is no reason to believe that our spending more time lecturing and working examples would lead to improved student performance. Students with no risk factors would be required to take this course with no substantial benefit to them.
    c. *Cost*: 6-9 additional contact hours annually.
4) *Change CHM 211 to a 4 contact hour course including 1 hour of recitation*.
    a. *Pros*: The recitation sections would involve going over homework problems with students. For students who are trying the homework, this could be a substantial benefit if homework was required. If not, the benefit would be greatly reduced. Minimal changes in instructor preparation.
    b. Cons: It would provide limited benefit for students with no risk factors.
    c. Cost: 20 – 35 additional contact hours annually. (20 student cap = 30 – 35 contacts hours, 25 student cap = 25 – 30 contact hours, 30 student cap = 20 – 25 contact hours) This option would almost certainly require the addition of 2 graduate lines to the Department.

5) *Create a 4 hour CHM 210 for most students, leaving CHM 211 for students with no risk factors*.
    a. Pros: Assuming 210 was designed as in points 3 and 4 above, it would carry with it the same pros and cons for at-risk students. Classes would be more homogeneous allowing better (more targeted) content delivery. Students with no risk factors could spend less time on familiar material, while weaker students could spend more time mastering the basics. Reduced number of additional contact hours required of the Department.
    b. Cons: A new course and a new preparation for whoever teaches it. Also, the vast majority of "A"s comes from the group with no risk factors. Thus the 210 course would have comparatively low grades if it were viewed as running parallel to the 211 class. This will hurt the reputation of the class making it more difficult to persuade students to take it. The current CHM 211 would become a de facto honors course.
    c. Cost: Same as 4, but saving about 2 contact hours annually.
6) *Create a 4 or 5 hour CHM 220 course to replace CHM 211 and 212.*
    a. Pros: Zero risk factor students would complete general chemistry in a single semester. Coupled to a change in 211 as proposed earlier, this would provide an incentive to good students to opt into the course because it would finish general chemistry a semester earlier.
    b. Cons: The course would presume competence in the basics of chemistry, which is likely inaccurate for some of the students who would qualify. The new course could be an honors course.
    c. Costs: Depends on what is done in the remaining sections. This could save one contact hour from that increase.

In the event that no method can be imposed as a prerequisite, we recommend that the dean's office provide incoming students with the following questionnaire and follow-up advice.

Introductory Chemistry Questionnaire

1) Is your math ACT score 20 or lower?
2) Did you make a "C" or lower in 2 or more of the following courses in high school? Chemistry 1, Chemistry 2, Geometry, Trigonometry, Algebra 1, Algebra 2, Pre-calculus, Calculus
3) Did you make a "C" or lower in Chemistry 1? (If you never took chemistry, answer yes.)
4) Did you make a "C" or lower in Chemistry 2? (Answer no, if you did not take this class.)
5) Is the average of your Algebra 1 and 2 grades 2.5 or lower? (If you did not take Algebra 2, use your Algebra 1 grade to answer.)
6) Is the average of your pre-Calculus and Calculus grades 2.0 or lower? (If you did not take Calculus, use your pre-Calculus grade to answer.)