6 Year Assessment Report
Department of Chemistry
15 June 2014

I. Introduction

Mission Statement

The mission of the chemistry department at Westmont College is to provide a nationally competitive chemistry program that helps students become competent, thoughtful, and theologically reflective scientists, teachers, health-care providers, and citizens of our world.

Department Goals and Outcomes (Key Questions)

1) **Our students will be prepared for professional careers in chemistry. (Key Question: Are our students prepared for professional careers in chemistry?)**
   - as skilled entry level employees in industry.
   - as enthusiastic educators in elementary and secondary schools.
   - as competent graduate students in chemistry, biochemistry, and chemical engineering.
   -as motivated medical and dental students.

   Outcome: Our graduates will enter the career path of their choice as defined above.
   Benchmark: 75% of our graduates will meet this outcome.

2) **Students will demonstrate a breadth and depth of knowledge in chemistry. (Key Question: Do our students demonstrate a breadth and depth of chemical knowledge?)**
   Outcome*:* Students will demonstrate their knowledge on the ACS National Standardized exams and on the MCAT.
   Benchmark: The average performance on ACS National Exams will be at least in the 60th percentile, with 30% of the students scoring above the 80th percentile, in each course that has an exam. The average score on the Physical Science (PS) and Biological Science (BS) areas of the MCAT will be at the 60th percentile or higher.

3) **Students will be skilled in working in the laboratory and will be competent in experiment design and problem solving by the time of graduation. (Key Question: Are our students skilled in working in the laboratory and competent in experimental design?)**

   Outcome: Our graduates will be involved in a summer research project; either at Westmont or another facility, and some of our students will complete a major honors project. Students will demonstrate their understanding of basic experimental design in a senior level physical chemistry laboratory essay.

Benchmark: At least 50% of our graduates will participate in summer research; at least two graduates each year will complete a major honors project; our seniors will score 24 on the senior level physical chemistry laboratory essay.

4) **Our students will develop a love of learning and an enthusiasm for chemistry as a science and a discipline. (Key Question: Do our students develop a love of learning and an enthusiasm for chemistry as a discipline?)**
Outcome: Our graduates will have a lifelong enthusiasm and love for chemistry.
Benchmark: At least 75% of our graduates will report that their Westmont chemistry experience developed a lifelong enthusiasm and love for chemistry.

5) **Our students will be experienced at reconciling Christian and secular scientific world views. They will be knowledgeable in the area of the interface between Christian faith and science. They will have a perspective that integrates their scientific and theological beliefs into a seamless whole. (Key Question: Can our students reconcile Christian and scientific world views and can they integrate their scientific and theological beliefs into a seamless whole?**
***Outcome*:** Our students will demonstrate their knowledge and perspective on an essay exam given as part of CHM 195.
Benchmark: Most of our students will attain at least a *satisfactory* score (according to our grading rubric) on their integration of faith and learning paper given in CHM 195 as graded by two department readers. 30% of our students will attain an excellent score or higher.

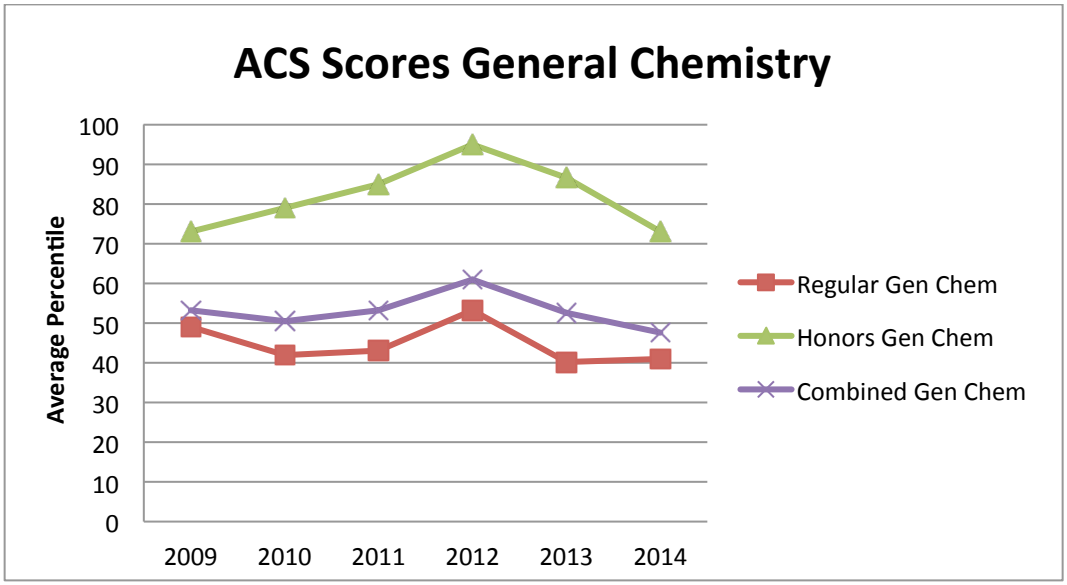
II. Findings

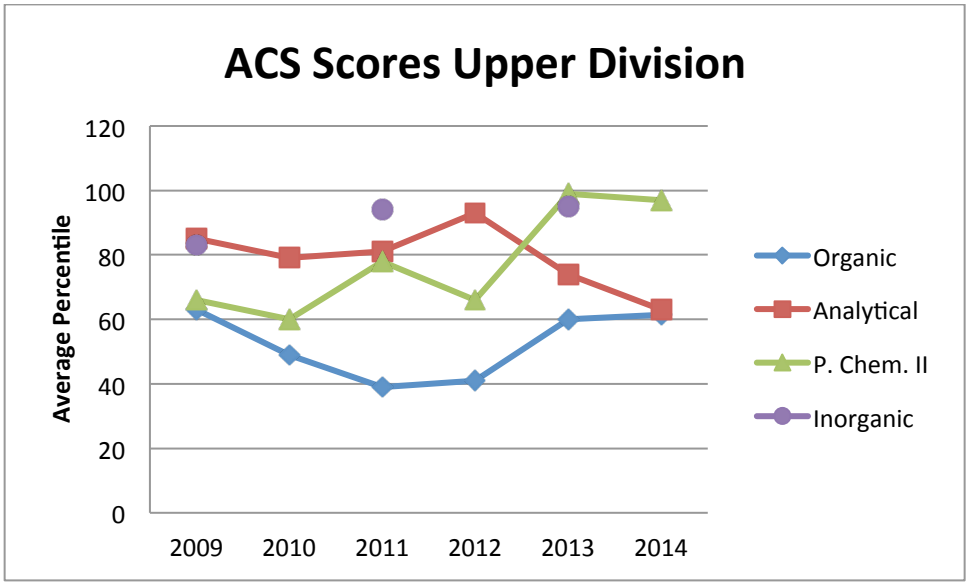
A. Student Learning

1) **Key Question: Do our students demonstrate a breadth and depth of chemical knowledge?** We have addressed this key question with two tools: a) the American Chemical Society (ACS) National Exams, and b) the Medical College Acceptance Test (MCAT) scores.

a) **ACS Results (2008-2014)**
The American Chemical Society (ACS) publishes regular exams for each of the major subjects within the chemical curriculum. We give these exams to our students as the final exam in the respective course. We track both the average percentile and the percent of our students scoring above the 80th percentile on these exams.

Average Percentile. The graphs below show the average percentile achieved by our students in each year for our courses over the past 6 years. The graphs are separated into General Chemistry and Upper Division courses.





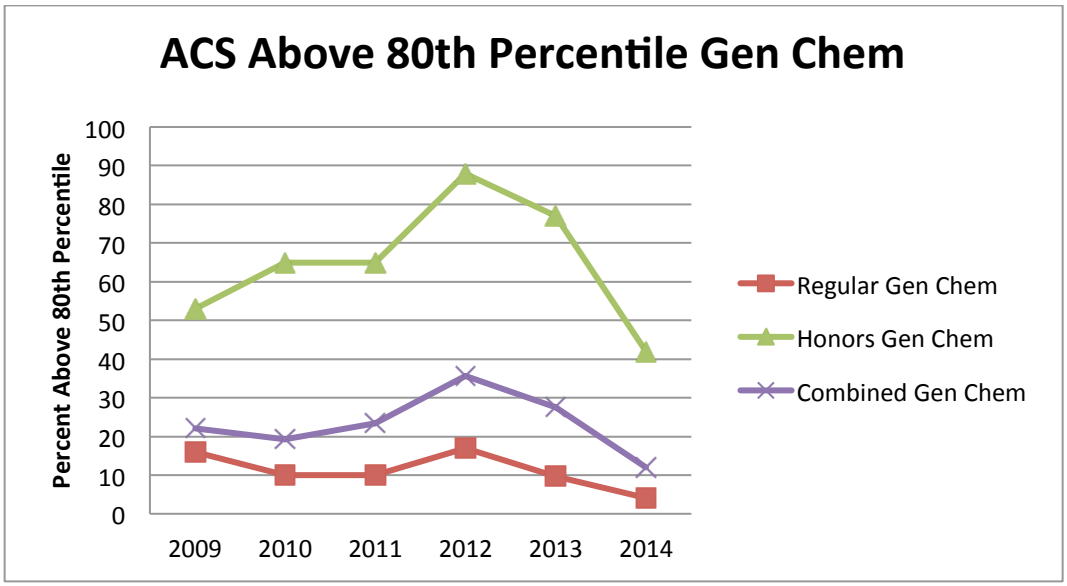
Six Year Average of Average Percentile. The table below shows the average percentile achieved by our students averaged over all 6 years displayed in the graphs above.

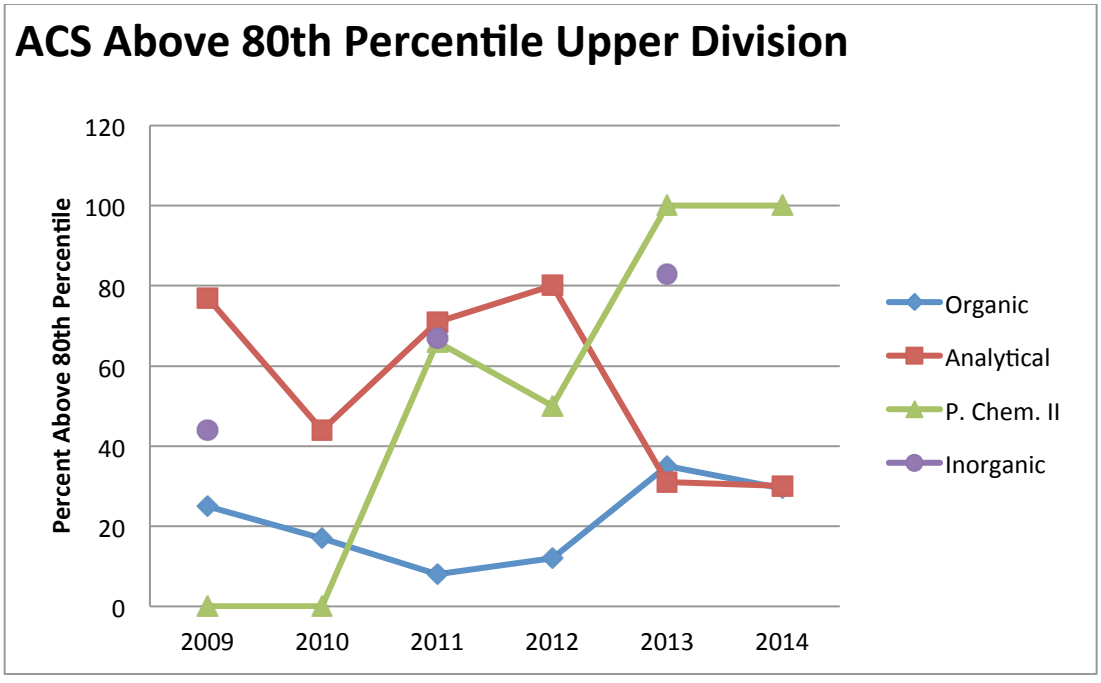
Gen Chem	Honors Gen Chem	Combined Gen Chem	Organic	Analytical	P. Chem II	Inorganic
44.7	**81.9**	**53**	**52.5**	**79**	**77.6**	**90.6***

* Offered in alternating year; 3 yr. average

For the 6 years summarized here, and considering the combined General Chemistry results, the department met its goals (60th percentile average score) in every course except Combined General Chemistry and Organic Chemistry.

Percent Above 80th Percentile. The graphs below show the percent of our students scoring above the 80th percentile on the ACS exam for each course over the past six years. The graphs are separated into General Chemistry and Upper Division courses.





6 Year Average of Percent Above 80th Percentile. The table below summarizes the percent of our students scoring above the 80th percentile averaged over all six years displayed in the graphs above.

Gen Chem	Honors Gen Chem	Combined Gen Chem	Organic	Analytical	P. Chem II	Inorganic
11.1	65	23.3	21.4	55.5	52.7	64.7*

* Offered in alternating year; 3 yr. average

For the 6 years summarized here, and considering the combined General Chemistry results, the the department met its goals (30% of students scoring above the 80th percentile) in every course except Combined General Chemistry and Organic Chemistry II.

Department Discussion of ACS Exam Results

The chemistry department is overall very satisfied with the performance of our students on the ACS exams in each course over the past 6 years. We are particularly impressed that our students are performing at such a high level in comparison with their peers at colleges and universities across the country. In most of our upper division courses, our students rank in the top one-third of their peers or higher.

Nonetheless, we were concerned about the lower performance in Organic Chemistry and our failure to meet our goals in this course in 2011 and 2012. We are also concerned about the combined General Chemistry perfomance in 2013 and 2014.

Response to Organic Chemistry Results

The department further investigated the low scores in Organic Chemistry by examining the results of the ACS Exam at the one-semester mark in the Fall of 2010 and 2011. The results of those exams for two years are shown below.

		Percentiles based on National Norms						
	Course Number	Number of Students	Score Ave. (70)	Average %Tile	Std. Dev.	Range	Above 80%tile	Percent above 80%tile
Fall 10	101	42	41.7	65	29	6-99	15	36
Fall 11	101	53	43.2	71	25	11-99	21	40
Spring 11	102	38	34.6	39	28	3-94	3	8
Spring 12	102	48	35.6	41	29	2-99	6	13

The results for the Fall semester in both years exceed our departmental goals. However, the results of the Spring semesters fall short. These data helped us to see that our failure to meet our goals lies in the Spring semester. The department identified several possible reasons for the Spring semester shortfall. Some of these reasons are beyond our control. For example, a full week of classroom time has been cut from the Spring semester over the last decade. Students have also been encouraged to take other time intensive science courses—such as Genetics—during the same semester as Organic Chemistry II. In fact, the Genetics final often falls on the same day as the Organic Chemistry II Final. Nonetheless, the department also identified a number of factors within our control. For example, for the two years summarized above, the Fall semester course had two smaller sections, while the Spring semester course had only one larger section. In fact, Organic Chemisty II is by far the largest upper division course we teach. We developed a set of actions to improve the ACS scores in Organic Chemistry II and close the loop.

Action	Implementation Date
Yearly ACS exam item analysis to identify areas where class coverage could be improved.	Spring 2012
Move at a faster pace early in the Fall semester to allow more time to cover the second semester topics earlier.	Fall 2012
Increase relative weight of final exam (which is the ACS exam) in overall grade to encourage students to take it seriously.	Spring 2013
Evaluate relative coverage of biochemistry during second semester. Biochemistry is typically not on the ACS exam, but is part of the MCAT, so careful balance here is important.	Spring 2013
Emphasize to students that they should read the Organic Chemistry ACS exam review booklets and purchase copies to put on reserve so that students can check them out to help them	Spring 2013

organize their studies for the exam.	
Planned to offer two smaller sections of Organic Chemistry II if total enrollment exceeds 40 students. Did not have to implement this since enrollment did not exceed 40 students.	Spring 2014
Scale back the scope of the second semester laboratory synthesis project. This project is extremely time intensive, which could cause students to have less time to focus on their lecture material. However, the department strongly supports the laboratory learning that occurs during this project and prefers not to overly diminish that aspect of the course.	Spring 2014
Evaluate the effectiveness of homework in the course, and perhaps initiate a homework/quiz combination to encourage students to take the homework more seriously.	Spring 2014

The good news is that these actions led to better to results. Both the overall average percentile for the class, and the percent of students scoring above the 80th percentile improved significantly in 2013 and 2014. For both of these years, student performance meets or exceeds our stated goals.

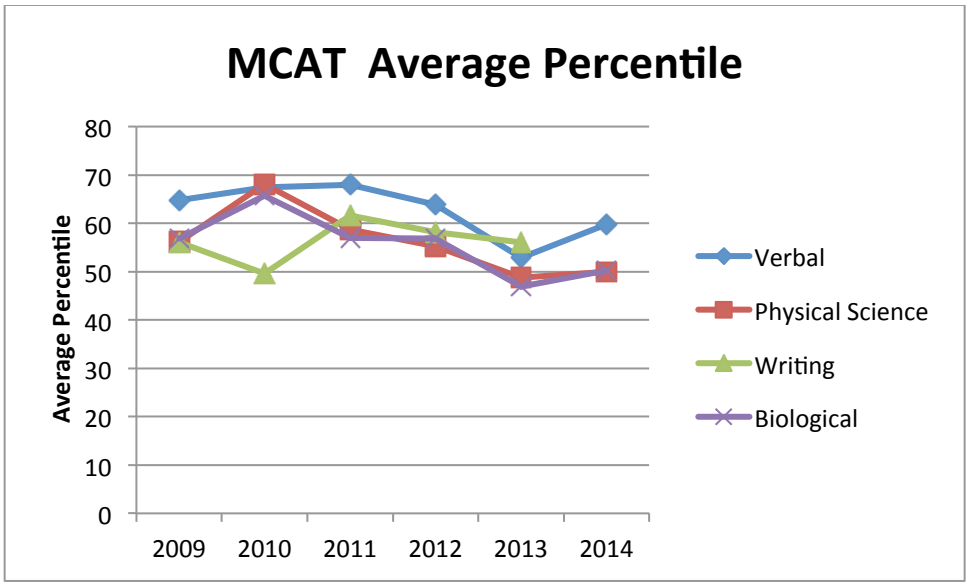
Response to General Chemistry Results

The department discussed several reasons for why the combined General Chemistry course performance on the ACS exams did not meet our set benchmarks. One of the reasons might be the changing student population. In recent years, the number of kinesiology majors at Westmont has grown substantially and have become a larger fraction of the course. These students, while capable, generally have less of a math background than the chemistry and biology majors that have historically populated the course. They might need additional help on math intensive topics. Another reason might be the switch from the 2009 version of the exam to the 2011 version of the exam, which occurred in 2013. The 2011 version seems to have a disproportionate amount of electrochemistry, which we cover, but perhaps in less depth than is required by the 2011 version of the exam. Nevertheless, we have developed a set of actions to improve the ACS scores in General Chemistry and close the loop.

Action	**Implementation Date**
Perform an item analysis to determine what topics are being most missed by our students and adjust course coverage accordingly.	Spring 2015
Consider changing to the 2013 version of the exam.	Spring 2015
Have daily assignments in course in addition to the existing weekly assignments so that students (especially those with weaker math skills) can pace themselves better.	Fall 2014
Purchase 25 ACS exam review booklets for General Chemistry and make the available in the library (on reserve) and for purchase.	Spring 2015

We are optimistic that these changes will lead to improved results for our students.

b) MCAT Results (2009-2014) A significant fraction of our senior chemistry majors take the MCAT. Since a significant portion of the MCAT involves chemical knowledge, we have tracked our students performance on this exam as a measure of the depth and breadth of their chemical knowledge. The graph below shows the average percentile achieved by our students on the MCAT over the past six years.



Six Year Average of MCAT percentile for Westmont Students The table below summarizes the average percentile of our students on the MCAT average over all four years displayed in the graph above.

Verbal	Physical Science	Writing	Biological	Total
62.7	56.15	56.28	59.2	63.3

For the period 2009-2014, the department fell short of it benchmark (60th percentile average score) for the MCAT results in physical science.

Department Discussion of MCAT results.

The chemistry department is somewhat concerned about the performance of our students on the MCAT exam over the past six years. However, we also realize that the MCAT is typically taken by the high achieving students of a college or university. The results tell us that our high achieving students are in the top 45% of their peers nationally, so the results are not terrible. In addition, the department feels that our courses are only part of what contributes to the overall physical science MCAT score of our students. Other courses in other departments, such as physics and math, also contribute to student physical science MCAT performance. Consequently, the department feels that the MCAT data may not be direct enough for us to develop effective responses. In other words, we feel like we have a direct measure of the depth and breadth of student knowledge in the ACS exams, so the MCAT data is a less reliable instrument for us. As a result, we will likely stop using the MCAT data in assessment in this area and rely solely on the ACS exam data.

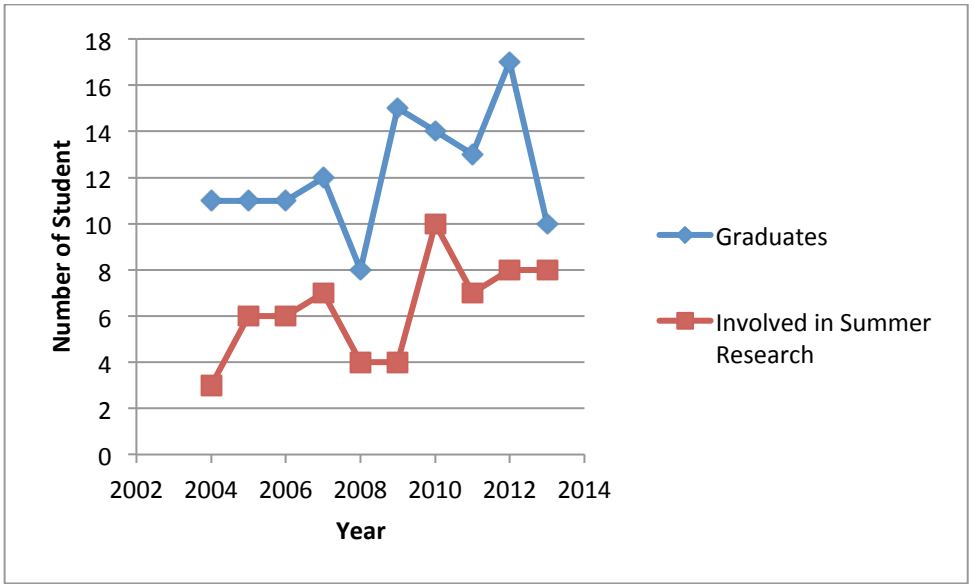
2) Key Question: Are our students skilled in working in the laboratory and competent in experimental design?

We address this question in three ways: a) By tracking the involvement of our students in summer research either at Westmont or another facility; b) by tracking how many of our students complete a major honors project; and c) by administering an essay exam on experimental design in the senior level physical chemistry laboratory.

a) Involvement of undergraduate students in summer research.

Number of Students

The table below shows the number of students involved in summer research in the chemistry department at Westmont as well as the number of graduates from our department for the period 2004-2013.



The number of students involved in summer research has grown slightly over the years. The average number of graduates over the previous 6-yr period covered by this report is 12.2 and the average number of students involved in research is 6.3, so the average participation rate is 52%, which exceeds our benchmark (50%).

Student Satisfaction with Undergraduate Research. The data below summarizes the overall results of questionaires administered to students involved in summer research for the period 2010-2013.

How would you rate your overall summer research experience?

Response	**# of Students**
a) Outstanding	18
b) Excellent	8
c) Satisfactory	1
d) poor	

How helpful do you think your summer research experience will be in helping you get into graduate school or find a job after graduation?

Response	# of Students
a) Very Helpful	26
b) Moderately Helpful	1
c) Not Helpful at All	

Would you recommend a similar summer research experience to your peers?

Response	# of Students
a) Yes	27
b) No	0

Please list the strengths of your summer research experience.
Common answers included:

- Improvement of lab skills
- Working closely with professors
- Learning how to use instruments
- Learning and improving lab techniques
- Hands on experience in chemistry
- Resume building

Please list the weaknesses (if any) of your summer research experience.

Most responses indicated no weaknesses. A minority of students mentioned these:

- Long hours
- Problems with equipment
- Would like the program to be longer

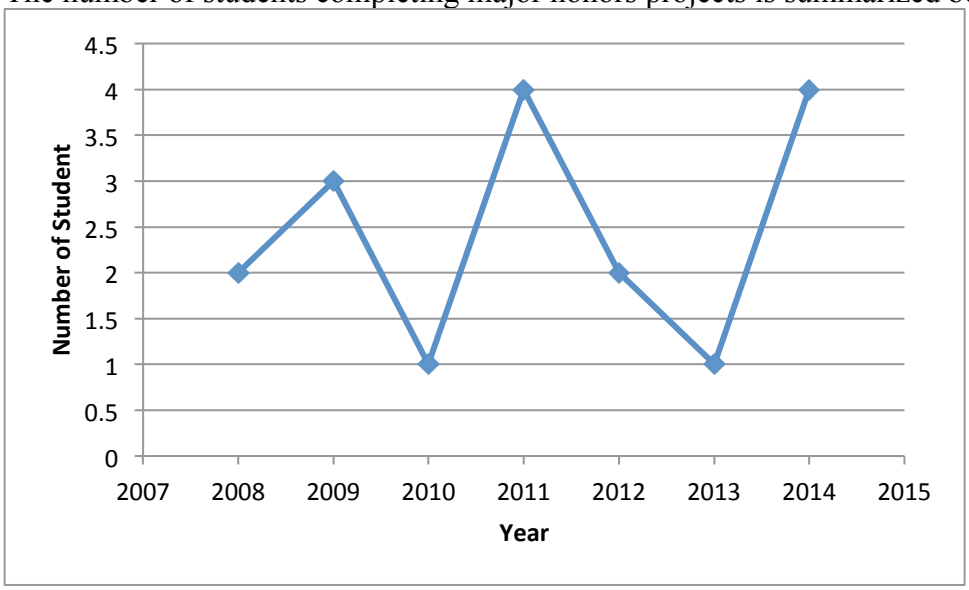
Department discussion of student involvement in summer research

The department is satisfied with the number of students involved in undergraduate research. In our department, over 50% of graduates participate in summer research. We doubt that many other chemistry departments in the country can boast that level of participation. We are currently limited, not by student interest, but by funding. We anticipate that the Stauffer challenge grant will provide us with additional funding

which will allow us to achieve an even higher participation rate. In addition, students seem very satisfied with their experience.

b) Students completing major honors projects.

The number of students completing major honors projects is summarized below.



The average number of students completing honors projects over the period is 2.4 per year.

Department discussion of students completing major honors projects.

The department is satisfied with the number of students completing major honors projects. The average of 2.4 students per year exceeds our benchmark (2 students per year). There is some concern that since this benchmark is an absolute number, rather than a percentage of graduates, fluctations in number of graduates may affect the outcome. However, we can mitigate against that by computing a rolling average over several years, as we did in this report.

c) Essay exam on experimental design

Our department administered an essay exam on experimental design in our advanced analytical chemistry course, which is populated by our juniors and seniors. The exam was based on a rubric published in the Journal of Chemical Eduation[1]. The entire

[1] S.E Shadle, E.C. Brown, M.H. Towns, and D.L Warner, *A Rubric for Assessing Students' Experimental Problem-Solving Ability,* J. Chem. Educ. 2012, 89, 319-325

rubric is posted in our departmental assessment folder. Briefly, the exam has three questions and each question is assessed on three criterion:

1) The student identifies the important or relevant features of the problem.
2) In formulating a strategy for the solution of the problem, the student presents a complete justification or explanation of the strategy.
3) The student provides an effective strategy that is likely to work to solve the chemical problem.

Each criterion is given a numerical score from 1-4 with 1 indicating that the student's response indicates an emerging understanding and a 4 indicating that the student's response indicates mastery. The maximum score on the essay exam is therefore 36, which would indicate mastery of all three criterion for all three questions. The exams were graded by two department members (Everest and Contakes) and average results are tabulated below.

2011 Results

	Question 1			Question 2			Question 3				
Student	C1	C2	C3	C1	C2	C3	C1	C2	C3	Total	Jr/Sr?
GJ	3	2.5	3.5	3.5	3	3	4	3	3	28.5	S
A	3	2	2.5	3	2	2.5	3	2.5	4	24.5	?
B	Did not answer			1.5	1	2	Did not answer			4.5	?
JM	3	2.5	3	3	2.5	3	3	2.5	4	26.5	S
DL	3	2.5	3	3.5	3	2.5	2.5	3	1.5	24.5	J
CO	3.5	3.5	3	2.5	2	3	3	3	2.5	26	S
AB	3	3	3	3	2.5	3	3	2.5	4	27	S
C	3.5	3	3.5	3	2.5	2.5	3	3.5	2.5	27	?
D	3.5	3	3.5	2.5	2	3	3.5	2.5	4	27.5	?
E	1.5	1	1.5	1	1	1.5	Did not answer			7.5	?
DC	2	2.5	2.5	2.5	2	2	2	2	2	19.5	?
SG	3.5	3	3	3	3.5	3	4	3.5	4	30.5	J
Averages:	2.95	2.59	2.91	2.67	2.25	2.58	3.10	2.80	3.15	22.79	
Stdev	0.65	0.66	0.58	0.75	0.75	0.51	0.61	0.48	0.97	8.31	
90% confi	0.32	0.33	0.29	0.37	0.37	0.25	0.30	0.24	0.48	4.11	

2012 Results

	Question 1			Question 2			Question 3				
Student	C1	C2	C3	C1	C2	C3	C1	C2	C3	Total	Jr/Sr?
HR	3	2.5	2	2.5	2.5	1.5	3	2.5	3	22.5	S
AC	2	2.5	2.5	3	2	3	2	2.5	1	20.5	S
TS	3.5	3.5	3.5	3.5	3	2.5	3	2.5	3.5	28.5	S
SL	3	3	2.5	2.5	2.5	1.5	2.5	2.5	2	22	S
EP	3	2.5	3.5	3	2	3	3	3	4	27	S
BD	2.5	3	2.5	3	2.5	3	3.5	3	4	27	J
HT	2.5	2	2.5	3.5	2.5	2.5	2.5	2.5	1.5	22	J
CB	2.5	2.5	2	2.5	2	2.5	2.5	2.5	1.5	20.5	S
A2012	2.5	2	2	3	3	3	3	2.5	4	25	?
SZ	3	3	3.5	3	2.5	3	3.5	3	3.5	28	S
Averages:	2.75	2.65	2.65	2.95	2.45	2.55	2.85	2.65	2.8	24.3	
Stdev	0.42	0.47	0.63	0.37	0.37	0.60	0.47	0.24	1.18	3.15	
90% confi	0.25	0.27	0.36	0.21	0.21	0.35	0.27	0.14	0.69	1.82	

2013 Results											
	Question 1			Question 2							
Student	C1	C2	C3	C1	C2	C3	C1 (avg)	C2 (Avg)	C3 (Avg)	**Total (Avg)**	Jr/Sr?
AB	4	3	3	3.5	3	1.5	3.25	3	3.25	27.5	S
JD	3.5	3	2	3.5	2.75	3	2.75	2.5	1.5	24.5	S
NG	3.5	2.5	2.5	3.5	2.5	3	3	2.75	1.75	25	S
EG	3	2.5	2	3	2.5	1.25	3	3	3.5	23.75	S
CH	3.5	2.75	2.25	2.5	1.75	1	2.75	2.5	2.5	21.5	S
JK	4	3	3	3.5	2.75	3	3	3	3	28.25	S
KM	4	3	3	3	2.5	2.5	2.5	2	1.5	24	S
RS	3.25	2	2	3.5	2.5	3	2.5	2.5	1.5	22.75	S
TV	4	3	3	3.75	3	3.5	2.5	2	1	25.75	S
BW	3.5	3	2.5	3.75	3	3	3.25	3	3	28	J
Averages:	3.63	2.78	2.53	3.35	2.63	2.48	2.85	2.63	2.25	25.10	
Stdev	0.36	0.34	0.45	0.39	0.38	0.89	0.29	0.40	0.90	2.27	
90% confidence +/-	0.18	0.17	0.22	0.19	0.19	0.44	0.15	0.20	0.44	1.12	

For comparison, the authors of the paper in which this rubric was published reported that their students achieved an average score of 20 as juniors and 28 as seniors.

Department discussion of essay exam on experimental design

The department is generally satisfied with the results of the essay exam on experimental design. Students met the benchmark (24) in 2012 and 2013. Nonetheless, we developed additional steps to further improve student performance.

Action	**Implementation Date**
Add an NMR analysis component to the deconvolution of IR spectra lab to illustrate the use of NMR to quantify relative amounts in a mixture.	Fall 2013
Add an NMR analysis component to the diethyl malonate methanolysis kinetics lab to demonstrate how NMR can be used to follow the kinetics of the reaction.	Fall 2015
Add more discussion of gas and liquid chromatography to the course to demonstrate a broader applicability of these techniques to chemical problems.	Fall 2015

3) **Key Question: Can our students reconcile Christian and scientific world views and can they integrate their scientific and theological beliefs into a seamless whole?** We have assessed this question by having our students who are enrolled in CHM 195 (chemistry seminar) write on the following prompt: *Describe the relationship between scientific knowledge and the Christian faith.*

24 student essays were evaluated over 2 years (2013-2014). The rubric used to grade the essays by two departmental readers (Tro and Contakes) is shown below.

	Poor (2 pts)	**Satisfactory** (5 ponts)	**Excellent** (8 points)	**Outstanding** (10 points)
Main Thesis (Does the response have a central clear idea about how the student's work as a scientist and his or her life as a Christian integrate with or relate to one another?)	No main thesis.	Contains a main idea, but main idea is weak.	Cogent, clearly stated thesis.	Strong, clearly stated, thesis.
Support and Focus (Does the body of the paper support the main idea or does it wander into irrelevant material?)	Body does not support the main idea.	Body moderately supports the main idea, but contains extraneous material.	Body supports main idea.	Body clearly and convincingly supports the main idea.
Maturity and Depth of Thought (Is the student's thinking at a mature level? Have they thought deeply about how these two parts of their lives fit integrate into a seamless whole?)	Ideas are immature and characteristic of those who have not thought deeply about the topic.	Ideas are okay and show some prolonged engagement with the topic.	Ideas are strong and show prolonged engagement with the topic.	Ideas are mature and well developed. The student has clearly thought about this a great deal.

2014	**Main Thesis**		**Support and Focus**		**Maturity/Depth**		**Total Score**		**Average Score**
Student	**Niva**	**Steve**	**Niva**	**Steve**	**Niva**	**Steve**	**Niva**	**Steve**	
1		8		8		8	21	24	22.5
2		9		9		8.5	24	26.5	25.25
3		9		8.5		8	27	25.5	26.25
4		9		8		8	24	25	24.5
5		8		7.5		7	19	22.5	20.75
6		9		8		6.5	13	23.5	18.25
7		7.5		7.5		7	14	21.5	17.75
8		6		6		6	16	18	17
9		8		8.5		8	23	24.5	23.75
10		9		9		8.5	30	26.5	28.25
11		9		7		8	27	24	25.5
Average							**21.63636**	**23.77273**	**22.70455**

Std dev							**5.590576**	**2.453198**	**3.777926**
%satisfactory or greater							**82%**	**100%**	**100%**
%excellent or greater							**36%**	**63%**	**55%**

2013	**Main Thesis**		**Support and Focus**		**Maturity/Depth**		**Total Score**		**Average Score**
Student	**Niva**	**Steve**	**Niva**	**Steve**	**Niva**	**Steve**	**Niva**	**Steve**	
1	9	8	8	7	8	7	25	22	23.5
2	7	5	7	7	7	7	21	19	20
3	7	6	6	6	5	5	18	17	17.5
4	8	7	5	5	6	6	19	18	18.5
5	9	7	9	8	9	7	27	22	24.5
6	7	7	5	6	6	4	18	17	17.5
7	9	7	8	8	9	9	26	24	25
8	10	10	10	9	9	8	29	27	28
9	8	7	6	6	7	5	20	18	19
10	10	8	9	9	9	9	28	26	27
11	7	8	6	5	6	6	19	19	19
12	10	8	8	8	9	7	27	23	25
13	10	9	10	8	10	9	30	26	28
Average							**23.61538**	**20.81818**	**21.77273**
Std dev							**4.51919**	**3.600505**	**3.907452**
%satisfactory or greater							**100%**	**100%**	**100%**
%excellent or greater							**54%**	**31%**	**46%**

The average score for both years was about 22/30 (between satisfactory and excellent). In both years, 100% of the student scored satisfactory or better and about 50% scored excellent or better.

Department Discussion Faith and Learning Essays.

The department is pleased with student performance in this area. Our students are meeting our stated benchmark and we feel that no further action is necessary.

B. Alumni Reflections

1) **Key Question: Do our students develop a love of learning and an enthusiasm for chemistry as a discipline?)**
Our department administered a survey to our graduates asking them about their view of chemistry and their enthusiasm for the discipline. The survey was sent to 100 alumni and 68 responded. The results of the survey follow.

1. My experience in the chemistry department at Westmont College developed in me an enthusiasm and love for learning chemistry.

	Response Percent	Response Count
a) Strongly agree	**63.2%**	**43**
b) Moderately agree	16.2%	11
c) Agree	16.2%	11
d) Disagree	4.4%	3
e) Strongly disagree	0.0%	0
	comment	25
	answered question	**68**
	skipped question	**0**

2. Regardless of your current occupation, how do you view the discipline of chemistry today?

	Response Percent	Response Count
a) Very positively	**61.8%**	**42**
b) Positively	32.4%	22
c) Neutral	5.9%	4
d) Negatively	0.0%	0
e) Very negatively	0.0%	0
	Optional Comment	12
	answered question	**68**
	skipped question	**0**

3. Please indicate the range of your graduation date.

	Response Percent	Response Count
a) 2000 - 2003	13.2%	9
b) 2004 - 2007	36.8%	25
c) after 2008	**50.0%**	**34**
	answered question	**68**
	skipped question	**0**

The survey shows that 95.6 % of our graduates agree, moderately agree, or strongly aggree that their experience at Westmont developed in them an enthusiasm and love for learning chemistry. Some selected comments follow: (For a full list of comments see Appendix I)

"I hated Chemistry in HS for various reasons, but Westmont completely turned that attitude around. By the time I graduated Westmont I wish I had been able to take more classes."

"All of my professors in the chemistry department had a clear passion for chemistry, and this had a direct impact on my enthusiasm for chemistry and my dedication to the learning process."

"I have carried on my love of learning chemistry into my graduate studies. Sometimes that love is tested..."

"For me, it was really the enthusiasm and joy of the professors that made me develop my own passion for chemistry. I may not be pursuing chemistry as my future, but it taught me a lot of skills I continue to use now in optometry/graduate school."

The results also show that 97.2 % of our graduates view the discipline of chemistry either positively or very positively. Some selected comments follow: (For a full list of comments see Appendix I)

"While my current occupation isn't in the field of chemistry, I view the discipline of chemistry, and the time I spent studying it, rich and valuable. My

understanding of chemistry provides me with a deeper appreciation of the world that I couldn't have gotten otherwise."

"I'm currently working in a lab that focuses on biology. While I have little to no interaction with chemistry on a day to day basis for my job, I do find that my knowledge of chemical interactions is beneficial and puts me above some of my peers who come from a strictly biological education background."

"I have begun to appreciate chemistry more as I have learned that chemistry does not live in a vacuum. The field of chemistry enriches and is enriched by many other fields of research in both academia and industry. Observing and understanding how chemistry impacts researchers in many fields today gives me a very positive view of the discipline of chemistry."

Department discussion of survey of graduates

The department is very pleased with the results of our survey of graduates. Our benchmark was that 75% of our graduates would self report that Westmont chemistry experience developed in them a lifelong enthusiasm and love for chemistry, and we have exceed that benchmark by more than 20 percentage points.

C. Curriculum Review

1) Curriculum Map

The chemistry department wants students to acquire certain skills and abilities (such as computational chemistry, writing , spectroscopy, and the ability to integrate faith and learning) during their time in our courses. We believe that students are acquiring these skills and abilities, but would like the student experiences of these skills to have better uniformity and consistency from one course to the next.

Action	**Implementation Date**
Develop a curriculum map that identifies the courses that include computational chemistry, writing , spectroscopy, and the ability to integrate faith and learning.	Fall 2015
Make sure that approaches to computational chemistry, writing, spectroscopy, and the ability to integrate faith and learning are consistent from one course to the next. For example, can we	Fall 2015

implement more consistency in the software used for computational chemistry throughout the curriculum?	

2) Full Year of Biochemistry

Most of the best chemistry programs offer one full year of biochemistry. At Westmont, we only offer one semester. We attempted to offer a second semester of biochemistry as an advanced topics course a couple of years ago, but were not successful in enrolling students in the course, partly because it was not a requirement for any of the tracks in our major. The chemistry department would like to make the second semester of biochemistry a requirement for the biochemistry track of our chemistry major. However, we are weary of simply adding another course to our major without removing a course, and since the majority of our students in the biochemistry track of our major are pre-medical students, we are also concerned about how changes to that major might affect them. In addition, the pre-medical requirements are undergoing substantial changes next year. Our pre-med advisor (Prof. Cantrell) will be attending a major meeting outlining these changes during the summer of 2014, so the department thought it best to wait until Fall 2014 to implement any changes to the biochemistry track of our major.

Action	**Implementation Date**
Review biochemistry track of chemistry major with an eye towards adding a second semester of biochemistry.	Fall 2015

3) Number of In-Depth Courses Offered Per Year

The chemistry department has applied for accreditation from the American Chemical Society (ACS). Although we have not heard back on the status of our application as of the writing of this report, it appears that the accreditation committee deemed that we do not offer enough in-depth chemistry courses per year to meet the requirements of accreditation. The ACS requires a minimum of four advanced courses per year. Because of alternating year courses, we miss the requirement by one course every other year. The department discussed several solutions to this problem including the addition of an in-depth biochemistry course to be offered on alternating years (see Full Year of Biochemistry discussion above). However, we will wait to formally hear back from the accreditation committee before we propose any action.

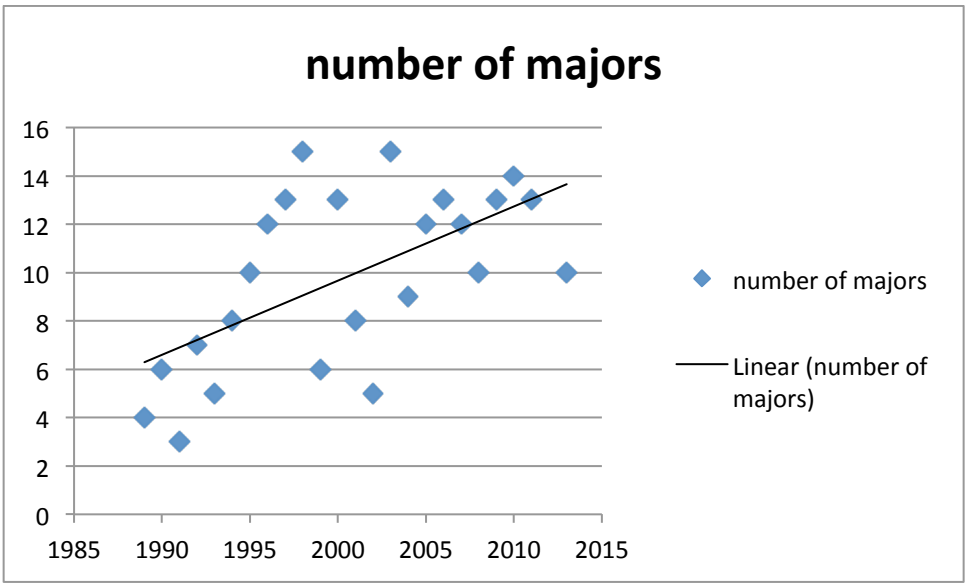
D. Program Sustainability

1) **Key Question: Is our program attracting and graduating a good number and a good mix of students?** We have addressed this question by examining the number of majors that have graduated from our department over time.

Short Term: 2008-2013
Graduates

Year	Total	Male	Female	White	Asian	Hispanic	Black	unkown	Am Indian
2008	11	8	3	9		2			
2009	14	6	8	9	3	1	0	0	0
2010	14	9	5	11	3	0	0	0	1
2011	13	5	8	11	1			1	0
2012	DEMOGRAPHIC DATA NOT IN ARCHIVE								
2013	10	5	5	6	1	3	0	0	0

Long Term: 1986 – 2013 Number of Majors



Departmental Discussion on number and mix of majors.

The average number of chemistry majors graduating from the chemistry department for the period 2008-2013 is 12.4. Given the size of the institution, this is a respectable (if not high) number. The chemistry department is satisfied with this number, and we realize that, given our resources, we probably could not handle a large increase in the number of chemistry majors.

2) Load Credit for Supervision of Student Research

The department has enjoyed a long history of engaging in research with undergraduate students. For many years, department members engaged in research during the summer months and during the school year with no monetary compensation or load credit. However, the chemistry department feels that such a program may not be sustainable over the long run.

Action	**Implementation Date**
The department will submit a proposal to the administration for getting a modest amount of load credit for supervising undergraduate research.	June 2014 (proposal submitted)

3) Research Requirement for Biochemistry Track of Chemistry Major

The chemistry department at Westmont has prescribed research (CHM 198) as a major requirement for many years. However, some of the students in the biochemistry track of our major have limited interest in research. These students often take up available slots (and faculty time) that might be better spent on more motivated students. However, the department is proud of the reputation we have earned, and of the experience that our students get, from their undergraduate research experience. The department feels that a good compromise on this issue is to reduce the CHM 198 requirement for the biochemistry track of our major from 2 units to 1 unit. This compromise would ensure that all of our majors still get research experience, but would free up faculty to focus more on those students for whom research is a genuine interest.

Action	**Implementation Date**
The department will submit a proposal to the registrar for reducing the CHM 198 requirement for the biochemistry track of our major from 2 units to 1 unit.	June 2014 (proposal submitted)

4) Key Question: Are our students prepared for professional careers in Chemistry?

We propose to assess this objective by simply tracking what our graduates actually do after leaving Westmont.

We have tracked our graduates career choices for the period 1999-2011, and the results are tabulated below.

Year	Total Grads	Industry	Grad School	Med/Dent	Teach	Other	Total to Chem Career	Percent to Chem Career
1999	5		2	1	1	1	4	80
2000	14	2	6	5	1		14	100
2001	5		1	2	1	1	4	80
2002	5			4	1		5	100
2003	15	1	4	2	2	6	9	60
2004	11	2	3	2	3	1	10	90.90909
2005	11	1	1	7	1	2	10	90.90909
2006	11	2	3	2	2	3	9	81.81818
2007	12	2	3	2		6	7	58.33333
2008	8			6		2	6	75
2009	15		3	4		8	7	46.66667
2010	14		5	1	1	8	7	50
2011	13	1	5	5		3	11	84.61538
							AVERAGE	**76.7886**

Industry = number of graduates going to work in chemical or chemical related industry
Grad School = number of graduates going to chemistry or chemistry related graduate programs
Med/Dent = number of graduates going to medical or dental school
Teach = number of graduates going into secondary or higher education

Departmental Discussion of Graduate Career Choices

The department discussed the results of tracking our graduates at two department meetings. Students clearly choose their own career paths, and at a liberal arts college, that career path might wander far from their major area. We all agree that a chemistry major at a liberal arts college could be a good foundation for a wide variety of careers, and we certainly do not want to limit our definition of success for our graduates to a career in chemistry or chemistry-related field. Nonetheless, we agree that the results of tracking our graduates provide good evidence that we are indeed *preparing* our graduates for professional careers in chemistry. In other words, the fact that 75% of our graduates go on to

professional careers that involve chemistry is in itself evidence that we are preparing them for those careers. We feel highly satisfied with the results of tracking our graduates and find those results to be compelling evidence that we are meeting goal 1.

The department also discussed how to "count" the careers that graduates choose. For example, one graduate initially went on from Westmont to teach high school chemistry. Several years later, she chose a different career path that did not involve chemistry. However, her initial career choice, and her ability to get a job in that career choice, demonstrates that she was prepared for that career. Consequently, we agreed to count her as a graduate that went on to a chemistry career. Because of this conversation, we have chosen to define the students that we "count" as having a career in chemistry as any student who within seven years of graduation chooses one of the career paths defined in goal 1 and stays in it for at least one full year. We feel that the ability of the student to engage that career choice for at least one year is valuable evidence that helps demonstrate their preparation for that career choice.

III. Looking Forward: Changes and Questions

A. Changes Made or Proposed as a Result of This Report.

The department has made and proposed numerous changes based on this report. These changes can be found as boxed items entitled "action" in Section II. We have also examined our mission statement and found it to be compelling for the past as well as the future.

B. Key Questions for the Next Review Cycle

The chemistry department has reviewed our Key Questions. We gauged which questions in this report seemed most relevant and useful. Based on this discussion, and based on recommendations from the Westmont Program Review Guide that Key Questions should

be limited in number to 2-4 questions, we cut back our Key Questions from five to three. We also cut the MCAT data from key question 1 (see Section IIA). The questions we propose for the next cycle are as follows:

1) **Do our students demonstrate a breadth and depth of chemical knowledge? (Question 1 in this report.)**
   Outcome*:* Students will demonstrate their knowledge on the ACS National Standardized exams.
   Benchmark: The average performance on ACS National Exams will be at least in the 60th percentile, with 30% of the students scoring above the 80th percentile, in each course that has an exam.

2) **Are our students skilled in working in the laboratory and competent in experimental design?(Question 3 in this report)**

   Outcome: Our graduates will be involved in a summer research project; either at Westmont or another facility, and some of our students will complete a major honors project. Students will demonstrate their understanding of basic experimental design in a senior level physical chemistry laboratory essay.
   Benchmark: At least 50% of our graduates will participate in summer research; at least two graduates each year will complete a major honors project; our seniors will score 24 on the senior level physical chemistry laboratory essay.

3) **Can our students reconcile Christian and scientific world views and can they integrate their scientific and theological beliefs into a seamless whole? (Key Question 5 in this report)**
   ***Outcome*:** Our students will demonstrate their knowledge and perspective on an essay exam given as part of CHM 195.
   Benchmark: Most of our students will attain at least a *satisfactory* score (according to our grading rubric) on their integration of faith and learning paper given in CHM 195 as graded by two department readers. 30% of our students will attain an excellent score or higher.

Appendix I.

Q1. My experience in the chemistry department at Westmont College developed in me an enthusiasm and love for learning chemistry.		
1	When I got to upper level courses I realized I was more interested in natural sciences, but I still retain my love of chemistry.	Feb 12, 2013 8:59 AM
2	I hated Chemistry in HS for various reasons, but Westmont completely turned that attitude around. By the time I graduated Westmont I wish I had been able to take more classes.	Feb 6, 2013 8:25 AM
3	Honors General Chemistry with Niva Tro was the beginning of my passion and "career" in chemistry.	Feb 5, 2013 9:59 AM
4	All of my professors in the chemistry department had a clear passion for chemistry, and this had a direct impact on my enthusiasm for chemistry and my dedication to the learning process.	Jan 29, 2013 2:42 PM
5	Best decision I ever made was to be a chemistry major. Not only did it give me a love of science, but a love of learning.	Jan 28, 2013 5:26 PM
6	I enjoyed everyone I worked with in the Chemistry Department. The introduction to research, I believe, truly changed my life. The seminar with Dr. Contakes was one of my favorite classes at Westmont - I felt I received some valuable tools to integrate faith and science. The research with Mako was so rewarding - even though he wasn't able to stay for the whole time. I can't say enough good things about the Chemistry Dept at Westmont.	Jan 28, 2013 6:42 AM
7	A love and enthusiasm for learning but not necessarily chemistry.	Jan 26, 2013 3:38 PM
8	While at westmont I felt overshadowed by other students in all my chemistry classes and I didn't feel that I was helped enough with planning out my career path for after graduation. I think something needs to be done for students who know they love chemistry but can't figure out the direction they want to go in yet. That being said I thought all my professors here conveyed the subject material excellently and I finished with a decent background in chemistry. My overall experience at westmont ultimately was very negative socially, but one of the few reasons I am glad I stayed the four years is my involvement with the chemistry department through research and classes. It is very intellectually challenging and should stay that way.	Jan 25, 2013 9:26 PM
9	My class with Tro did this. He was an awesome prof to have for an intro chemistry class and his own book was very helpful. I really liked the professors after that like Contakes, but the subject material just was never as interesting as the life around me at westmont. I always felt that maybe I should have bee a bio major or something else. (As is I am pursuing a masters degree in Marine Biology currently in Monterey Bay)	Jan 25, 2013 6:01 AM
10	I am glad for what I learned while in school, however I have no desire to learn anything that in depth in the future. My interest lie in the overarching principles.	Jan 24, 2013 8:36 PM
11	I have carried on my love of learning chemistry into my graduate studies. Sometimes that love is tested...	Jan 24, 2013 7:04 PM
12	I especially found a love for physical chemistry	Jan 24, 2013 5:27 PM

Q1. My experience in the chemistry department at Westmont College developed in me an enthusiasm and love for learning chemistry.		
13	Originally I was a bio major and upon getting involved in the chemistry department I discovered my love for chemistry. I now plan to teach chemistry in the future after I get my PhD.	Jan 24, 2013 5:07 PM
14	I initially disliked chemistry, but learned in honors general chemistry that chemistry was in fact the building blocks of why I understood science so well. The lessons I learned at westmont still inspire me in my learning now as a medical students, and drive me to inspire other young students in the high school science afterschool program I run.	Jan 24, 2013 4:31 PM
15	I was on a pre-med track and so I never envisioned myself doing much with chemistry after undergrad.	Jan 24, 2013 4:30 PM
16	This is a really tough one, because I think I would have studied something else, if I could do it all over again. But, that's not fair to you guys, because I don't think I was ready to choose a discipline at that point in my life. I think I really chose chemistry because the professors (tro, mako, contakes) loved it so much. I didn't really see that in any other professors. I really wanted to enjoy something as much as you guys did. I liked gen chem because of Tro, and i convinced myself everyone hates ochem, so i pressed on. by the end of ochem, I realized that chemistry isn't my thing. I had to either finish, or spend another year there, and another $40,000+, so I finished, and found something I liked better in graduate school. If I could, I'd choose the bubble that said "Westmont instilled in me an enthusiasm and love for chemistry my first year, but then by my third year I realized that awesome professors can't make me enjoy something that I just don't like." Sorry for the long response.	Jan 24, 2013 3:45 PM
17	For me, it was really the enthusiasm and joy of the professors that made me develop my own passion for chemistry. I may not be pursuing chemistry as my future, but it taught me a lot of skills I continue to use now in optometry/graduate school.	Jan 24, 2013 3:35 PM
18	I am a physician now. Chemistry was something I could do and a means to a career end. I was better at math than rogue memorization, thus I choose chemistry over biology as a major.	Jan 24, 2013 3:24 PM
19	While I considered going to grad school before I ever got to Westmont, it was my experience with all of the professors that ensured it. The enthusiasm that was exhibited in the classroom, the thirst for knowledge and understanding in discussion, and all of the attention given to the students was key in this.	Jan 24, 2013 3:18 PM
20	Though chemistry is not the field into which I am entering, my time at Westmont instilled in me a love and passion for the chemistry behind every aspect of medicine. It is remarkable, and I credit the Chemistry Department at Westmont for this enthusiasm.	Jan 24, 2013 3:17 PM
21	The professors and staff were great and very enthusiastic.	Jan 24, 2013 3:17 PM
22	I came to Westmont as a biology major, but my experience in lower division chemistry classes inspired me to switch to a chemistry major.	Jan 24, 2013 3:07 PM
23	Though my interests have moved away from the sciences since graduating, the	Jan 24, 2013 3:06 PM

Q1. My experience in the chemistry department at Westmont College developed in me an enthusiasm and love for learning chemistry.		
	educational experience at Westmont in the Chemistry Department was wonderful. I am grateful to have been able to participate in research, learn from accomplished and challenging professors, and integrate science (and chemistry) with my Christian faith.	
24	The enthusiasm of the faculty is apparent and contagious!	Jan 24, 2013 3:04 PM
25	I definitely love learning chemistry and I feel that all of my chem profs at Westmont truly love chemistry as well as learning and teaching chemistry too!	Jan 24, 2013 2:59 PM

Q2. Regardless of your current occupation, how do you view the discipline of chemistry today?		
1	I'm a farmer that processes our own fruit. Chemistry is all throughout my job.	Feb 12, 2013 8:59 AM
2	While I may not be doing Chemistry in my day to day life, the classes, labs, and research helped me develop creative problem solving skills that I do use day to day.	Feb 6, 2013 8:25 AM
3	While my current occupation isn't in the field of chemistry, I view the discipline of chemistry, and the time I spent studying it, rich and valuable. My understanding of chemistry provides me with a deeper appreciation of the world that I couldn't have gotten otherwise.	Jan 29, 2013 2:42 PM
4	It's given me a strong background for my profession.	Jan 28, 2013 5:26 PM
5	Chemistry is so broad and interesting and I love that aspect.	Jan 26, 2013 3:38 PM
6	Grad school has helped me figure out what subject areas in chemistry I'm interested in and I have enjoyed every class I have taken so far, and the research I've been involved in here.	Jan 25, 2013 9:26 PM
7	I'm currently working in a lab that focuses on biology. While I have little to no interaction with chemistry on a day to day basis for my job, I do find that my knowledge of chemical interactions is beneficial and puts me above some of my peers who come from a strictly biological education background.	Jan 25, 2013 6:18 AM
8	I think Chemistry is very important and respect the people who can be passionate about chemical research. At some level everything around us is chemistry and to understand ourselves and our world better, we need the careful insight of skilled chemists	Jan 25, 2013 6:01 AM
9	Even though my job is classified as biochemistry, I frequently use my knowledge of chemistry to understand and interpret experimental results. Chemistry as a discipline is paramount to any scientific career.	Jan 24, 2013 8:36 PM
10	I have begun to appreciate chemistry more as I have learned that chemistry does not live in a vacuum. The field of chemistry enriches and is enriched by many other fields of research in both academia and industry. Observing and understanding how chemistry impacts researchers in many fields today gives me a very positive view of the discipline of chemistry.	Jan 24, 2013 7:04 PM
11	They only thing that could make me love chemistry more is if I could make ice cream with liquid nitrogen more often :P	Jan 24, 2013 4:31 PM
12	I admire people that can do it and enjoy it. Before I decided to do something else, I was scared I'd be working for a pharmaceutical company that did nothing but rewrap old drugs to get a new patent to keep making money. At the time, it seemed absolutely necessary to go to graduate school to do anything but be a lab rat	Jan 24, 2013 3:45 PM