

THE ACS REFORM OF INTRODUCTORY SCIENCE COURSES  
FOR  
NON-SCIENCE MAJORS PROGRAM

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**Final Report (10/15/06)**

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*The Impact of Highway Traffic on  
Atmospheric Chemistry and Biological Processes:*

*A New "Lab" Science Course for Non-Science Majors  
at Washington & Lee University.*

Date of grant approval: February, 2006

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### ***Report Summary***

In February of 2006, the ACS awarded the authors of this report (Hamilton and Tuchler) a grant to establish a new science course at W&L that would be directed at non-science majors and taught during W&L's Spring term. The equipment necessary for the proposed field course was received before the beginning of the Spring term and was successfully used by the students in the course.

The course, "Atmospheric Science: From the Ground Up", was taught during the 6 week spring term and had an enrollment of 11 students. The background of these students was mixed, ranging from no science background to one biology major with no knowledge of the atmosphere. The work accomplished by these students included classroom study, field research, data analysis, active discussion of the data, individual reports to the class, and active collaboration with both PIs regarding the field work and the individual reports. Finally, student evaluations of the course and a survey of student understanding of various terms and concepts introduced during the course were collected at the end of the term.

Data acquisition and analysis continued for 6 weeks during the summer of 2006 by an undergraduate student. This work involved both exploration of trends in aerosol formation noticed by students in the spring term and identification of additional sites for aerosol monitoring. Both Hamilton and Tuchler were active in the summer work. Based on this work, they have identified the need for pressure gauges on each weather station. The money for this purchase will come from internal resources.

This report will be structured according to the “Final Reporting Guidelines” provided by the ACS regarding the Keck program “Reform of Introductory Science Courses for Non-Majors”.

***Original Goals and Objectives:***

The four fundamental goals of this grant are:

- 1) to establish a field course to study the impact of local highways on both atmospheric composition and plant health as a function of distance and elevation relative to a major highway. This course is to provide credit for students general education requirement as a lab science course. This course is to have no prerequisites;
- 2) to provide non-science majors a science vocabulary and understanding of science methodology through both “active” (field research) and classroom learning as they address an important societal topic that is familiar to them and has significant implications for public policy;
- 3) to create a setting in which active, informed discussion can occur between scientists and non-scientists about a common, important issues affecting the community;
- 4) and to expose students to the inter-relationships among different disciplines of science and the importance of this relationship for addressing problems of societal importance.

***Ways the Goals/Objectives Were Met:***

- 1) In February of 2006, the PIs submitted a proposal to the University Faculty Committee on Courses and Degree describing the new course and requesting that the course fulfill a lab science general education requirement. The committee acted quickly to approve the course with its general education status and made it available for the spring term registration. (Bio/Chem 120, “Atmospheric Science: From the Ground Up”, 4 credits, General Education credit 5a for laboratory science);
  
- 2) At the end of the Spring term, the students were asked to fill out both course evaluation forms and vocabulary recognition and comprehension survey. The vocabulary covered in the survey ranged from concepts discussed in class (e.g., photosynthesis, respiration, tropopause, albedo, box model) to vocabulary that we would use regularly in the field or when analyzing data (e.g., transport, aerosol, PM 2.5). Generally, we were impressed with the results of the survey, as it demonstrated both recognition and self-reported comprehension of all the vocabulary. Note that the survey was taken at the end of the class. The next time the class is offered, the survey will be given both at the beginning and end of the course.
  
- 3) The group of students that were in this course had a broad range of backgrounds, many of which did not have science included. The discussion of the material presented in class was very active, with those who had the least

background providing the greatest number of questions. Although we tried to get the students to engage each other when asking and responding to questions, most responses to questions were provided by Hamilton and Tuchler. In the future, we will end the class with a series of questions that the students will need to investigate prior to the next class. The questions will be chosen so as to introduce the students to the topic to be discussed in the next class. These questions will be in addition to or replacing other homework that we assign.

The discussion of the field work was very active and collaborative among the students. This interaction was a major success for the course. The discussions ranged from how to problem solve difficulties that we encountered in deploying the equipment to developing a protocol for data acquisition to data analysis to seeking correlations among the variables measured in the experiment. With regard to seeking correlations, the students were introduced to statistical analysis using SysDat software. Their enthusiasm and competence in managing this software and extracting legitimate correlations was a pleasant surprise to both Hamilton and Tuchler.

- 4) As one would expect, this course exposed the students to elements of chemistry, biology, physics, and geology. In addition, engineering ideas were discussed when the class was in the field and we considered the design of the

equipment and the specifications of the equipment (especially regarding the DustTraks).

Based on their paper topics, student interest ranged from “Measuring Global Warming” to “Acid Rain: Sources, Formation, and Effects” to “Environmental Costs Alternative Fuel Sources”. All of the papers involved concepts and vocabulary that was introduced in the course, and many of the papers went well beyond the concepts and vocabulary introduced.

***The evaluation/assessment process used, including instruments used to evaluate/assess the project.***

We evaluated the student presentations in terms of their content and sophistication. We made clear that our expectation for their papers and presentations was that they would incorporate material from the course in such a way that they demonstrated understanding. Generally, the students received very high mark for their presentation and we were please with their comprehension of concepts of atmospheric science.

As Mentioned above, we also administered a survey (anonymous) and a course evaluation. The response to both is instructive and will help us modify the course. The course evaluations is included as an attachment to this report.

***If you were to redesign your project, what would you do differently and why? (What are the “lessons learned?”)***

Lesson 1: Assign more outside reading that will prepare the students for the material that is to be discussed in the next class.

Lesson 2: Expand the enrollment of the course in order to increase the amount of data that can be acquired and analyzed by groups of students. A larger collection of data will lead to clear trends in the evolution of aerosol mixing ratio when compared with other variables (e.g., temperature, humidity, wind speed, wind direction, sunlight).

Lesson 3. Design more robust weather stations that can withstand the “mistakes” that students make when setting up and breaking down.

***How have you shared the results with ACS colleagues and beyond ACS?***

Tuchler will present our work at the Science Reform and Teacher Education Workshop on October 26-28, 2006 at Birmingham-Southern College. Professor Linsey Marr from Virginia Polytechnical Institute will visit W&L this fall and we will discuss with her our program and any collaboration opportunities she may have. Professor Marr is an atmospheric transport modeler whose insights will be very useful as we move into the maturing phase of the project that was born as a result of this grant. Finally, Tuchler will attend the Atmospheric Chemistry Gordon conference in August of 2007 and will share our ongoing project and any results with scientists there.

***Complete financial statement:***

Proposed Budget Item	Quantity	Proposed Expense	Actual Expense
1 Dusttrak Aerosol Monitor Filter Cassettes for Particulate	2	\$9,000	10138
2 Analysis	6	\$450	300
3 Ashing Furnace	1	\$2,500	1500
4 Crucibles for Ashing	24	\$560	137
5 Portable Weather Stations	2	\$2,260	1467
6 Diffusion Tubes (NO <sub>x</sub> , SO <sub>x</sub> , and CO)	130	\$1,100	351

7	PI Summer Salary	2	\$4,000	4000
8	Summer Research Student	1	\$0	1550
9	Replace Wind Speed/Direction Smart Sensor (balance paid by internal grant)	1	\$0	550
			\$19,870	\$19,993

***Permission for the ACS to post original proposal and the results the work on the ACS Science Reform website.***

Hamilton and Tuchler hereby give the ACS permission to post the original proposal, *The Impact of Highway Traffic on Atmospheric Chemistry and Biological Processes: A New “Lab” Science Course for Non-Science Majors at Washington & Lee University*, and the contents of this final report on the ACS Science Reform website.

***Conclusion:***

Tuchler and Hamilton are very pleased with how effective this course has been. The eager participation by the non-science majors was better than expected and the results of our exit survey indicate that all students dramatically improved their vocabulary in the field of atmospheric science. The PIs are currently searching for additional funding to purchase two more DustTraks and two more weather stations as a first step to expanding the class for the next offering to much larger enrollments. We are grateful for the opportunity that the ACS and Keck have provided us with this course and look forward to sharing our results with you and other member of the community at the upcoming meeting at Birmingham-Southern University.

## Attachment: Course Evaluation

### 2006 Bio/Chem 120 - Atmospheric Science: From the Ground Up

**1. In what ways do you think this course can be improved or made of greater benefit, and still achieve its goal: “to apply basic principles of more traditional fields such as physics, geology, chemistry, and biology to describe the processes that control the chemical composition and evolution of the Earth's atmosphere and environment.”**

[organization is the key- keep things focused- do not include as much extraneous material that many don't have the background to comprehend.]

[I think this class could go in two directions. First, it could require a pre-requisite that would allow more advanced theory to go on in the lecture and lab. Or, it could remain as it is, which was very good, but be very careful to not leave any students behind who have little science experience on the college level.]

[More coffee.]

[Overall I felt the class accomplished this. Once there is a better feel for the equipment and data, I think this course will be even more beneficial.]

[I felt some of the material jumped from basics to really advanced in a matter of days without much explanation. It's a pretty advanced field and it could be overwhelming at times.]

[A bit more structure/order to the lecture series would be nice, sometimes it can be hard to connect different lectures to one another.]

[Spend more time concentrated on specific activities, have more direction and less free data time.]

[More of an explanation of statistics and using programs like SYSSTAT and STATVIEW at the start would have made it easier to analyze data.]

**2. Please comment on the format of the class. If you have suggestions regarding changing the format to improve the class, please include them here.**

[lecture was fine- I was not a big fan of the quizzes- for what they were, they shouldn't carry all that much weight. If you missed one question you basically have a C on the quiz- not all that fair. The lab portion of the class was extremely unorganized- for the next go around- make sure you have some assignment/ task for each lab period- give some sort of goal. I can think of at least 3 lab periods where almost nothing was actually accomplished- not because of apathy- but b/c no one actually knew what they should be doing- we had little to no direction.]

[pretty laid back. lectures had a conversational tone. made class enjoyable and interesting]

[I thought the format of the class was very good, I would not change it.]

[Having class from 8:00-10:00 then 1:00-5:00 is kind of brutal. Also, it would have helped to have a definite schedule for deployment/extraction.]

[Felt somewhat disorganized and inefficient. The lectures went in a logical order, but it seemed that especially in lab there was a lot of time being wasted.]

[I enjoyed the class format.]

[A schedule for collecting data would have probably produced more data. More structure in the data analysis would also have helped.]

[no 8 AM classes, at least wait til 9]

[It's harder to pay attention to a lecture or take a quiz at 8AM during spring term.]

**3. What was(were) your favorite topic(s)?**

[I enjoyed learning about greenhouse gases and global warming's repercussions towards photosynthesis.]  
[the carbon cycle]

[I really enjoyed learning about weather patterns and transport, and how the affected particulate matter. I also enjoyed learning about greenhouse gases and global warming.]

[Greenhouse gases and global warming were interesting.]

[I enjoyed most of the chemistry topics, especially when we talked about how the chemistry changes at different altitudes in the atmosphere.]

[Global climate change and the ozone layer. ]

[Carbon cycles and their influences on global warming.]

[GHGs and global climate]

[Greenhouse gases, ozone]

#### **4. What was your least favorite topic?**

[all of the cycles- it was never very clear what we should have taken away from each cycle/ how much we should know]

[the nitrogen cycle]

[The nitrogen cycle.]

[Carbon/nitrogen cycles.]

[The carbon and nitrogen cycles. Lots of numbers and figures and too little explanation of the actual processes.]

[The Carbon, Nitrogen and Oxygen cycles.]

[Box models. Easy enough, I think less time could have been spent on these.]

[nitrogen cycle]

[Nitrogen cycle]

#### **5. Is there anything that we did not cover that you would have liked to cover?**

[can't think of anything right now]

[No.]

[Nope.]

[We covered a lot in six weeks, and I think a pretty good job was done with a least touching on a lot of topics. The paper/presentation assignment allowed for individual explorations of topics of interest.]

[No.]

[Alternative energy sources, but student presentations covered them to some degree.]

[more in depth climate aspects]

[Since we focused on I-81 in our lab work, explanation of vehicle emissions, specifically truck emissions, would have been helpful.]

#### **6. If you have any additional comments, please include them here.**

[Make your expectations more clear and I think everyone would appreciate the class more- I felt like I was just floating around without direction for most of the term. I also don't feel overly comfortable with huge portions of my grade being completely subjective.]

[I really appreciated that the professors recognized and didn't care that I was a non-science major. This made me more at ease to ask questions and take a genuine interest in the material. I definitely learned more than I was expecting to learn.]

[Organization, please!]

[Thanks for the food.]

#### **7. Please comment on the ease of use of the field study equipment.**

[very simple to use- the GHG detecting vials are not easily read- but everything else is ok]

[not difficult. small learning curve.]

[I thought the introduction to the use of the field equipment was very thorough, and I was very comfortable setting them up and disabling in the field by myself/with other students.]

[Very easy.]

[Great hands-on experience with actual experimental data collection.]

[They were easy to use.]

[Very easy to learn.]

[using the field equipment was useful to getting an understanding of how research is conducted, since our results are somewhat inconclusive, we're left wanting more]

[DustTrack and Weather Station were really easy to set up and use.]

**8. Please comment on your experience with data analyses. Specifically, comment on what you learned from performing this analysis.**

[I didn't learn all that much- but it was nice to re-familiarize myself with excel and learn the basics of the two other programs we used intermittently]

[gained an understanding of statistical programs and the production of graphs to observe the correlation between two data fields]

[I learned a great deal about data analysis, especially using new computer programs, statview and such, that were different from excel. I think these skills will be applicable in almost all my other courses of study. I also enjoyed comparing the graphs and figuring out trends, it made out work more exciting.]

[Data analysis gave me a much better understanding of Excel and more confidence in my ability to interpret the results of an experiment. Also, it was a great opportunity to apply what I had just learned in my Statistics class to real world data.]

[Interesting if somewhat unproductive. Useful at first, but became pretty monotonous after a few weeks. A learning experience for everyone that could definitely be improved for future classes.]

[I learned some from data analysis, but the comparisons were not all that conclusive. I felt that I lacked the experience with the statistics program to perform efficient analysis.]

[Systat refresher. Spending one lab period going through statistics terms etc. to a larger degree might have been productive.]

[we spent a lot of time analyzing the same information and could have learned more techniques or tools to analyze it instead of doing the same thing over and over]

[Having a wider variety of days and times would have been more useful. It was difficult to look at the effect of certain factors such as wind speed when all data that has low wind speeds also has high humidity. Also we don't know what effects high volumes of truck traffic have as we didn't get to compare days with high vs low truck traffic.]

**9. Please include any additional comments on your field/laboratory experience.**

[Great experience being able to look at experimental data as opposed to lab data with a generally known outcome.]

[It would have been nice to have been able to use more of the equipment earlier in the term.]