

To: Lori Gonzalez, Provost and members of the General Education Advisory Group
CC: Kenneth Peacock, Chancellor
CC: Anthony Calamai, Dean College of Arts and Sciences
CC: Claudia Cartaya, Chair A.R. Smith Department of Chemistry
From: Faculty, A.R. Smith Department of Chemistry
Re: Response to June 19, 2012 General Education Advisory Group Report
Date: September 27, 2012

The A.R. Smith chemistry faculty was dismayed by the June 19, 2012 General Education Advisory Group (GEA) proposal to reduce the requisite hours for Science Inquiry from 8 c.h. to 7-8 c.h. We strongly oppose this change. This proposed change effectively drops one of the two laboratory courses currently required and destroys the model of a tightly choreographed lecture/laboratory sequence.

I. Why Scientific Inquiry Is Integral to the Education of Our Students.

At some point during their development most every child innocently will ask, “Why is the sky blue?” As answered by an anonymous grade school teacher, “The sky is blue because it reflects the color of the ocean.” When further asked, “Well, why is the sky blue in Iowa?” the teacher responded, “Because the ocean is so big.” If this were your child wouldn’t you want the teacher to offer an age appropriate yet correct explanation of light refraction and Rayleigh scattering? Even the reply “I’m not sure, but we can go find out!” would be much better than an incorrect answer because it would demonstrate the investigative skills necessary to find answers and fuel the spark of inquiry that excited the child.

Science pervades our lives from the simplest childhood questions to the most complex technological innovations. Many citizens are not professional scientists yet play a profound role in developing the policies, regulations, and undertakings based on processes ruled by science. As citizens of a democratic society, and as the stewards of our own bodies and environment, it is our responsibility to have a functional understanding of the world around us. We need to learn to appreciate the context of our actions and gain the ability to distinguish truth from fallacy. For many Appalachian students, General Education Science Inquiry is the last formal science education they will receive. Our current Science Inquiry program teaches students the critical thinking, problem solving, and quantitative reasoning skills needed to be responsible citizens and participate in meaningful careers in the 21st century.

Overall, the value of science education is highlighted in a recent PCAST report emphasizing, “a need for approximately 1 million more STEM professionals than the U.S. will produce at the current rate over the next decade if the country is to retain its historical preeminence in science and technology.”¹ Comparable sentiments have been expressed in many reports examining educational outcomes at the national level, such as *Rising Above the Gathering Storm* (RAGS). In this latter report, the need for a STEM educated workforce is juxtaposed against the reality that while approximately, “30% of students entering college in the United States intend to major in science or engineering,” these programs have, “the lowest retention rates among all academic disciplines.” The RAGS report goes on to call for, “a focused and sizeable national effort to stimulate undergraduate interest and commitment to... {STEM}... majors.”² Closer to home, the 2007 UNC Tomorrow report notes that college graduates, “must possess the ‘hard skills’ that are

relevant to the global economy and to dynamic business needs, such as expertise in science, mathematics, and technology.”³ This aspiration is echoed in a 2006 survey of business leaders, which found that an increased emphasis on science and technology was the most widely desired change to higher education.⁴ Science education, and the quantitative literacy that supports it, are essential components of the well-rounded liberal education that will prepare graduates for the careers of the 21st century. Any threat to the quality of science and math education in this country is a threat to the future competitiveness of America in an increasingly technological and global economy.

II. The Chemistry Department Response to the GEA Suggestions.

The GEA states three reasons for the proposed change, summarized as:

1. Science Inquiry goals can be met through “lecture-mediated examples and exercises” in place of some laboratory hours,
2. a reduction in hours will make better use of limited resources and,
3. there will be a reduced burden on transfer students for meeting the Science Inquiry requirements.

We emphatically disagree with each point of this assessment. First, there is a logical disconnect between the first and second justifications provided by the GEA. As was eloquently noted in a September 5, 2012 memo from the General Education – Science Inquiry Faculty Coordinating Committee, inquiry-based lectures can be an effective pedagogical technique, but only when resources are available to accommodate small, material-intensive lectures. The cost of implementing such inquiry-based lectures may well exceed the cost of maintaining our current, effective model.

Furthermore, though lecture courses do an excellent job imparting the knowledge of a discipline, students learn the process of science in the laboratory. A laboratory course offers the experiential learning that is central to understanding. Science is an inherently iterative process that requires the constant questioning of prevailing dogmas and the verification of results. Experiential learning develops the abilities one must have to accurately observe the world around you, draw conclusions from raw data, and understand that something may not be true simply because “experts say so” in a news bulletin. It is in the laboratory where students gain the confidence to apply scientific principles to activities in their daily lives. A student may learn facts in a lecture, but a student learns science when they troubleshoot a failed experiment in the laboratory or have an exciting and possibly career-changing “eureka” moment. Teaching science without a laboratory is like teaching dance by looking at pictures of the steps.

In response to the GEA’s third rationale for the proposed change, while we are concerned with the difficulties facing transfer students, a sampling of Fall 2012 enrollment suggests that less than three percent of incoming students would be affected by the proposed change to the Science Inquiry requirements.⁵ Our department already provides 1 c.h. laboratory courses that can remediate deficiencies in transfer student records. Informal conversations with other Science Inquiry departments indicate that each would be willing to offer 1 c.h. options such that transfer students can complete General Education without undue burden. We do not believe that weakening the General Education requirements for all students is an appropriate solution and

strongly advocate discussions to accommodate transfer students without degrading the entire program.

Many students are undecided on the path they might choose when they begin their education at our university. General Education allows students to sample many disciplines and many students are recruited into a Chemistry major after experiencing inquiry-based learning and one-on-one student/faculty interactions in introductory labs. The proposed changes would mean the de facto elimination of the second semester laboratory (CHE1120) from the General Education curriculum. While the first-semester laboratory provides a scaffold for further learning, many of the most interesting concepts only are addressed in the second-semester laboratory once students have sufficient background to appreciate the context. Without experiencing the dynamics of a second semester lab many students may miss the opportunity to consider science for their career, short-changing Appalachian graduates of a well informed career choice. By discouraging students from taking a second lab course, the proposed change may set a student behind in their schedule to graduate if they later decide to major in a science, since they will need to go back and complete their second lab before progressing further in their science major. The proposed changes to Science Inquiry would weaken our curriculum more than is implied by the elimination of a single credit hour.

The GEA proposal also deviates from recent national efforts to enhance laboratory experiences by incorporating research-based coursework into the introductory laboratory.⁶ Undergraduate research experience has been shown to increase student retention in the sciences, especially among underrepresented minorities.⁷ Consequently, major initiatives are underway (for instance the UT-Austin FRI program⁸ and the Ohio REEL program⁹) to engage more students in STEM disciplines through publication-quality scientific research in place of the traditional freshman laboratory experience. The GEA instead proposes weakening our own science and math requirements, thus lessening the impetus for students to pursue STEM careers.

Robust general education programs in American universities have been credited with helping to close the science education gap between the United States and other nations when comparing individuals with high school and bachelor's degrees.¹⁰ The proposed changes to Science Inquiry and Quantitative Literacy in our General Education Program threaten this success. These proposed changes will provide little or no cost savings, will not ease the course burden for a significant fraction of Appalachian students, and will not adequately prepare our graduates for the future.

The success of Appalachian graduates in attending graduate or professional schools, attaining meaningful careers, and contributing to the well being of society results from the rigor of our current standards. Weakening the requirements for Science Inquiry and Quantitative Literacy would be a disservice to our students, our state, and our country. Additionally, renaming Science Inquiry as Science Literacy falsely would imply that students can learn science at arms length as they read about it. This is simply not the case as science is a "hands-on" discipline.

We adamantly oppose all three of these GEA proposals.

¹ Executive Office of the President, President's Council of Advisors on Science and Technology (2012) *Report to the President, Engage to excel: Producing one million additional college graduates with degrees in science, technology, engineering, and mathematics*. www.whitehouse.gov/sites/default/files/microsites/ostp/pcast-engage-to-excel-final_feb.pdf (Accessed September 21, 2012).

² National Academy of Sciences Committee on Prospering in the Global Economy of the 21st Century: An Agenda for American Science and Technology, National Academy of Sciences, National Academy of Engineering, Institute of Medicine. (2007). *Rising above the gathering storm: Energizing and employing America for a brighter economic future*. http://books.nap.edu/catalog.php?record_id=11463 (Accessed September 21, 2012).

³ University of North Carolina Tomorrow Commission (2008) *UNC Tomorrow Final Report*. http://www.northcarolina.edu/nctomorrow/reports/commission/Final_Report.pdf (Accessed September 21, 2012).

⁴ Hart Research Associates (2009) *Trends and Emerging Practices in General Education*. <http://generaleducation.appstate.edu/trends-and-emerging-practices-general-education> (Accessed September 21, 2012).

⁵ Rex, J. Director, Office of Transfer Articulation. Personal communication. September 19, 2012.

⁶ (a) Weaver, G. C.; Russell, C. B. and Wink, D. J. (2008) Inquiry-based and research-based laboratory pedagogies in undergraduate science. *Nature Chemical Biology*, 4, 577-580. (b) Peterson, E. and Hunter, R. F. (2012) Making bigger better: Scaling up research opportunities in introductory science courses requires a new way of thinking and working. *HHMI Bulletin*. http://www.hhmi.org/bulletin/may2012/features/research_courses.html (Accessed September 21, 2012).

⁷ Russell, S. H.; Hancock, M. P. and McCullough, J. (2007) Benefits of undergraduate research experiences. *Science*, 316, 548-549.

⁸ <http://fri.cns.utexas.edu/> (Accessed September 21, 2012).

⁹ <http://ohio-reel.osu.edu/index.php> (Accessed September 21, 2012).

¹⁰ Raloff, J. (2010) Science literacy: U.S. college courses really count. *Science News*, 177 (6): 13.