Subcommittee on Research and Science Education
of the House Committee on Science and Technology

"Improving the Laboratory Experience for
America's High School Students"

Testimony

Submitted by
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My position with the Chemistry Department at Cleveland State University (CSU) has provided me the opportunities to assess the status and effect of high school science laboratory instruction from two perspectives: 1) the performances of the students, both prior to and as they enter into post secondary science education; and 2) the information I have received either directly from public school teachers whom I have taught as part of the Ohio Teaching licensure program or those teachers I have interacted with in several CSU/Cleveland School programs. Although most of my teaching at Cleveland State University has been involved with students enrolled in freshman chemistry courses, I have had many occasions to instruct high school students (*CSU Upward Bound Summer Program*), Middle School Teachers (*Mathematics and Science Partnership*) and High School Teachers (*Cleveland Teaching Leadership Program*). Through these interactions with both students and teachers, including my participation in programs such as the regional *Northeastern Ohio Center for Excellence*, *NEOCEx,* and the CSU funded 9 – *16 Committee* I believe myself to be adequately prepared to both comment and recommend

on the subject of the importance of science laboratory experience in the education of high school students.

While preparing my testimony for this Subcommittee, I decided to put the numbers and studies aside for a moment and indulge the thoughts of those primarily affected by this situation. Instead of starting the 8:30 lecture with a graded quiz question projected on the two screens at the front of the lecture hall, I confronted my general chemistry class with some background questions concerning their high school laboratory experiences. My survey consisted of several questions, to which the students would respond with their "clickers" (i.e. electronic personal response transmitters).

Of the 66 students who participated in the survey 85% took a high school chemistry course which contained a laboratory component. Although 79% of those students felt that their lab instructors were well informed, only 62% believed the lab instructions were clear and comprehensive, and only 56% thought the labs were well equipped.
Having addressed the instruction and equipment aspects of the courses, I used the final three questions of the survey to summarize their high school lab experiences:

1) *Did the lab portion of the course help you to better understand chemical concepts? (44% agreed)*;

2*) Did the lab portion of your high school chemistry course stimulate your interest in chemistry? (33% agreed)*;

and finally, 3) *Did the lab portion of your high school chemistry course help to prepare you for your college chemistry course? (21% agreed).*

Although this survey only represented a minor population of all those CSU students enrolled in the College of Science, the results parallel the current national trend of students receiving substandard or insufficient high school science laboratory experience. Although I presently do not have the tools to accurately quantify the success or failure on individual high school chemistry lab courses, I do have first hand experience with incoming freshmen who generally lack the sufficient interest or skills to properly engage in a college chemistry course.

Each fall semester, the final grades of my General Chemistry course reflect approximately 25% of the class receiving letter grades of D, F, or W (a withdrawal from the course). The 2006 Book of Trends published by Cleveland State University indicates similar final grades in other freshman science courses: College Chemistry courses (Chemistry for non science majors) with 33% - 36% of the class receiving letter grades of D, F, or W; and entry level Biology courses with similar results. Results which indicate that 25 – 36% lack the sufficient foundation in science to successfully compete in post secondary science courses.

Similar trends are occurring at the university level at CSU. As an urban university, consisting of 18% Black and 2% Hispanic student enrollments, retention rates of 41% and 36% respectively are of much concern.

In a response, to better prepare high school students for the academic challenges of post secondary education, CSU has aligned itself to the teachers in primary and secondary

institutions by participation in grant programs designed to better prepare the public school students for post secondary education:

1) *Teaching by Inquiry: Nature of Science, Academic Standards, and Supervising of Instruction.* PI: Dr. Frank Johns, Professor Emeritus, College of Education, Cleveland State University.

   Teaching secondary school principals to observe and evaluate science lab teaching.

2) *Partners for Success,* PI: Dr. Joann Goodell, Associate Professor, College of Education, Cleveland State University, and Facilitator: Dr. Robert Ferguson, Assistant Professor, College of Education, Cleveland State University.

   Augmentation of content knowledge and including laboratory experience. The program consists of four meeting sessions over the academic year and a one week session during the summer, with a two commitment by each cohort.

3) *Urban Stream Scholars,* PI: Dr. Robert Ferguson, Assistant Professor, College of Education, Cleveland State University, and Dr. Michael Walton, Associate Professor, College of Science, Cleveland State University.

   This program trains secondary school teachers to perform science labs and incorporate research methods and hands-on activities into the classroom (start up date: summer 2007).

4) *Mathematics and Science Partnership,* PI: Dr. Joann Goodell, Associate Professor, Cleveland State University

CSU is working in collaboration with Youngstown University, John Carroll University, and the University of Akron to educate both Middle School and High School Teachers in the content of laboratory training in the sciences.

5) *NEOCEx,* PI: Dr. Joann Goodell, Associate Professor, College of Education, Cleveland State University; CoPI: Dr. Roland Pourdavood, Associate Professor, College of Education, Cleveland State University.

Northeastern Ohio Research Center for Excellence consists of four universities: Kent State University, University of Akron, Youngstown State University, and Cleveland State University

The focus of the research is to understand and interpret how the Learning of Science and Mathematics effects high school students' attitudes and disposition toward science.

Throughout my years as a teacher of freshman chemistry, I had tried various ways of engaging the interest and commitment of my students enrolled in one of the traditional lab courses with varying degrees of success.

An instructive laboratory exercise doesn't need to be costly, dangerous, or steeped in convoluted instructions and incomprehensible scientific concepts. With a laboratory

balance, a package of toy balloons, and a three dollar package of dry ice, I have conducted the following exercise in an ordinary classroom and illuminated a couple dozen students about the nature of gas behavior, the function of proportionality constants, the implication of significant figures, and the importance of group work:

Before conducting the exercise, the students break into groups of three and each group receives a balloon. The groups are instructed to record the mass of the balloons before the instructor places approximately one gram of dry ice into the balloons. The groups then tie off the end of their balloons before recording the mass of the balloons containing the dry ice. After the dry ice has completely sublimed and the balloons are completely inflated the groups are instructed to measure and record the circumferences of the balloons.

With the mass of the dry ice and the circumference measurements, students are instructed to 1) calculate the volume of the balloons using the proper numbers of significant figures, and 2) determine the value of the proportionality constant in the equation relating the volume to the mass of dry ice. Another sample of dry ice in a weighed balloon is given to each group. Using the derived equations, each group is instructed to calculate the expected volume their balloon should produce. Finally, the calculated volumes are compared to the resultant volumes.

I have presided over this exercise in classrooms of high school students, classrooms of college students, and classrooms of school teachers with similar positive results in all.

The high school laboratory experience can also be set up with real research situations in which the students learn to function and think as scientists. Early in my career, first as an industrial research chemist with the Lubrizol Corporation and later while working on my doctorate degree at Case Western Reserve University, I found laboratory routine and research the most vibrant part of my work. Whether it was a problem involving chemical synthesis or the employment of investigative techniques to characterize substances, the physical pursuit of the science was always pulling me back into the laboratory. It is the nature of this physical pursuit which can inform, and sometimes enlighten, and within the proper setting, such as a high school laboratory, even provide opportunities of growth and inspiration.

Traditionally these opportunities cannot be found in the normal experiences found in high school science labs, which are highly structured around classical laboratory techniques and chemical synthesis. These exercises although instructive, don't motivate or inspire. It should be our chief concern to replace the traditional high school lab exercises with experiences of exploration and discovery. With the participation of local colleges and universities, such laboratory experiences maybe developed and readily accessible to area high school students.

An example of such a program is now ongoing at CSU: The Chemistry Department of Cleveland State University is participating in a 5 year NSF funded program, which provides such opportunities for its undergraduate students. The *Research Experience to Enhance Learning* program addresses the issue of students experiencing the discipline of

Chemistry through participation in actual research situations. Instead of performing a series of lab "experiments" listed on a syllabus, the students learn to design and execute green chemistry experiments performed on local environmental samples. At this time, the focus of the work is on the presence of PAH, polyaromatic hydrocarbons-- pollutants that exist in the Cleveland community. During the course of the semester, students utilize many of the topics covered in the corresponding General Chemistry lecture in addition to advanced laboratory instrumentation and techniques unavailable to students enrolled in traditional general chemistry lab courses. The assessment at the end of the course is based on individual Power Point presentations of each student's research accompanied by their written reports. Students are also encouraged to publish their research in the *Journal of Undergraduate Research* as well as making presentations at the REEL Chemistry symposiums and local ACS Meetings in Miniature.

Although this particular program is set up on a university campus, with additional funding and proper training of school teachers, this type of program could be offered at a secondary school level. Within this type of laboratory experience, students are soon to acquire a sense of ownership of the subject. Participating in actual research situations instills maturity in students. They are no longer just learning for the grade, but instead applying their knowledge to real life problem solving. But this depth of experience for the students would only come with a similar depth of commitment from the teachers.

In conclusion, I strongly support House Bill HR 524 goals of enhancing the teaching of laboratory teaching in the High Schools. Of the articles under subparagraph B, article v,

which identifies the need of funding for *professional development and training for teachers*. As important as supplies, equipment, and well constructed laboratories are in the implementation of a viable teaching program, I strongly believe that the failure of our high school students to successfully participate in college level science curriculum is, in part, due to our failure to inspire them. This inspiration will only come from well informed teachers with strong attachments to their subjects. But I further recommend that a continuous series of science courses will not remedy this situation. Good science teachers need to be well grounded in their turf. They need opportunities outside of the normal course work to continually develop not only as teachers, but also as scientists. And this can evolve by building closer associations between the secondary school teachers and the college and university research faculty. By implementing programs which enable school teachers to actively participate in summer research opportunities within their area universities, high school teachers would be better able to appreciate and understand the nature of science.