

General Chemistry – Looking In from the Outside

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INTRODUCTION

When I was asked to "speak" at this internet symposium a few months ago and was told the topic was "General Chemistry", I wasn't sure I could offer anything of value to it. After all, I am a chemical technologist working in an industrial R&D lab and I haven't really thought about General Chemistry courses for about 20 years. The organizer, who had heard me speak on something I do know about (polymer chemistry and the importance of including it in a Chemical Technology curriculum), thought I did. After pondering a little, I decided I did have a couple of things to say about general chemistry specifically and the teaching of chemistry generally. I decided to say a bit about something that I think is missing from many chemistry courses – real-world industrial chemistry and all the great things that have been accomplished by industrial chemists. I also wanted to include some input from those closer to General Chemistry than I, so I conducted an informal survey of the co-op and intern students working at The Dow Chemical Company this summer on their experiences in General Chemistry. All of them had taken General Chemistry within the past few years, and I think you will find some of their comments interesting, and perhaps surprising. Finally I will make a few comments on how I think most undergraduate chemistry degrees prepare people to work in industry. Please note that this will be an informal paper, intended to stimulate discussion, and the opinions I express are my own unless I attribute them to others.



WHERE ARE ALL THE GREAT THINGS THE CHEMICAL INDUSTRY DOES?

Those of us whose vocation is in the chemical sciences know that one thing we often come up against is the poor public perception of chemistry – and particularly of the chemical industry – even among well-educated people. A recent guest editorial by Bill Stavropoulos, CEO of The Dow Chemical Company, in *Chemical & Engineering News* (1) stated that a survey conducted by the Chemical Manufacturers Association pointed out that most people don't know much about the chemical industry and they don't see it being relevant to their daily lives. They also found that the majority of people are willing to hear more about the industry before they make up their minds, one way or the other. To quote Stavropoulos' editorial, "the science of chemistry and the chemical industry have prevented death and eased suffering, extended life, and improved the quality of life for people in the developed world as well as some of the most remote places on Earth". What bothers me is that even though many people take chemistry in high school and college, they are not introduced to all of the wonderful things that chemistry has done. This was brought home to me a few years ago when I interviewed a graduating student applying for a position as a lab technician at Dow. Even though she was applying for a job in the chemical industry, she still saw the industry as one of the "bad guys" – polluting our environment with all those "toxic chemicals" and her ultimate goal was to work for the EPA. Scary, isn't it, to think that someone educated in chemistry still has such a low opinion of the industry?



Since I had not been in a General Chemistry class for 20 years and had not seen a text the same amount of time, I asked some of my educator friends to lend me copies of texts that are commonly used. You will find a list of the seven texts I perused as an appendix to this paper. I hope they are representative. Below are a few general comments on what I saw in these texts:

- The same basic topics I learned in General Chemistry 20 years ago are still being taught today. Although a somewhat longer time period, this is in general agreement with the findings by Hesty L. Taft of the Educational Testing Service, Princeton, NJ, who stated the College Board's surveys at "leading colleges and universities" (2) found "relatively minor changes in content" between 1986 and 1993.
- They have added information on environmental chemistry and biochemistry (a good thing).
- They have examples and excellent photos of chemical reactions and chemicals.
- Most do a great job in relating chemistry to everyday life.
- Only two of the seven texts regularly included examples of industrial applications of chemistry, two others had only few examples and three barely mentioned the existence of the chemical industry!



I do realize that the text doesn't reflect everything that is taught in a course, and I hope that where the text fails the instructor steps in and makes up for it. But in my experience (and I have interacted with quite a number of educators through the Partnership for the Advancement of Chemical Technology and the Center for Chemical Education at Miami University), many of those who teach chemistry and chemical technology are far removed from industry. They normally have not had the opportunity to interact with industrial people regularly or to work in industry.

General Chemistry is a course taken by many people – those planning careers in scientific fields and others. Shouldn't this be a time when they are introduced to the wonderful world of the chemical industry? We all think the ads are kind of hokey, but shouldn't they learn "What Good Thinking Can Do" (The Dow Chemical Company), and "The Miracles of Science" (E. I. du Pont de Nemours and Company), about "Expertise with Responsibility" (Bayer Group) and "Simply Great Chemistry" (Union Carbide)? Ad campaigns aside, shouldn't students learn how agricultural chemicals have increased food production to help feed the world's hungry, how chemicals (pharmaceuticals and other medical products) have increased their life span and their quality of life, how chemical companies are creating less waste



and are active participants in Responsible Care (the Chemical Manufacturers Association continuing effort to improve the industry's responsible management of chemicals), that "all natural" and "organic" products still do contain chemicals -- just naturally occurring ones, and how chemistry *is* the "central science" and is needed to learn about other sciences and about everything around us?! If, as a regular

part of *all* chemistry courses from high school through college, students are given information about the chemical industry and the real people who work there – chemists, chemical engineers, technicians, biochemists – perhaps in another generation or so, chemistry and the chemical industry will be found at the top of the opinion polls instead of near the bottom. Ultimately these kinds of efforts may help assure the long-term viability of the chemical industry by motivating young people to consider technical careers and by making the public perception of science more favorable.

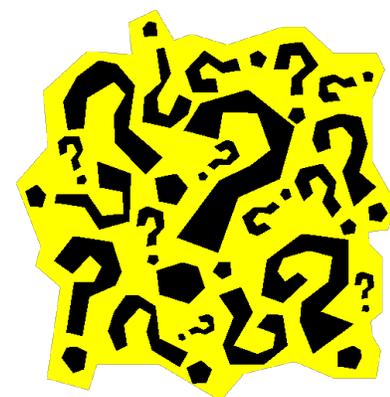


STUDENTS' VIEWS OF GENERAL CHEMISTRY

I sent an e-mail survey to 126 students working as summer interns or co-ops at The Dow Chemical Company asking the following questions:

What was the course title and the name/author of the text?
What was the lecture hours/lab hours split?
Looking back on what you learned in general chemistry:

- What was missing?
- What was over-emphasized?
- What helped you with your co-op / intern experience?
- What helped you in subsequent courses?
- What would you have changed about the course or how it was taught?
- Finally, please give me any general comments about your experiences in general chemistry -- what you liked, what you didn't like, or any other comments you may have.



I received 31 responses, about 25%. Not all questions were answered on all returned surveys. The students are all undergraduates at a variety of colleges and universities across the country, very good to excellent students, most majoring in chemistry or chemical engineering.

Most respondents could not remember the name of the text they used or the author. Most also could not remember or failed to answer the question on the numbers of hour in lab and lecture. For the ones who did answer, 3 hours in lecture and 3 hours in lab was a common split. A couple students had no lab with the lecture. A few also had a recitation period.

Students found only a few things missing from General Chemistry:

- an introduction to organic chemistry would have been helpful
- the math was oversimplified
- basic information was skipped because the prof assumed that everyone had high school chemistry (from a computer science major)
- industrial chemistry



There were many more answers to what was over-emphasized:

- nomenclature (many agreed here -- it was the most common answer)
- conversions
- the electron shell
- too many examples done in class
- balancing redox equations
- electrochemistry
- biochemistry



As to what helped with co-op experiences or with subsequent courses, most commonly it was the overall general knowledge of chemistry and lab techniques. Specific answers included the following:

- organic chemistry (mentioned several times)
- periodic table
- dimensional analysis
- significant figures
- stoichiometry
- balancing equations
- molecular weights
- nomenclature



- acid-base reactions



The most common answer given in how the course should be changed was to reduce the class size. Most students were in large lectures. The second most common suggestion for change was that more emphasis should be given on realistic problems and the relevance of what is being learned (**Why** is it important to know this?).

General comments, by and large, had to do with how good they thought the course was or was not. The number one reason for thinking a course was good was the person who taught it – many respondents said they had a great professor!

The most surprising thing about this survey was that the most common answer to all the questions on "what you learned in general chemistry" was "I don't remember". One person wrote that he didn't remember anything from General Chemistry and another wrote that he didn't remember anything from his whole freshman year! And these are all students that are probably at or near the top of their classes!

General conclusions I would draw from this un-scientific survey is that students want a great professor, smaller classes, more organic chemistry, less nomenclature and more relevance. But overall, these students thought that their General Chemistry classes were helpful in their subsequent courses and their industrial co-op jobs because of the good basic knowledge they gained in chemistry and lab techniques.

ARE THEY REALLY PREPARED?

Finally, I'd like to say a few words about the readiness of students graduating with a baccalaureate degree in chemistry to work in industry.

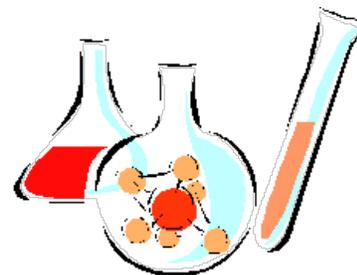


Many companies these days have fewer entry-level positions for BS level chemists. Why is this? Technicians are doing the jobs that BS chemists did just a few years ago – bench chemistry and analytical work, technical service and development, managing quality control labs and more. Scott Read, then a recruiter for Proctor & Gamble in Cincinnati, stated at a recruiters' panel discussion at the August 1994 American Chemical Society (ACS) meeting that although there are only a "minuscule number of A.A.S. graduates" each year, they prefer to hire them because "B.S. graduates are geared for graduate school, not industry". This was echoed in a survey done for the ACS by Arcola Research Company in 1995 (3) which found that even if they could hire BS degreed people, employers preferred to hire those with associate degrees for laboratory jobs. That is not to say that a BS degree in chemistry isn't worthwhile. It is a great preparation for graduate school no matter what the student's ultimate goal may be. Combined with an MBA or even just a minor in business as an undergraduate, it can lead to great opportunities in technical sales and market research. Many smaller companies hire BS chemists to work in or manage their labs. A BS degree in chemistry plus applicable work experience is very advantageous – for example, working technicians who obtain their BS increase their value to their employers and the likelihood of advancement. But, if you want to be hired right out of school as a chemistry professional, the trend seems to be moving toward hiring those with advanced degrees,

preferably PhD's, or associate degrees. One possible exception may be the relatively new bachelor's degree in Chemical Technology offered by the University of Cincinnati. In that program students have several terms of co-op work combined with laboratory intensive coursework. It may be the ideal program for those interested in an industrial career with a baccalaureate degree.

CONCLUSION

My "view from the outside" of General Chemistry is that for the most part, it prepares students well for the work ahead of them in the classroom or as an industrial co-op or intern. Could General Chemistry be improved? Of course. Including more industrial content shouldn't be too difficult to achieve - use a more "industry-friendly" text, invite an industrial chemistry professional to the classroom or laboratory, take a tour of a chemical plant or research lab, assign students to learn more about the history of the chemical industry in your area, use materials in class produced by industrial companies (educational materials are available from most major chemical companies). Even more important is the industrial awareness of the instructor. That will take more time and effort, but could be achieved by attending industrial seminars, gaining industrial experience by internships, or forming a local alliance with industrial and academic partners to review course content and revise labs to be more closely aligned with work experience. These kinds of efforts could do wonders for the future of chemistry.



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REFERENCES

1. *Chemical & Engineering News*, 77 (22), May 31, 1999.
2. *Journal of Chemical Education*, 74 (5), May 1997.
3. *Chemical Technician Study* prepared for the American Chemical Society, Arcola Research Company, March 1995.

APPENDIX



General Chemistry texts:

Chemistry, 4th Ed., Zumdahl

Chemistry & Chemical Reactivity, 4th Ed., Kotz and Treichel

General Chemistry, 5th Ed., Ebbing

Chemistry, 2nd Ed., McMurray & Fay

Chemistry, The Study of Matter and Its Changes, 2nd Ed., Brady and Holum

General Chemistry, An Integrated Approach, 2nd Ed., Hill and Petrucci

Chemistry, 6th Ed., Chang

BRIEF PROFESSIONAL BIOGRAPHY

Connie Murphy is a Sr. Research Technologist in Materials Research & Synthesis of Corporate R&D at The Dow Chemical Company in Midland, MI. She obtained an Associate in Applied Science degree in Chemical Technology from Milwaukee Area Technical College in 1980. She has been involved in the leadership of the American Chemical Society (ACS) Division of Chemical Technicians (TECH) since its formation, serving as the 1996 Chair and currently as TECH Councilor and Webmaster. She has been featured in several articles, books, magazines and brochures about chemical technicians' careers and has been an invited speaker at several forums and symposia, speaking on career and educational issues. She serves on the Advisory Committee for the Chemical Technology program at Delta College and is a member of the ACS Chemical Technology Program Approval Service (a subcommittee of the Society Committee on Education). In 1994 she was honored by the Outstanding Technologist Achievement Award, presented by the Dow Central R&D Scientists Organization, and in 1997 was the recipient of the Midland Section of the ACS Outstanding Chemical Technician Award.

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