provocative opinion

Are the "Best" Universities Wasting Chemical Talent?

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Is there a generalized perception at the most prestigious universities, for example, some of the Ivy League, some of the West Coast, and some of the major Midwestern public and private universities, that only the most single-minded and most dedicated students can possibly hope to succeed in the undergraduate chemistry curriculum? Is there, in fact, at the smaller, highly to extremely selective colleges, a different perception of the chemistry major as a hard-working and very bright, but not totally single-minded, individual? Are students who have been adjudged successful candidates by organizations such as the International Baccalaureate and Advanced Placement entering university chemistry courses beyond the introductory level with generally positive expectations but finishing their first year at major universities feeling that they are oversold on the subject in high school, that the drudgery involved is not compensated for by the intrinsic fascination of the subject? If the latter is often true, is that an indictment of university chemistry or just an indication that the sorting processes of the higher education processes are working as they should? Is it possible that some universities are purposely placing obstacles in front of talented students in their zest to have their graduates recognized as having covered as much with a baccalaureate degree as other schools might require from a master's or beyond? If a highly talented but not precocious student switches, say to a public policy major, might future public policy be tinged with memories of humiliations or drudgeries not intrinsic to the productive and creative needs of chemistry? In short, are the perceptions, not only of the continuing as well as the discouraged students, but also of their classmates who are majoring in other or allied fields, healthy for chemical education in the coming century?

I began to wonder what my students find in chemistry when they attend some of the big-name universities following a session in which about a dozen graduates of our International Baccalaureate program returned to our school to give an orientation program to their successors in their freshman through senior years. The unsettling impressions were bolstered by my own experiences while participating in a summer program for high school teachers given by my alma mater, a school that fits the descriptive categories listed above. They were further reinforced by presentations, and conversations, one by a senior and highly regarded chemical educator whose institution fits into the above categorization, and others by doctoral students at similar schools. They were made intensely personal for me by my own history of total discouragement in chemistry during my college career and my discovery in later life when I "retreaded" into the teaching of chemistry that the discouragement was premature and the subject one of intense intrinsic interest, experiences which have been paralleled by more than one colleague.

The recent Lincoln Park High School alumni who spoke were indeed a select group, numbering many National Merit Scholarship finalists and awardees. Most of the others had been commended by the National Merit Corporation. All had compiled a distinguished record in obtaining the International Baccalaureate diplomas and passing advanced placement tests; several had received science fair scholarships based on highly successful long-term experiments. All had successfully completed at least a year in the type of distinguished institutions indicated above, and the oldest had just been awarded a significant fellowship for graduate studies in a nonscientific field. Many had entered their universities anticipating a scientific or medical career. It must be said, in defense of university chemistry, that only one of this particular group had, in fact, taken the IB/AP chemistry course that I teach at our high school. But this student recounted a personal story of foresaking almost all else in his successful struggle to earn an A in a second-semester organic chemistry course, and his expectation that that course would be his last, because he questioned the worth of what he had learned. The other students spoke either of their experiences with first-year chemistry taken on the basis only of high school sophomore honors chemistry or on their perceptions of the experiences of their collegiate friends. Nevertheless, the perceptions were almost universally negative. Successful university chemistry majors and students were seen or experienced as spending all their hours holed up in libraries studying thousands of organic reactions, probably arbitrarily selected by sadistic professors, forced to foresake not only normal interests of collegians in persons of the opposite sex, but even the kinds of outside activities that led them to be considered for admission to their institutions in the first place, such as exceptional achievement in music or sports in addition to their high academic aptitude and achievement. Taken by itself, this small and quite possibly unusually highly biased sample would hardly rate as a provocation, although it seems that, in general, others of our students who have attended like universities have had similar experiences, while those attending highly selective schools with somewhat less academic glitter seem to have gained or retained the type of enthusiasm seen for chemistry in high school. It is the reinforcement of the impression from experiences of older observers that prompted this piece.

The doctoral candidates, near their final doctoral defenses, clearly deeply committed to chemistry at prestigious universities (and certainly not describable as hermits covered with dust from their respective moldly libraries), seem to have a single impression. One gave a formal presentation to a group of high school students; others have given their views less formally. Interestingly, giving strength to the argument, they themselves have been products of smaller, usually though not always, highly selective and well-known

colleges. Their recommendations have been that interested chemistry students avoid the universities with major graduate schools and seek out the smaller schools where they will have enhanced opportunities to do significant undergraduate research with full-professorial mentoring and to expect a degree of personal interest and attention from enthusiastic full professors.

One of the undeniable leaders in university-level chemical education, legendary among his students for the inspirational level of his honors freshman chemistry class (reflected, by the way, in the outstanding number of ACS-accredited graduates of his institution)[1], has publicly indicated that students whose interest was piqued early by their rigorous, college-level high school courses had to face an extremely onerous substitute course if they placed out of his offering and even were disadvantaged when it came to the available mentorships. He seemed surprised by the idea that his recommendation that high school teachers not teach equilibrium to able, highly motivated students was based on his experience in teaching those students who had been only moderately successful and possibly marginally motivated in learning chemistry in high school, or *had not had access* to advanced-level instruction. Even within his program, those with the greatest academic success, he said, tended not to be the chemistry majors, reinforcing the question of what is happening to the perception of chemistry as an attractive field beyond the freshman level or in the absence of a caring and/or charismatic instructor?

Tony Mitchell asks "What do Instructors Expect from Beginning Chemistry Students?"[2] He queried high school teachers, community college instructors, science education faculty, university faculty, freshman chemistry instructors, and four-year college faculty, and purported to show that most of the items high school teachers feel are necessary to teach are considered by post-secondary faculty to be nonessential. Interestingly, the article does not consider asking the students' opinions as to whether their previous chemistry education experiences in any way influenced their college success, enthusiasm, or time needed to absorb and apply concepts or constructs. If compared with reasonable measures of their success in the courses being taught at the college or university level that might take into account what the high school experiences of said students, at least on a formal level, might have been, one might have some useful data as to the effectiveness of high school teaching. One cannot, however, at least from part I of the article, make any sort of assumption as to why the students being taught by the faculty polled were taking post-secondary chemistry at all. One's own learning experiences, however, might make one suspect that for students the second pass at difficult concepts might be more meaningful than the first, and one can probably summon up anecdotal evidence for that hypothesis.

The present article takes the opposite tack. It presents the reader with students believed, on the evidence of their high school achievements to be not only motivated, but able and accomplished in the field of chemistry. These are youngsters who have sought out challenges in the past and evidenced a willingness to postpone immediate gratification in the pursuit of goals they deeply believed were worthwhile. There does not seem to be any question of their ability to retain concepts from one year to another. As they leave high school, they appear to provide a most promising pool of potentially productive and creative chemists. If they return a year or five later with negative concepts of what is required to be a chemist, the intellectual rewards thereof, and the personal aridity of people who opt for this profession, has there been a failure at the upper level or merely the propensity for young adults to try to shock their elders?

My synthesis is based on my personal experience with the study of chemistry. I entered the university with approximately the formal knowledge of chemistry recommended by the faculties surveyed by Mitchell, and little laboratory experience. In this regard, I was quite different from the students I now describe, though similar in having been admitted with otherwise excellent qualifications and eventually graduating Phi Beta Kappa and with an NSF fellowship for my graduate work in biology education. On return to the same university 30 years later for a seminar for teachers of chemistry, it appeared to me from the textual material as well as some of the grading practices described at this school that all the factors that had quickly persuaded me that I had not a molecule of an aptitude for chemistry were still firmly in place. Yet, clearly I have adequate although not prize-winning aptitude for the subject: my Graduate Record Exam score, grade-point average, and success on the master's final exam winning me a plaque for outstanding graduate student at the regional state university I attended. I have successfully taught chemistry for a number of years and had the satisfaction of having a number of my students describe me as their most influential teacher when asked by their colleges or universities for nominations. I wonder if students who attend universities like the one I attended are, like me, being too quickly discouraged by programs that are intended as screens rather than excursions into a course of study of unending fascination or, contrariwise, are being excluded from the very mentoring that their early prowess would suggest would be of crucial interest to the profession to develop. I wonder if the universities that attract their interest have at least tacitly emphasized the liberal arts or social sciences major, creating at the same time an influential group whose negative impressions of members of the chemical fields to which they might once have aspired will have significant effects on the funding for, and public perception of the practitioners thereof. I also wonder who will be available to teach the next generation of academically and scientifically able high school students.

Able students leave my classroom convinced, I believe, of the interest and power of chemistry. Those entering a nurturing collegiate environment seem to have a good rate of success with their further studies, to retain and enhance their enjoyment of chemistry and science, and to use it in their life work, either directly or indirectly. Are the most selective and most prestigious schools driving students out of chemistry by presenting it as dry, uninteresting, inaccessible, and unattainable for all but a few souls as desiccated or as soggy as the subject matter too many students perceived chemistry to be?

My hope is that I am reading too much into too little. In the absence of hard data, my judgment is that students who hope to be chemists or to take college programs that require a large investment of time and attention to chemistry and related subjects should be advised to look very carefully at the available evidence that the institutions they are interested in will provide not only challenge but also nurture for their aspirations. They should seek out contact with students successfully majoring in chemistry at these schools, should consult articles such as that cited above in *Chemical and Engineering News* detailing graduation rates in the field, and should carefully consider the options for mentored projects before taking prestige of the institution as a whole as the last word. But since, in the end, a 17-year-old and that students' parents will inevitably be swayed by the power of a brand name, the question remains: is it possible that our system is misdirecting our future chemical potential?

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[1] Heylin, M. *C&EN* **1989,** *67*(25), 93–99.
[2] Mitchell, T. *J. Chem. Educ.* **1989,** *66,* 562–564.