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Individualized Instruction in Chemistry is Possible

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Why Individualized Chemistry?

Chemistry for the non-science student is a concern I have heard voiced at two conferences I attended in 1979. One was in April, at the Chemical Congress which met in Honolulu, where I participated in a symposium on the High School Instructional Interface. During the discussions of this symposium a concern for the general student was emphasized. It was noted at this time that a larger percentage of our population needs a technical education for enlightened citizenship, and physical science (chemistry and physics) should not be restricted to an elite group of students.

During the Dublin International Chemical Conference in August, 1979, the same concern was expressed by countries similar to ours in economic development. They said that the younger generation must be educated so that our future citizens will be able to make value judgments in a technological society. Many of our college-bound students avoid "solids" such as chemistry and physics if they do not need these courses as a direct preparation for their professional careers. Yet these students are some of our most intelligent and most literate youth.

My experiences at these two conferences reinforced my decison, made several years ago, to attempt to introduce more students to chemistry . . . students who would normally not elect chemistry because they have heard that it is hard and a "lot of work."

Over the last few years I have attempted to attract these reluctant students to the chemistry laboratory. It was difficult to change my direction at first because I had been successful with the more elite students and did not want to water down the chemistry course. There had been years of a feeling of accomplishment when the youngsters did well in the local American Chemical Association competitions, and I had great pride in being considered a tough teacher.

I guess the big step came for me in 1974 when our new high school—Torrey Pines High—opened. It meant a chance for a new start. The facility was planned for flexibility, and I was able to design the laboratories.

The students were asked to choose a text for the beginning chemistry course, Introductory Chemistry. They sampled each potential text by studying a chapter from each and then voted for the one they felt was best. Incidentally, the choice was not the easiest text. The one they chose was "Interdisciplinary Approaches to Chemistry," known as IAC, which offered seven booklets of chemistry, accenting laboratory and topics relative to everyday life.

Because Torrey Pines High is an open classroom school and is centered on a multi-media approach, I decided to teach IAC by individualized instruction. By requiring that the student complete five of the seven booklets, I was able to plan a course which could be designed in part by the student, based upon his interests and needs, and in the sequence he wished.

Organization is a Challenge

The booklets were quite readable; however, I had to develop "Experimental Comments" to supplement the laboratory instructions and to guide the students as to the contents of a good laboratory report. These "Comments" eventually were combined into a laboratory notebook, which also included general rules of operation and record sheets for grades.

I learned as I went along that my organizational skills would

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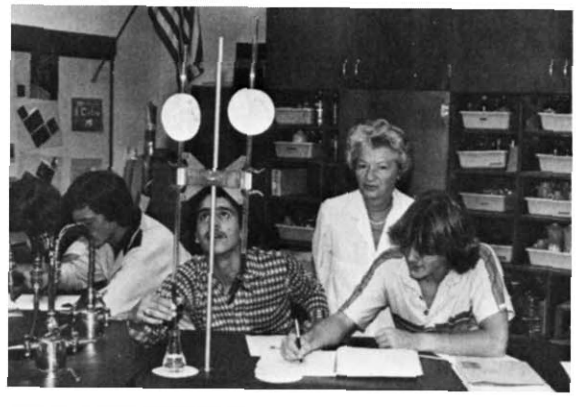
Mrs. Richardson has been very active in science education, having participated in CBA, CHEM Study and Harvard Projects summer institutes as well as having been selected as a Shell Merit fellow at Stanford and Cornell summer workshops. She has also assisted in the leadership of a science supervisors' summer workshop in the Interdisciplinary Science Instruction System (ISIS) project.

For the past 16 years she has been the district science coordinator and science department chairperson in the San Dieguito Union High School District. She currently teaches at Torrey Pines High School, which has a student population of approximately 1800 students. Her current teaching load includes Honors Chemistry, which utilizes CHEM Study and CBA materials, and an Introductory Chemistry course implemented on an individualized basis, using Interdisciplinary Approaches to Chemistry materials.

In 1979 Shirley received the James B. Conant award for the teaching of high school chemistry.



NAME_____ PERIOD_____ 1981-2

Circled labs are optional

INTRODUCTION TO CHEMISTRY

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Record Card. Note that code letters for experiments indicate booklets, e.g., I = periodicity; P = physical chemistry.

be tested to the utmost. Some days it seemed as though I were conducting a three-ring circus, but gradually over the last seven years things seem to be under better control. One of the biggest problems to conquer was record keeping. But eventually a 5 × 8-in. card became the way to keep track of each individual's record (see figure).

Motivation is Important

Now, you may ask, how does this help the non-science student? First, by use of motivating topics, such as, how does chemistry affect pollution? What is the chemistry found in our households? What is chemistry's role in physiological processes, in medicine? How does industry utilize chemical principles? For example, here are two of the relevant topics students study in Introductory Chemistry. Colloidal suspensions are studied when youngsters bring samples from home of materials such as cold cream, aerosol sprays, lotions—and investigate their properties. These labs are in the physical chemistry booklet called "Communities of Molecules." A lab in the "Diversity & Periodicity" booklet includes the titration of vinegar and household cleaners, which students bring from home. They check the labels to see if the manufacturer has been honest. This leads to discussons on how our state laboratories protect the consumer from unfair merchandising.

Individualized instruction also aids the general student by giving him more time to learn certain concepts of chemistry. By self-pacing students may vary their testing time and gain reinforcement in certain aspects of chemistry. Also, the booklets are written in such a way that redundancy is built into the course. For example, acid-base chemistry is taught in the "Diversity & Periodicity" module but will also be found in the "Delicate Balance" (ecological chemistry) module, which approaches acid-base theory from a different direction. With this redundancy comes more opportunity for success and offers the chemistry student a better self-image thereby.

Of course, the opportunity for small group work and one-to-one student-teacher experiences in the chemistry classroom offers a chemistry course somewhat custom built to student needs. The students enjoy, and in fact expect, personal attention, and they like to be able to make some of the decisions on how they spend their time. In the student evaluations of the course they often say how nice it is to be able to turn the teacher off. This comment repeats so often in their evaluations that I have come to recognize its importance to the student.

The Nitty Gritty

Perhaps you would like a little more detail on how the course is organized. We have approximately 30 students per class in a laboratory-type classroom. Two chemistry teachers team teach three periods of the day. Vicki Coordt, my co-teacher, and I have found that individualized instruction is more feasible with two teachers sharing the 60 students, and, of course, a laboratory assistant who has taken the course and is willing to be of service to the students.

In September we start with the "Reactions & Reason" booklet, which is a general overview of chemical principles. This first booklet is taught in a traditional manner. We lecture in a large group, give the students practice worksheets and require the same homework assignments of all students. Quizzes are taken in a large group, and laboratory experiments are done by the whole class. During this time we teach basic concepts such as the mole, bonding, and the geometry of molecules. We drill on symbols, formulas, equations and what is entailed in a good lab report. We establish standards of quality, laboratory skills are taught, and we attempt to learn our students' names while they are in assigned seats.

About the end of October we complete the "Reactions & Reason" module, while gradually introducing the students to some of the organization of individualized instruction. Then the students have a choice of two booklets: "Diversity & Periodicity" or "Form & Function." About 50% choose the periodicity booklet, and the rest opt for the organic module. The students know that five booklets are required to complete the course and that three of the booklets must be "Diversity & Periodicity," "Form & Function" and the "Reactions & Reason" module just completed.

Each student receives a calendar for the booklet chosen and is told that the pace is suggested but not absolute. An experiment listed for, say, Monday could be done any day that week, but the write-up must be in a week after the experiment appears on the calendar. Due dates are also listed on the calendars. We have found that a little flexibility is good, but that complete freedom to self-pace can be disastrous.

Each of the booklets is planned for a six-week period, and students are encouraged to get ahead of the schedule. There

are many laboratory experiments. For example, the Periodicity students do 12 experiments in 6 weeks. The materials for these experiments are available in labeled tote trays around the room—on labeled shelves. Even the individual reagent bottles are labeled with experiment number so that the materials may be returned to the proper trays. When a student is ready for an experiment, he gets the proper tray and sees to it that the tray is returned in good order. However, student monitors are needed to maintain good organizaton, and students are eager to volunteer for such service if it helps their classwork grade.

The class starts with a 10-minute large group meeting for attendance purposes and general announcements. Students are reminded of what is due that day and what small groups will be held. My co-teacher and I prearrange which small groups we will conduct. I may send my periodicity students to Vicki, while I am discussing concepts with organic chemistry students. Our small groups are held in a carpeted study corridor, where we utilize portable chalk boards. Students passing by see previews of coming attractions, and this may be helping with the popularity of our course. When we are free both teachers move back and forth in the contiguous classrooms, helping students with their experiments.

The study corridor also contains a test center which is open every day and supervised by volunteer members of the community. When a student is ready for one of the four quizzes planned for each booklet, she checks her progress by use of a Self Quiz (samples of which are in pockets on the wall of the classroom) and fills out a transmittal slip to the test center, which the teacher signs. Students may take as long as they wish to complete a ten-question quiz, but they average 15 minutes. Three forms of each quiz are rotated by the test center aide so that the students do not know which quiz they will receive. By the way, the papers for a given booklet are color-coded. For example, organic chemistry is on blue paper and periodicity is on canary yellow paper. This color coding helps the aide, and the teachers, to keep track of the papers. At the end of the day the aide places the quiz answer sheets in the respective teacher's mail box.

During the class period we invite students to review their quiz results of the previous session, and at this time we have an excellent opportunity to reinforce concepts and correct misconceptions on a one-to-one basis. I may ask a student if he has time to go over a quiz. He may say "Sorry, I'm busy right now with an experiment. I'll let you know when I am free." It seemed strange at first to be "rejected" by students after my years of traditional planning of time. But now I enjoy the maturity with which the students make decisions about their time.

The quizzing culminates in a 20-question test on the booklet at the end of 6 weeks. The students average "B" on these tests, which have four forms and are rotated as the students appear at the test center. These tests usually take about 30 minutes to complete.

The third round of booklets includes four choices: periodicity, organic chemistry, physical chemistry, and biochemistry. The latter may not be chosen until basic organic chemistry has been studied. We conduct small group discussions (about 20 minutes long) on each booklet the day a quiz is scheduled on the student calendars. If the students want any other small groups, they may request them during the large group session that starts each class. Sometimes a prelab or a postlab is requested. There are also audio-tutorial lessons available in the classroom which help students with difficult concepts or skills. For example, in organic chemistry we have two audio-tutorial lessons, one on functional groups and another on isomers.

This third round is not as difficult as might be imagined when four booklets are going at once. Those who did organic chemistry ("Form & Function") on the second round help those currently involved, and the former periodicity students are ready references for the ones struggling with "Diversity & Periodicity."

By round four we have six booklets in action but also have "experts" in biochemistry and physical chemistry by then to help the others. This peer teaching has been helpful in relieving the teacher bottle-neck, but also is useful in reinforcing in the students the information they have learned. During the fourth round students must complete the periodicity or organic chemistry booklet not completed up to this date, so that all required booklets are finished. Therefore the fifth, and last, round has only four modules working: nuclear chemistry and ecological chemistry, as well as physical chemistry and biochemistry.

There is a lot of diversity in such a classroom structure. Some students may be using a Geiger counter to check the radioactive shielding ability of materials, while others may be investigating the gas laws in physical chemistry. Those in biochemistry might be plotting the change in reaction rate with change in pH, and at the next bench a student may be titrating water for oxygen content, as part of the ecology booklet. The students do only five of the seven booklets, but they see activities in all seven modules. These students are probably exposed to more chemical phenomena than the honors students I teach in a more intensive course, which includes more mathematics.

Mathematics is a problem for the general student. Many times we must deliberately teach simple mathematical manipulations and stress careful laboratory calculations in student write-ups. But the mathematics is not esoteric and does not seem to turn the students off. Some write-ups, such as the ones on titrations, are heavy with mathematics.

Help is always available at noon and after school. We rotate the supervision of the laboratories at these times so that the open laboratory gives students more opportunity to make up absences and experiments which just did not work the first time. Slower students get more teacher time this way. The laboratories are rarely empty.

In Summary

Planning individualized chemistry instruction has been a lot of work, and has included many frustrations, but the hours spent have been worthwhile. Student evaluations have been very positive, and their recommendations to future students have resulted in a swelling of our classrooms. There were 60 chemistry students before this course was started; now there are over 220 chemistry students (over one tenth of our school population) who take chemistry each year.

I feel that Introductory Chemistry is a good solid course, which teaches basic and relevant chemistry in such a way that most students come out with a better self image. Their average grade is "B", and their comments about the course include repeatedly statements such as . . .

It's fun . . . interesting; Demands much but is worth it;
You learn a lot of things; I proved to myself I could do it.

We also feel that the self-pacing experience will be helpful as the students attempt to be successful at the college level, and our returning graduates indicate this. As for the teacher, if you survive the planning stages it is a rejuvenating experience. After twenty-five years of teaching chemistry I had begun to get tired of listening to myself talk.

Our new high school facility has provided us with the flexibility to present a multi-media chemistry program at several levels. I do not not feel that we are giving precollege students a watered-down chemistry course, but find that the course is encouraging students to feel comfortable in the chemistry classroom and causing many of these students to include more chemistry in their future plans.

I was pleased to learn in the conferences I attended last year that the American Chemical Society is encouraging the high school and university chemistry teachers to entice the general student into their classrooms. When recognition comes to the teacher for doing this instead of just producing science fair winners, "fives" in advanced placement exams, and Westinghouse scholars, more of us may place our focus on the general cross-section of our future citizens.