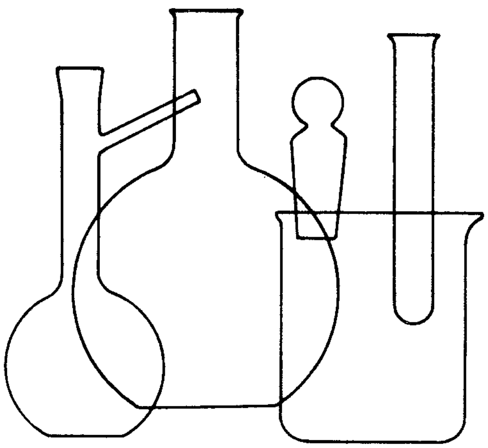

CHEMISTRY
IN THE
TWO-YEAR COLLEGE

VOLUME XX, SPRING 1980

COMMITTEE ON CHEMISTRY IN THE TWO-YEAR COLLEGE
DIVISION OF CHEMICAL EDUCATION • AMERICAN CHEMICAL SOCIETY

Foreword

The papers in this Journal were delivered at the last four Two-Year College Chemistry Conferences. The diverse nature of these papers reflects the wide interest and needs of chemistry teachers at two-year community colleges.

The changing problems and challenges of teaching chemistry at a two-year college produces a unique set of circumstances for the need to communicate with our fellow colleagues. We need to know about new developments in programs and, in teaching techniques used to meet the chemical education needs of a changing group of students.

In order to better promote this exchange of information, more of our two-year college chemistry teachers should be presenting papers on the types of programs and teaching techniques being used at their colleges. If any of you are involved with, or know of someone who is involved with a new approach to teaching chemistry for under prepared students, nursing students, non-science majors as well as any other unique courses or programs, please send a letter to our COCTYC chairman or to any program chairman listed in our news letter.

In the past 12 years of attending $2YC_3$, I have used the information obtained to develop an audio-tutorial introduction to chemistry course and a textbook. I have also developed an elements of organic and biochemistry course for nurses from talks I have attended at Two-Year College Chemistry Conferences.

As you read the articles in this edition, I hope you find the ideas or information which can solve some of your problems or increase your background knowledge in some relevant or current area of interest.

Paul Santiago
Chairman, COCTYC

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SPECIAL TEACHING METHODS

Have a Quickie Before Class

Marvin Parent
Oakland Community College
Auburn Heights, Michigan 48057

Presented to the Sixty-Third, Two-Year College Chemistry Conference, Columbus Technical Institute, Columbus, Ohio, May 12, 1979.

The Chinese have an old aphorism which goes like this: I HEAR - I FORGET, I SEE - I REMEMBER, I DO - I KNOW. There are three facets of the educational process implied in this venerable bit of ancestrial wisdom and they are: lecturing, demonstrating, and experimenting. The time limitation on my talk precludes me from spending much time jousting with the lecture aspect of teaching, but let me interject this thought. In order for one to be an effective day-to-day classroom teacher you need to include in your educational blender the essential ingredients of enthusiasm and variety. The ultimate purpose behind every conference is the stimulating effect it has on all of the participants. This stimulation should result in more enthusiasm by the individual teacher. How tragic it is for a student to receive his only exposure to chemistry from a teacher who fails to find ways to display excitement for the learning process and enthusiasm for the science of chemistry. Granted, we all have our own styles and mannerisms that are our classroom hallmarks for teaching, but if we routinely lack enthusiasm for the teaching of chemistry, then our students will never acquire the enthusiasm for the learning of chemistry.

With that as an introductory note on the lecture process allow me to concentrate on the second line of the Chinese aphorism: I SEE - I REMEMBER. My part is to share with you some classroom demonstrations which I find much success with. Demonstrations, by the way, are an excellent way to add variety to your classroom efforts. If I had been asked to supply my own title for this talk, rather than the one listed in your program, I would have given it the following caption, "Have a Quickie Before Class." Quickie is my own acronym standing for Quality Undergraduate Instruction Calls for Keen, Imaginative Explanations. The type of Quickie I'm obviously referring to are those demonstrations that require only a minimal amount of time and very little effort to prepare. By minimal amount of time I mean a scant 3 minutes or less of total preparation time. When I began to work on this presentation I fantasied that I'd like to be as brilliant, whitty and entertaining as Prof. Hubert Alyea and literally charm the socks off your feet by means of vibrant color changes, a few well spaced puffs of smoke and a clock reaction set to music. Anything that follows this paragraph let me preface by saying do not take me wrong for I idolize Professor Alyea. If I were to perform aristocratic demonstrations somewhat approaching his style (my closest approach would be by a factor of 10^{-2}), you might be more sufficiently entertained. My first question would then be how many of the demonstrations would you immediately add to your own repetoire. I know I usually find myself first revering Professor Alyea and then rationalizing my own level of mediocrity by saying I don't have the time, energy nor the kind of technical assistance he has to get those demonstrations ready. My day is just too hectic!

Well, shame on me for saying that after watching the eminent professor evangelically demonstrate his heart out. Now, shame on you even more if you sit there through the next 25 minutes of demonstrations without picking up on 2 or 3 things that you will immediately use in your next general chemistry class for my demonstrations are of the QUICKIE variety. So here goes!

I. The Existence of Chemical Equilibria

Materials: Approx. 0.25 g of $Fe(NO_3)_3$ into 500 ml of H_2O
Approx. 0.25 g of KSCN into 500 ml of H_2O
Solid $Fe(NO_3)_3$; Solid KSCN: 1000 ml beaker; 2-600 ml Beakers

II. The Dynamics of Chemical Equilibria

Materials: 2 large culture dishes (from Biology Dept. 2" deep by 10" in diameter)
Water plus 0.5 g of $KMnO_4$ for color
3 casseroles (evaporating dishes with handles) of varying sizes

III. Electrochemical Series

Materials: Au ring; Mg ribbon: 6 M HCl; 2 large test tubes; matches

IV. Endothermic Reaction

Materials: $Ba(OH)_2 \cdot 8\ H_2O$ (10 g); NH_4SCN (5 g); stirring rod

$$Ba(OH)_2 \cdot 8\ H_2O + 2\ NH_4SCN_{(s)} \longrightarrow Ba(SCN)_{2(s)} + 2\ NH_{3(g)} + 10\ H$$

V. Weak Basic Anions

Materials: Solid $NaC_2H_3O_2$; Na_2CO_3; 2 - 600 ml beakers; water; stirring rods

VI. Preparation of Buffer

Materials: pH meter; 100 ml of 0.01 M HCl; 100 ml of 0.01 M Na(
400 ml of 1 M $HC_2H_3O_2$; approx. 35 g of $NaC_2H_3O_2$

In closing let me reemphasize that two of the most essential ingredients in successful teaching are enthusiasm and variety. I cannot reach inside of you to elevate your classroom enthusiasm level. That you alone control. What I do suggest is that each of you do a self critique to determine what level of your love for chemistry is being translated into varying degrees and manifestatations of enthusiasm as you teach. My aim for the past 30 minutes was to try to elevate your awareness level concerning ways to add variety to your classroom teaching through using QUICKIE demonstrations. Please be appraised of the fact that these are certainly not the most ostentatious demonstrations in my personal repetoire. I merely chose these to illustrate how simple, easy to prepare demonstrations can be effectively used to hold interest and provide for that much needed variety in the classroom.

I will close with a quote taken from Professor Alyea by saying that chemistry instruction without the use of demonstrations is dessicated chemistry. Don't be known around your campus as a dessicated chemist. Once you earn that label, then you will find your classes will become harder to fill as we are all competing for students within a dwindling supply. Finally, those who do sit in your class will never know the real excitement that chemistry can bring for those students will have become dessicated too.

Letting Piagetian Theory Help Students Pass Introductory Chemistry

Marion Baker
Valencia Community College
Orlando, Florida 32802

Presented to a Special Session, "Communicating Chemistry" of the Sixty-Second, Two-Year College Chemistry Conference, Brookdale Community College, Lincroft, New Jersey, March 23, 1979.

Introduction to Chemistry, at Valencia, is a course for students who have had no high school chemistry training or who took high school chemistry more than five years ago. Some of the students are A.S. degree candidates in nursing, medical technology or fire technology, etc. Others are seeking an A.A. degree, planning to major in science or engineering. Only a few are liberal arts students fulfilling general education requirements.

My success rate with students in this course was not as good as I would have liked. Typically only 50% were finishing the course with A's, B's, or C's. I was amazed at how unsuccessful I was in getting across the most basic chemical concepts. I could list many possible reasons for this, e.g. laziness, illiteracy, lack of motivation, poor class attendance, poor study skills. I was fascinated, however, by one possibility; intellectually, the students may not be <u>able</u> to grasp these concepts.

Jean Piaget's model of intellectual development is rapidly becoming familiar to chemical educators. We know that the highest level of intellectual development, according to Piaget's scheme, is the formal operational level.

1. The formal operational thinker can transcend the here and now.

2. He can imagine the possibilities inherent in a situation.

3. He can design experiments and isolate variables.

4. He can operate on hypotheses.

5. He can think about thinking and classify classifications.

6. He can separate the form of an argument from the truth or falseness of its premise.

The level below this highest level is the concrete operational level. The concrete thinker cannot transcend the here and now. He cannot imagine the possibilities inherent in a situation nor can he design experiments and isolate variables. He cannot operate on hypotheses and he cannot think about thinking or classify classifications. He cannot separate the form of an argument from the truth or falseness of its premise. The formal thinker lives in a world of ideas that is unknown to the person who is still in the concrete stage.

As I investigated the relationship between Piaget's theory of intellectual development and the teaching of chemistry, I discovered what I had always suspected; chemical educators are caught in a three part dilemma.

1. Many educational programs require that introductory chemistry be a prerequisite to or a part of their curriculum.

2. Research shows that approximately 50% of entering college freshmen do not operate on the formal level.

3. Approximately 80% of the topics in introductory chemistry courses are formal operational concepts. Meaning cannot be acquired through the senses but only through imagination and logical relationships.

There is hope, however. Piaget's model says that nearly all human beings can reach formal levels of thinking if they are trained properly.

The concrete thinker, however, does not become a formal thinker by being confronted with formal tasks. New material must be presented at the concrete level and he must be led from the concrete to the formal. Piaget advises, "Let the student create his own understanding from first hand experiences instead of telling about the teacher's understanding or experiences."

With Piaget's theory by my side and with the help of the NSF Faculty RULE grant, I conducted an experiment. My experimental design was as follows. (Figure 1) Two instructors had two sections of twenty-five students each of introductory chemistry. Each instructor had one experimental section which used specially designed lecture kits and one control section in which the kits were not used. All one hundred students were tested using Piagetian clinical tests to determine their level of intellectual maturity. Thus, each experimental section and each control section contained concrete thinkers and formal thinkers.

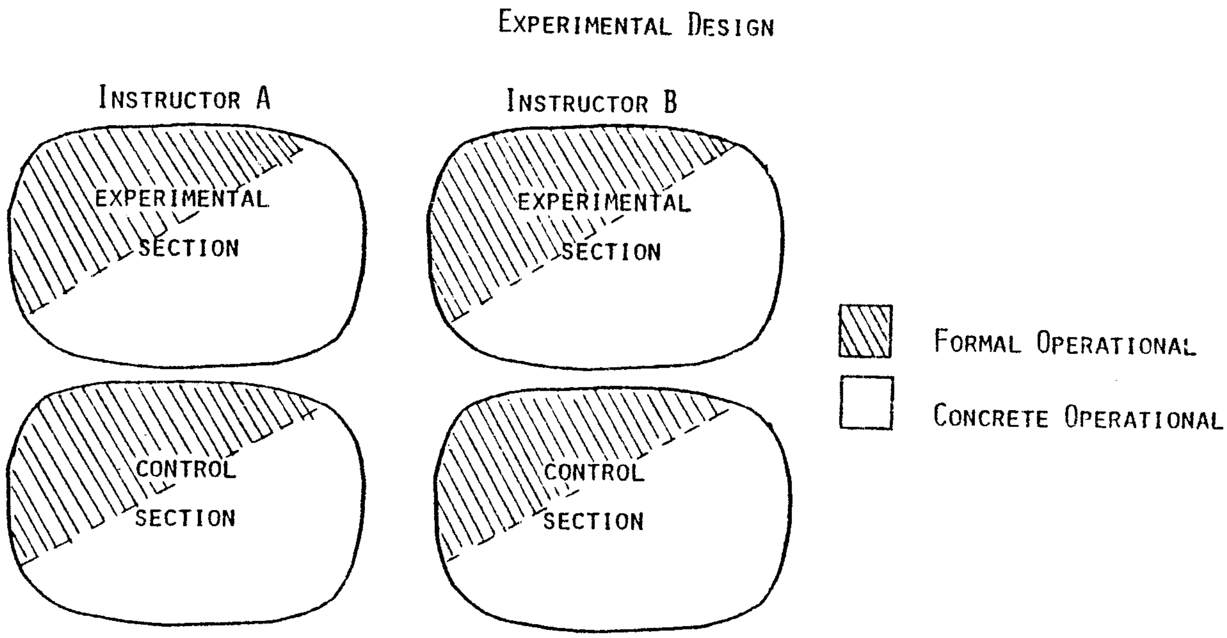

Figure 1

I tested the groups to find if they were similar to each other before they enrolled in the course (Figure 2) and found that they were similar by all measured tried. Control and experimental groups were similar in their reasons for taking introductory chemistry, in the last mathematics course completed, in current mathematics courses, in chemistry background, and also in their attitude concerning how much they liked chemistry and in how easy they thought chemistry was. The groups were also similar in pretest mean scores.

SIMILARITY OF CONTROL AND EXPERIMENTAL GROUPS BEFORE TREATMENT

Basis	X^2	X^2 at $P < .05$
Reasons for Taking Intro Chemistry	3.21	4.61
Last Mathematics Course Completed	1.49	6.25
Current Mathematics Course	0.575	2.71
Chemistry Background	0.029	2.71
Attitude: "I Like Chemistry."	0.681	2.71
Attitude: "Chemistry is Easy for Me."	1.000	2.71
PRETEST MEAN SCORES	T = 0.245	T=2.00

Figure 2

I devised sets of materials and called them lecture kits. The contents of the kits would help me present abstract notions in a concrete way and, in my mind, they were much better than teacher performed demonstrations since each student would be performing his own demonstrations. Also, it was important to me that these were done in lecture, rather than in a lab, since I wanted the concrete and the abstract to be presented simultaneously to help the student cross the bridge into formal thought.

Here are some examples of the twenty-eight exercises we used in the experimental section.

<u>Objective</u>: Given an instrument, read a measurement on that instrument to the proper number of significant figures.

<u>Material</u>: Three rulers for each student. A commercial ruler graduated in centimeters and millimeters, a paper ruler (green) with graduations in centimeters but without millimeters being marked off, a paper ruler (orange) with graduations at the 10 cm, 20 cm and 30 cm marks only.

<u>Objective</u>: Define density and work problems involving the concept density.

<u>Material</u>: Each student is given a brass key (perhaps from a laboratory drawer) and a piece of corregated paper which weighs the same as the key.

<u>Objective</u>: Use subscripts and coefficients correctly in chemical symbols.

<u>Material</u>:

Pairs of red beads	Re_2
Pairs of gold beads	Go_2
Single reds	Re
Single golds	Go
Red/gold pairs	ReGo

These same materials can be used for related objectives; e.g., distinguishing between mixtures and pure substances, elements and compounds.

<u>Objective</u>: Define and distinguish between a physical and a chemical change.

<u>Material</u>: Pairs of red beads
Red/gold pairs

<u>Objectives</u>: Given the atomic masses of the isotopes of an element and their relative abundances in nature, calculate the atomic mass of the element.

<u>Materials</u>: Beaker of styrofoam balls, one with a tack in it.

<u>Objective</u>: Define and demonstrate five types of reactions: combination, decomposition, replacement, metathesis and neutralization

Materials: Three styrofoam balls with one wooden connecting stick set in each. One of these should be red, one yellow and one white. The white one should have "OH" printed on it with big black letters.

Three styrofoam balls with one plastic sleeve set in each. One of these should be green, one blue and one white. The white one should have "H" printed on it with big black letters.

Objective: Observe metathesis reactions, write equations (molecular, ionic and net ionic) for metathesis reactions, and relate these reactions to the solubility generalizations.

Materials: Vial of $CuSO_4 \cdot 5H_2O$

Vial of $Na_2CO_3 \cdot H_2O$

Vial of CuS

Dropper bottle of H_2O

Dropper bottle of HCl

Wood splint or spatula

Four small test tubes

Dropper (long)

Objective: Observe qualitatively the relationship between the pressure applied to a gas and the volume of that gas, at constant temperature. (Boyle's Law)'

Material: Plastic, disposable syringes (not including the needles) mounted and sealed on squares of balsa wood

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Objective: Observe qualitatively the relationship between the temperature of a gas and its volume. (Charles' Law)

Materials: 3mm OD, 1 1/2 mm ID glass tubing, cut in 16 cm lengths, sealed at one end, with a drop of mercury at the bottom of the tube and a drop of mercury three-quarters of the way up the tube. These tubes are in an ice water bath.

Did this treatment help? Yes and no. First, I wanted to know if the students grew. I had to compare where they ended up with where they started. I defined a growth quotient (Figure 3) based on pretest and post-test scores and found that the experimental group, using the kit, grew significantly more than the control group. (Figure 4) Separating the entire group into concrete members and formal members, I found that the concrete members of the experimental section grew more than their counterparts in the control section, and even the formal members grew more in the experimental sections than in the control sections.

GROWTH QUOTIENT (GQ)

$$GQ = \frac{\text{Post Test Score} - \text{Pre Test Score}}{50 - \text{Pre Test Score}}$$

50 = Maximum Score on Both Tests

Figure 3

HYPOTHESIS: MEAN GROWTH QUOTIENTS (GQ) ARE THE SAME FOR EXPERIMENTAL AND CONTROL GROUPS.

Group X, experi-mental	Group Y, control	$\overline{GQ}_x$	$\overline{GQ}_y$	F[a]	t[b]	Ho
all members	all members	.524	.362	.975 (1.76)	4.37 (2.00)	reject
concrete members	concrete members	.465	.362	1.096 (2.39)	2.581 (2.042)	reject
formal members	formal members	.559	.419	1.087 (2.61)	2.616 (2.042)	reject

[a]Numbers in parentheses in this column are the rejection values for the F ration, $p < .05$.

[b]Numbers in parentheses in this column are the values for t, $p < .05$.

Figure 4

The kits helped even the formal members. Often formal thinkers prefer having new concepts introduced on concrete terms. It is thought that this is a matter of preference rather than the inability to learn from an abstract introduction.

I defined a measure which I called achievement. (Figure 5)

ACHIEVEMENT (A)

A = Sum of Scores

Quizzes
Hour Tests
Final Exam
Lab Reports
Lab Practical

Figure 5

Achievement is a total of scores on tests, lab reports, homework assignments, etc., and I found that (Figure 6) the total experimental group achieved significantly more than the total control group. The concrete subgroups in the experimental section achieved more but in this measure the formal subgroups did not seem to be helped by use of the lecture kits.

HYPOTHESIS: MEAN ACHIEVEMENT MEASURES (A) ARE THE SAME FOR EXPERIMENTAL AND CONTROL GROUPS.

Group X, experimental	Group Y, control	$\bar{A}_x$	$\bar{A}_y$	F^a	t^b	Ho
all members	all members	799.6	713.5	0.412 (1.76)	3.211 (2.00)	reject
concrete members	concrete members	783.1	691.7	1.77 (2.51)	2.287 (2.042)	reject
formal members	formal members	808.8	749.7	0.3076 (2.50)	1.53 (2.042)	fail to reject

[a]Numbers in parentheses in the F column are the rejection values for the F ratio, $p < .05$.

[b]Numbers in parentheses in the t column are the rejection values for t, $p < .05$.

Figure 6

I was very pleased with the results thus far but my purpose at the outset was to get a higher success rate. I wanted more of my students to pass the course and in this I failed. Defining success rates (Figure 7) as the number of students successfully completing the course with the grade of A, B, and C divided by the number of students starting in the course, I found not only that the control sections did no better than past base line sections (Figure8) but also that the experimental and control sections were indistinguishable from each other by this measure. (Figure 9)

SUCCESS RATE OF A SECTION (SR)

$$SR = \frac{\text{Successful Students}}{\text{Total Students}}$$

Successful Students = Number of Students Completing the Course with a Grade of A, B, or C.

Total Students = Number of Students Attending at least three class meetings

Figure 7

HYPOTHESIS: THE NUMBER OF SUCCESSFUL STUDENTS IN EXPERIMENTAL SECTIONS WAS NO DIFFERENT THAN IN CONTROL SECTIONS.

	Experimental sections[a]	Control sections	Row totals
Instructor A			
Successful	16 (14.1)	7 (8.9)	23
Unsuccessful	11 (12.9)	10 (8.1)	21
Column totals	27	17	44

Note. $\chi^2 = .751$. $\chi^2(1) = 2.71$, $p < .05$.

	Experimental sections[a]	Control sections	Row totals
Instructor B			
Successful	22 (20.2)	17 (18.8)	39
Unsuccessful	6 (7.8)	9 (7.2)	15
Column totals	28	26	54

Note. $\chi^2 = .626$. $\chi^2(1) = 2.71$, $p < .05$.

[a]Numbers in parentheses are expected frequencies.

Figure 8

HYPOTHESIS: THE SUCCESS RATE IN CONTROL SECTIONS WAS NO DIFFERENT THAN IN PAST SECTIONS.

Base line success rate	Observed successes in control section[a]	Expected successes in control section	z
	Instructor A		
52.4%	7 (17)	8.9	.922
	Instructor B		
68.8%	17 (26)	17.9	.381

Note. $z(1) = 1.96$, $p < .05$.

[a]Numbers in parentheses are the total numbers of students entering the course in the sections.

Figure 9

Finally, I wanted to see if the attitude of the experimental sections toward chemistry changed more than the attitude of those who did not use the kits and I found (Figure 10) that they all ended up "liking" chemistry more and thinking chemistry was "easier to understand" than they had at the beginning of the course. The amount of change in attitude in the experimental and control groups was not significantly different.

HYPOTHESIS: THERE WAS NO DIFFERENCE IN THE CHANGE OF ATTITUDE TOWARD CHEMISTRY BETWEEN EXPERIMENTAL AND CONTROL GROUPS.

Average change in response		F	t
Experimental group	Control group		
"I like chemistry."			
.359	.438	.737	.363
"Chemistry is easy for me to understand."			
.051	.031	.660	.351

Note. $F(30, 38) = 1.76$, $p < .05$; $t(60) = 1.671$, $p < .05$.

Figure 10

Did the students who were judged by me to be formal operational actually get better grades? Are the students defined as concrete actually the ones who fail? From Figure 11 you can see that 80% of the A's in the class went to formal students. No students got D's. Many did withdraw - for one reason or another. Concrete and formal students seem to be equally able to get B's and C's. Here is where study skills, motivation, and regular attendance may come in.

FINAL GRADES OF FORMAL OPERATIONAL (F) AND CONCRETE OPERATIONAL (C) STUDENTS IN INTRODUCTORY CHEMISTRY

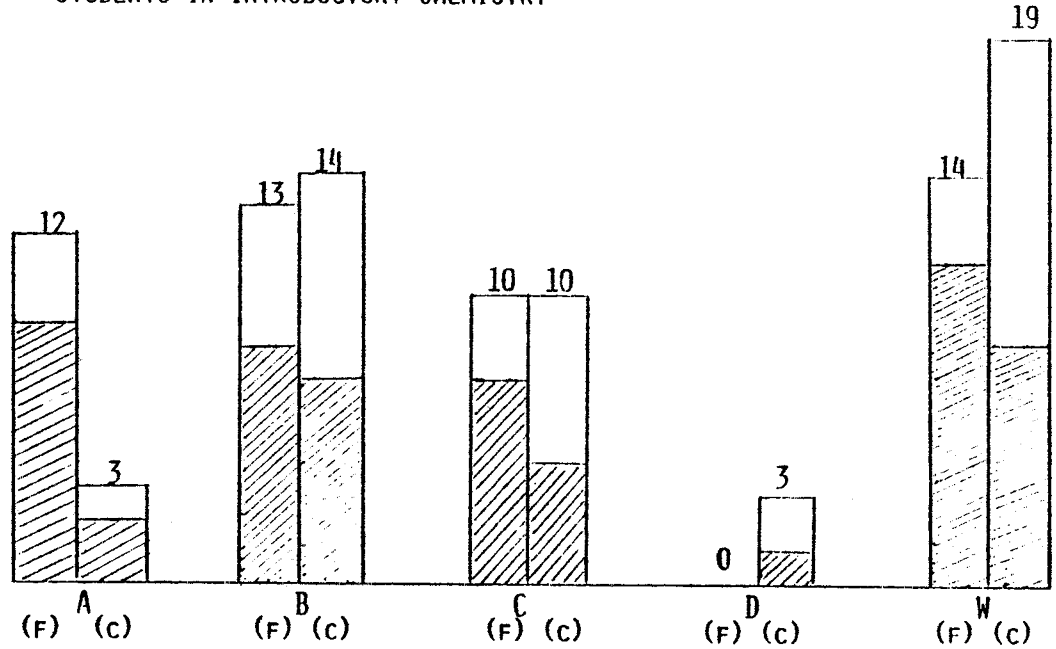

Figure 11

(SHADED = EXPERIMENTAL GROUP)

The experiments left me with two important things. The best part of my experiment was the production of the kits which are still used by me and my colleague, Judy Jones, at Valencia's East Campus. Secondly, I'm convinced that formal concepts must be introduced on a concrete level for at least half of our students in Introductory Chemistry. I look for opportunities to do this for every concept in every chemistry course. I recommend that you do also.

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Safety Standards in the Academic Labs
How to Meet OSHA Standards

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Presented to the Fifty-Ninth, Two Year College Chemistry Conference, Essex Community College, Baltimore, Maryland, April 7, 1978.

The time has come for us to convert our concern for meeting Occupational Safety and Health Administration (OSHA) standards into a clear course of action. The mist surrounding the relationship of OSHA to the academic lab is clearing. We must now embark on a course of action which will lead to a result from which we will derive substantial benefits.

The questions regarding OSHA's treatment of the academic lab have not all been answered, but OSHA is not standing still. We are already feeling the impact of OSHA's regulations. We will eventually see some regulations directed specifically at the academic lab. The two-year community colleges must be sufficiently educated and organized to help OSHA arrive at the most appropriate set of regulations to govern and enhance our chemistry programs. In short, we need to pool our resources and produce a plan to help ourselves.

The Occupational Safety and Health Act was passed by Congress in 1970 and signed into law in 1971. Since that time, the Act and its operating bodies, the Occupational Safety and Health Administration, and the National Institute of Occupational Safety and Health, have been experiencing a continual maturation process. Now, in 1978, the public is feeling and seeing the full scope and power of this act.

The initial set of standards issued in May of 1971 was taken from already-existing sources, and as a result was overlapping in several areas. The primary emphasis was safety and the prevention of bodily injury by avoiding accidents. More recently, there has been increased emphasis on health standards.

The present activity in the area of health standards is to research, promulgate, and clarify standards, and to increase the emphasis on compliance with health regulations. The first formal move into the area of health standards came in June of 1972 with regulations on worker exposure to asbestos fibers. On January 29, 1974, the Federal Register published permanent standards to protect workers against fourteen (14) carcinogens. Since 1974, there has been a more or less continual flow of new, improved, and proposed regulations on a list of chemicals which now has 400 entries, but will likely have many more in the future. Augmenting the emphasis on health standards is an attempt by OSHA to obtain compliance officers trained to detect health hazards as well as safety hazards. At the same time, OSHA will probably rewrite vague standards to make them clearer and more useful to the compliance officers and to employers.

Coinciding with the increased emphasis on health standards, the Administration is streamlining the general industry safety and health standards. On December 13, 1977, the Federal Register published plans by OSHA to remove provisions which generally have no direct bearing on employee safety and health, and to remove provisions for certain industries which overlapped with other, more general, OSHA standards. This initial move toward efficiency is being continued by President Carter's inter-agency task force, which is commissioned to provide ideas for strengthening the Federal role in protecting workplace safety and health. The task force will present incentives which will supplement safety regulations and suggest methods for improving OSHA management. These trends toward improved management, clarification of regulations, and increased scope of activity, will undoubtedly lead to, among other things, enhanced protection of what most Americans hold as a major resource -- our youth.

Academic facilities are being inspected along with, and by the same guidelines, as industrial job sites. However, schools are presently low in priority among sites to be inspected. Most OSHA visits are initiated by complaints from students or staff, or result from an accident. Some institutions have requested an OSHA inspection, and others have been inspected under OSHA's initiative.

An article in the March 1977 issue of the Journal of Chemical Education described the frequency of OSHA-type inspections of chemistry departments; i.e., inspections done by federal or state OSHA agencies, state labor departments, insurance agencies, campus safety organizations, consulting firms, or outside committees. Of the sample population, 20.7% of the respondents had been inspected -- 15.6% of the primarily undergraduate departments, and 25.5% of the PhD granting departments. There was no indication of data from two-year colleges. However, if this limited survey is a true indication, the two-year college will probably be inspected at less than a one in six frequency rate.

The most likely areas of non-compliance with safety and health regulations in academic laboratories were specified in the same March 1977 Journal of Chemical Education article. These major areas were (1) improper electrical wiring, (2) unguarded belts, pulleys, blades and wheels, (3) improper chemical storage, (4) poor ventilation and fume hood design, and (5) insufficient personal protection facilities. These areas are substantially safety oriented and reflect concern for preventing accidents. Items related to health and work practice are almost non-existent, but inspections now and in the future may show a different distribution.

The impact of OSHA compliance on the academic laboratory is or will be, felt in three major areas: economic, legal liability, and curricula. The cost of full compliance with OSHA, from a quick survey of available literature, ranges from $15,000 spent by Stanford University in 1973 to $400,000 required at the Massachusetts Institute of Technology in 1972. Both sums, although not fines, resulted from OSHA inspections. One article reported an average cost of $250 to $500 per student for campus-wide compliance. None of the available figures were specific to two-year colleges. However, many two-year institutions are heavily involved in training students for industrial technology positions, and have very active on-the-job or hands-on training programs. For these, the cost of compliance will probably be higher than for those institutions with more classic, strictly academic or transfer programs.

A budget for an OSHA compliance program may include costs for new equipment, such as eyewashes (preferably the type supplied by the house plumbing) and new fume hoods. Upgrading old equipment, such as grounding electrical motors, etc., may be a significant budgetary item. Many facilities have inadequate storage for chemicals, and may need a new structure constructed for this purpose, or new cabinets and explosion-proof refrigerators. Fire protection equipment, such as extinguishers and especially self-contained breathing apparatus is necessary. Some programs may require a supply of personal protective equipment for student and faculty use. In many cases this equipment must be assigned on a single individual basis. Otherwise, it must be sterilized to protect succeeding users. The last major budgetary item is the on-going costs arising from the conduct of an OSHA-approved safety program. Most of these involve payment to personnel or payment for educating personnel. Failure to conform to the OSHA safety and health standards may bring fines of as little as the $175 Caltech paid in June 1974 for 746 violations, or the fine may reach $1,775 as did the one MIT paid for 1651 violations. In any case, the cost of compliance will only be increased by procrastination.

The legal impact of OSHA is two-fold; i.e., from the Act itself, and from the use of the Act as a guideline in tort liability cases. Compliance with OSHA is a legal burden on every employer, but non-compliance carries no implication of guilt of anything other than not meeting the standards. On the other hand, if an accident occurs and results in bodily harm to a student, compliance with OSHA regulations may be used as a test for safe and healthy working conditions, and knowledge of OSHA regulations may be used as a test of the competence of the instructor. Additionally, OSHA regulations might be used to define "ultrahazardous" substances or activities for which liability is absolute, and negligence need not be proven to obtain compensation for damages resulting from an accident. It is interesting to note here that the legal responsibility of the employer for the health and safety of an employee extends beyond the confines of the primary workplace. A case reported in the September 19, 1977 issue of Safety Management pointed out that an employee loaned to another employer remains the responsibility of the original and primary employer as regards on-the-job safety. An analogy might be drawn between this situation and a professor loaning a student to an industry for on-the-job training. Some may argue that the student is not an employee, but in some cases the student does receive a stipend from the institution for the work performed. Would the student not then be an employee of the school? In cases where no money is involved, we must consider the view reported by Dr. John F. Adams in an article for the National Association of College and University Business Officers. In short, the public has the right to expect security precautions at least equal to the standards for employees. Thus, we might reason, even if a student is not an employee, he or she is definitely the public and the professor is still an employer with full responsibility for safety and health of the student.

Clarification of the legal requirements for academic and technical programs is obviously an urgent need. The two-year college must not leave itself open to liability suits. Ignorance of "ultrahazardous" materials and practices is not a viable defense against tort actions. Further, we must obtain a clear definition of the institutions' responsibility to its students in off-campus, on-the-job training programs.

The analysis of the trends in OSHA management, and the impact of OSHA on academic is a never-ending and somewhat inconclusive exercise. We are, however, clearly governed by OSHA regulations and must act to comply. The process of achieving compliance is time-consuming and complicated. As with all such processes, a starting point must be established. A model for reference is useful; advice from those experiencing the same problems is helpful, and knowing you are not alone is encouraging. To provide you with at least some of these necessities, the following history of our safety program follows herewith:

The Charles County Community College was founded in 1958 and is presently comprised of 2545 students, 150 faculty and staff, four academic buildings, a student center, a maintenance building, and a sewage treatment plant. At present, there is no comprehensive, campus-wide safety program, other than a fire protection plan published in 1975. Individual departments provide their own safety programs as time, money, and staff permit.

The safety program of the Pollution Abatement Technology/Chemistry Department began in October 1976, when the department chairman selected one faculty member to investigate OSHA regulations and attend the American Chemical Society safety course, "Laboratory Safety-Recognition and Management of Hazards." Prior to October 1976, the safety program was characterized by a casual approach in both the workplace and in work practices. The physical facility was, and is, reasonably modern, having been opened in 1971. At that time, there were four laboratories in the complex: a general/organic chemistry lab, a sanitary chemistry lab, a microbiology lab, and an instrumentation lab. The electrical system included a grounding leg, and each lab had sufficient means of egress in case of emergency.

Fire protection was provided entirely from extinguishers. There was only one eyewash for the four separate and distinct laboratories, while two deluge showers were available in two of the labs. The floor plan of the sanitary chemistry lab provided very limited access to, and egress from, this lab. The general chemistry/organic chemistry lab, alone, had main utility cut-offs.

Our work practices in the lab prior to 1976 were not guided by an document promulgated by the school, other than a list of safety regulations presented to freshmen in general chemistry. Accident reports were filled out for some injuries, and the department head during this period, advised each faculty member to provide uninterrupted supervision when students were working in the labs.

Following the selection of a department safety coordinator in October 1976, a safety committee was established but soon dissolved, due to changes in department personnel. Nevertheless, progress has been made in bringing the lab facilities into compliance with OSHA regulations, and department faculty are making a concerted effort to educate themselves and their students in hazard identification and accident prevention.

The laboratory facilities have been improved and expanded. The floor plan of the sanitary laboratory was modified to improve traffic flow. Eyewashes have been installed in all labs and fire blankets are available in two of the labs. New exhaust hoods were installed in the instrumentation lab above the atomic absorption instruments, and the old hoods are being repaired after having been smoke tested. The ventilation available in the general chemistry laboratory remains inadequate. Emergency lighting has been installed in three labs.

The new organic lab, used since January 1978, has eyewashes, a shower, and utility cut-offs, but would benefit by a fume exhaust system for individual work stations, a fire blanket, and emergency lighting.

In the classroom, students are regularly instructed on the hazards of the chemicals and procedures for each lab. In addition, special assignments are made for outside investigations into the hazardous properties of specific chemicals. Safety films on the general chemistry lab, handling compressed gases, and industrial safety are used where appropriate. In March of this year, a fire safety demonstration by a local fire science instructor was given to one class and videotaped for later use in other classes. The old safety rules have been retained, with increased enforcement, and additionally, a questionnaire is used to obtain information on health problems which might affect, or be irritated by, working in the lab.

Probably the most important advancement in the overall progress toward compliance has been the education of the safety coordinator. Useful information has been gained from: (1) the Maryland OSHA regulations (2) the Manufacturing Chemists Association's "Laboratory Waste Disposal Manual," (3) the Manufacturing Chemists Association's "Guide for Safety in the Chemical Laboratory" (4) the J.T. Baker Company's Hazardous Chemical Safety School (5) the "OSHA Report" published by Man and Manager, Inc., (6) the "Journal of Chemical Education" (7) the American Institute of Chemist's publication, "The Chemist," and (8) the "Laboratory Safety Checklist" available from Lab Safety Supply Company. A mo complete listing of useful materials is available upon request. In general, three types of documents are important: reference materials for technical information on safety, listings of federal or state regulations, and periodicals to provide up-to-date information on lab safety and government regulations.

The cost of the safety program in the Pollution Abatement Technology/Chemistry Department over the past eighteen months has originated substantially, from personnel education, and equipment purchase and installation. By combining the actual dollar outlay for courses taken, and the paper cost of man-hours spent, the cos for the safety coordinator is approximately $1,500 to date. The laboratory modifications cost about $2,500 to purchase and $1,000 to install. The total bill so far is $5,000 and achieving full compliance may cost another $10,000.

By applying perfect 20/20 hindsight to our PAT/CHEM Department safety program, we can see several important aspects. Appointing a single safety coordinator for the department was an excellent first step. There must be a single leader to provide a unified approach, and that leader must have the public endorsement of the department chairman in order to act effectively.

The main area of program development in our department has been in facility modifications. Modifying the facility is probably the part of the program which shows the most dramatic improvement quickly. A new lab floor plan is so obvious, and a $1,500 explosion-proof regrigerator is easily the pride of a small chemistry department. It is easy to feel content and satisfied while viewing these major changes, but small items like signs are important too. A recent court ruling in Michigan found an instructor to be negligent because signs requiring the use of safety glasses in a vocational shop were not posted. An eye for the fine details, and continual vigilance are necessary to complete and maintain the facilities in a condition of compliance.

The one area of our program which has yet to be developed is administrative procedures. This is probably a consequence of having one faculty member with a full teaching load doing the bulk of the developmental work. For this part of the program, a committee would be useful or, alternately, the coordinator could be allowed a light teaching load for one semester.

A document containing the complete administrative procedures will provide the continuity to overcome changes in personnel and all but the most drastic reorganizations or facility changes. If the procedures are truly complete, they may save the safety coordinator from the embarrassment of having an instructor point out, in the middle of a class, that a newly installed deluge shower in a brand new lab is inoperable because the water supply valve was never turned on.

We must now face the task of combining our knowledge of the areas of OSHA impact, and the experience gained in our initial efforts at realizing OSHA compliance, to develop effective safety programs at the campus, state, and national levels. Through such a multi-layered organization we could publicize two-year community college programs. We would be able to develop fast, efficient means of exchanging information with one another. We would have the combined weight to influence legislation to be sensitive to our special problems, and to help us fund our programs. We could pool our resources to provide training programs for faculty, staff, and students.

A campus safety program for a small, two-year community college might best be organized and administered in a manner similar to our federal and state programs. A campus safety and health department would be created with authority given by a high administrative office. A safety coordinator would head this department.

Each of the other departments would be required to appoint a safety monitor and develop plans for an intra-departmental safety program. The campus coordinator would unify the individual programs, advise the departments as to the fitness of their program and ensure that all departmental programs were administered properly. Additionally, the coordinator would provide campus-wide inspections, record-keeping, and regulations.

The safety and health department for a school similar to the Charles County Cojmunity College would need only one safety coordinator and a secretary. The department safety monitors would serve as a school safety committee and would give technical assistance to the campus coordinator when necessary.

When setting up the campus safety program, there are several sources of assistance. State occupational safety and health departments generally have a consultation service; however, personal experience indicates that the Maryland OSHA consultant is slow to respond to requests for assistance. Independent safety engineers can be hired to give advice, or the college's insurance carrier may provide an inspection service.

The state and national organizations for two-year community college safety programs could be developed fairly quickly by alliance with an already established organization such as ACS or the National Campus Safety Association.

There are many benefits issuing from a campus safety and health program. Compliance with OSHA standards is fairly well assured. There can be substantial savings due to reduced accident rates. Safety will become a recognized budgetary item. There is comfort in knowing that the activities of the college are on firm legal ground. The community college can become a leader in yet another community activity, and finally, most importantly, we will produce a better graduate.

Assessment and Placement of Students in Mathematics

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Presented to the Sixtieth, Two-Year College Chemistry Conference, Miami-Dade Community College, Miami, Florida, September 8, 1978.

INTRODUCTION

This presentation will treat assessment and placement as an integral part of a comprehensive program of instruction in mathematics. The logic of this approach is easily seen when one realizes that any viable system of assessment and placement must match and funnel students into a compatible system of instruction

Increased importance has to be placed on assessment and plac ment because of the type of student who is entering college today Judging by the results of the nationwide Scholastic Aptitude Test scores for 1977, this last year saw the least academically prepared freshmen in the history of the examination. Perhaps more illuminating have been the results of the statewide minimum competency testing in Florida. Over one third of the 130,000 high school juniors who took the test failed because they could not score at the 70% level on eighth grade level mathematics.

These same students are applying and being admitted to our two and four year colleges. Their presence on our campuses has perpetuated a perplexing pedagogical crisis. How can the basic skills of these students be improved to a level where they may have a fair chance to earn a college degree? The remainder of this talk will be devoted to describing a system which has great promise of providing an answer to this problem.

A SYSTEM OF ASSESSMENT AND PLACEMENT

The assessment and placement system used in the Mathematics Learning Center of the New World Center (Downtown) Campus of Miami-Dade Community College is one which consists of combining the results of two paper and pencil inventories. The first inventory is a multiple choice mathematics test geared to the course which the student has indicated he wants to pursue. The second inventory is the Canfield-Lafferty Learning Styles Inventory designed to determine an individual's preferred way of learning. Through a set of decision rules programmed into a computer the student is assigned to one of four modes of individualized instruction.

A SYSTEM OF INSTRUCTION

The assessment and placement system tries for a best fit between the student's professed ideal learning style and an available mode of instruction for the four courses: arithmetic, introductory algebra, intermediate algebra, and trigonometry. The four modes of instruction for each course consist of one or more of the following: audio-tutorial materials (graded for reading level), programmed materials, tape/slide materials, and work-texts combined with video or audio tapes. The Auto-tutor, a branched programmed teaching machine, and the SRA Skills Kit are used to give additional practice to needful students. A paraprofessional and/or student peer teacher is always available to answer questions concerning the content of instructional materials.

A COMPUTERIZED SYSTEM OF EVALUATION AND MANAGEMENT

Each course taught in this program is divided into twelve units or modules. The student is required to take a test after each unit. In addition, he/she is expected to take a comprehensive mid-term exam and a comprehensive final exam. All exams are multiple choice so that they may be scored by computer. A student must meet criterion on each of the unit tests before he/she is allowed to go to the next unit. If criterion, eight out of ten, is not met on the first attempt to pass a unit test, the student must review the material missed and do extra problems before he/she is allowed to take a retest which consists of a different version of the first test. The criterion for the retest is raised to nine out of ten.

If a student is still not successful he/she is assigned to a tutor who takes over supervision of his/her learning program until mastery is demonstrated for the material of the particular unit. Upon certification of success by the tutor, the student re-enters the mainstream of the computer system.

Learning and evaluation is managed by a computer using the college's RSVP, Response System with Variable Prescription, computer program. RSVP begins by writing the student an introductory "letter" outlining the instructional system and detailing what is to be expected. It also delineates the individual's program of study by listing the appropriate educational objectives by listing the materials to be studies, and by specifying how far to proceed in the designated material before a test is to be taken The student works at his own pace with a gentle reminder that by specific dates a certain number of units should be completed. When he/she is ready, a test is taken. The test is scored by computer and the student receives a printed analysis of his/her test including the score on the test, which problems were missed, what they covered, and where he/she may go in the materials to find the particular topic. Review of all missed items is recommended before the student proceeds. A record of each student's progress is kept by the computer.

RESEARCH AND EVALUATION

This system is currently being evaluated by a comprehensive program of research designed to answer the following questions: Should a student be selected for the program on the basis of learning style or on the basis of mathematical deficiency? Is a better result obtained by analysis of learning style for assignment to a mode of instruction or by random assignment to an instructional mode? How does participation in this program affect student attitude toward mathematics if at all? Can this individualized, computer managed, multimedia, mathematics learning center do as good or better a job of preparing a student as the classroom? And very importantly, is such a system of instruction cost effective?

CREDIT

The above system of instruction was developed under a three year grant from the C.A.U.S.E. program of the National Science Foundation. All inquiries concerning similar funding should be directed to the Division of Science Education Resources Improvement, NSF, Washington, D.C. 20550.

Getting Published

Herb Spiegel

Presented to the Sixtieth, Two-Year College Chemistry Conference, Miami-Date Community College, Miami, Florida, September 8, 1978.

One of the hardest parts of getting published is to get started. That doesn't sound like a very profound statement, but if you had gone the route of many an author, it is the only one that can be made.

As a potential first-time author, you are full of ideas of how to write a much better textbook, at least better than the one you are presently using. You think your presentation would make much more sense and it would certainly be better organized. You want to get started immediately and you start daydreaming of the royalties you are sure will be forthcoming. But how do you find someone that is interested in your idea and what is the first step.

One way is to sit down and write your text. After it's finished you can send it to the many commercial publishing houses and hope that someone will think it has some potential. However, many more times than you like to think, rejection letters are all that is left for your many hours of labor.

If you are really set on seeing your work in print, you can approach a vanity publisher who, will print just about anything you wish to pay for. But you must do all your own advertising, promotion, and distribution. This is not really the setup you want for your text.

If you are not really interested in profit, but only to see your name in print, you can self publish, as have thousands of authors before you have done. In this case, you need to find a reputable printing concern and in the long run this method may be quite costly. Again you must be your own advertiser and distributor.

It seems to me that the easiest way to get your book or textbook published is to take the following steps:

1. Research your subject area thoroughly by reading other books on the subject. This will accomplish two things. One, you will find out which publishers already have such a text on the market and two, you will readily see if your idea was as novel as you thought.

2. Come up with a title, draw up an outline and write a sample chapter complete with the type of pictures and illustrations you would like to use.

3. Thirdly, and most importantly, write a brief description of how your book will be different from those already published. Add to that, what you think the marketability of the book is and how much competition there will be. To a commercial publishing house this is most important since they are in it strictly for profit and not for your benefit. Publishers seldom take a chance on books that do not show a potential profit no matter how good it is. They certainly want quality but profit comes first.

After having accomplished the previous 3 steps, you are now ready to market your idea. Notice I said market not sell. A salesman makes a pitch and waits for a reaction. A good marketer has done previous research into the subject. He has found out that what he has is needed, has a ready market and who are his potential customers. He then designs his presentation, tailored to their needs. He concentrates on only those he thinks he will get a positive response.

Sure there are other ways of approaching this subject area. You can sit back and wait for the book salesman to come along and maybe ask you if you are thinking of writing a book. This might be a way to get started, but I personally don't know too many authors who went this route successfully. I personally like this approach:

1. Send the outline, sample chapter and marketability statement to at least 3 publishers. A few reasons for choosing one publisher over another are:
   a. They don't have a text such as the one you want to publish
   b. They have an excellent name in the business
   c. They have a large sales and distribution force
   d. They will do a large amount of advertising
   e. They have a trade division as well as a text division, just to name a few.
2. Wait a couple of weeks and follow through with a personal contact by phone to further explain your idea if it is needed.
3. Talk to the salesperson from that publishing house and have him push it for you.

In summary, let me say that it is not that difficult to get your book published by a reputable publisher, and after the first book the others are much easier. This is because you are now an accomplished author. To me, the hardest part of the whole mechanism is the changing of editors. They seem to come and go as if changing jobs was an everyday occurrence. (I had 5 before my first book was in print - each with a different set of ideas). The other hard part was to convince the publisher that a 2nd edition is warranted after 2-3 years.

Experience Using Guided Design

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Although Guided Design is a teaching and learning method originally devised by Wales and colleagues at West Virginia University to complement an undergraduate Engineering curriculum, it has more recently been adapted to several disciplines at a variety of institutions. Typically, Guided Design is planned and used in a course in the form of modules, which are self-contained short stories in serial form. Each episode in a series contains an instruction to each group of four or five students in the class to make one or more decisions ultimately leading to instructor feedback and to further instruction in the next episode. The units are thus planned as a sequence of open-ended problems, usually of increasing complexity, with a unifying theme. The students learn their background material by using audio-tutorial methods.

We have utilized Guided Design while team teaching our sophomore course, "Computers in Chemistry" and plan to adopt it in other courses. It is most useful in simulating real-life situations.

INTRODUCTION

Guided Design (G.D.) is a teaching and learning method devised by Wales and coworkers[1] at West Virginia University, initially specifically for their Engineering curriculum. It has more recently been adapted to other disciplines in large part because the EXXON Education Foundation it as part of its IMPACT[2] program, whereby grants are made to individuals interested in implementing one of the educational innovations supported by the IMPACT program. As part of the IMPACT program the EXXON Education Foundation has made films for free use demonstrating the educational innovation[3]. In this way, and in others, the principles of Guided Design have been modified to include diverse subjects in the Humanities, the Social, Biological, and Physical Sciences.

Its first striking feature is thus one of adaptability probably because the idea of the originators was a simple one, and that was the combining of Open-Ended Problem Solving with Self-Instruction. The strategy of Guided Design is to have the students work through a well-planned sequence of these open-ended problems, making decisions at each step. The order of the problems, might be either ascending in difficulty or else a chronological one in perhaps a real life situation. Stress therefore is made on practicality. It assumes that we are teaching students not so much chemistry as to be chemists, and a chemist must be one who is able to communicate with others in a professional capacity, often being judged not just on his/her ability but also in how he/she interacts with other people. Thus, while many alternatives to the traditional classroom lecture have been devised, this one is remarkable in that it has a design, or a structure, to it.

In order to utilize the method, the problem as devised is broken into a sequence of decision-making steps, A, B, C, etc., to be tackled in order. Within each of these are several phases as outlined in Table I.

TABLE I

The Structure of Guided Design

Steps	Phases
Defining goals	Introduction
Generating solutions	Instruction
Gathering information	Feedback
Applying restrictions	Information
Evaluating solutions	Bibliography
Synthesis	

In addition to the two most important phases, Instruction and Feedback, any step such as Gathering Information might have any or all of the phases included.

The class, say of twenty students, is broken into groups of four or five people who stay together on the problem until the assignment is completed. Later, for a new project, a shuffling will occur and the process is restarted. Each group selects a recording secretary who also acts as discussion leader and group spokesperson. The instructor gives a written instruction and the group has the responsibility to make decisions and come to a conclusion. Then a model answer is distributed by the instructor for the next phase, and so on. Typically, Guided Design is used in a course in the form of modules which are self-contained short stories in serial form. The learning of the subject matter is effected by means of self-instructional modules indicated at appropriate times in the project.

Implementation:

Chemistry 7 (Outline in Table II) is a three-unit sophomore course in which there are about twenty students enrolled per semester. While some of these are majoring in scientific disciplines both pure and applied, many of them are participants in our program which leads to the A.A. degree in Chemical Technology, which was instigated in cooperation with local industry and in which Chemistry 7 is a core course. The course, like the college as a whole, enrolls a significant proportion of minority students (Asian, Black, Hispanic, etc.). The course[4] has been in existence since 1972, and is an integral part of series of computing features we have introduced into the practices of the Chemistry Department at City College of San Francisco.[5,6,7,8,9,10]

TABLE II

COURSE OUTLINE - CHEMISTRY 7

I. General Topics
   A. What is a computer?
   B. Number systems
   C. Operators and functions
   D. Problem solving techniques (G.D.)
   E. Algorithms and flow charts (G.D.)
   F. Time sharing and batch system for "canned" programs

II. Programming Languages
   A. Language considerations (G.D. design a language)
   B. BASIC - self instruction with unit tests
   C. FORTRAN - "improved" BASIC, why?
   D. Programmable calculators
   E. Debugging a program or programs (G.D.)

III. "Individual" Projects (G.D.)
   A. Gas Law generalization
   B. Processing instrumental data

The only prerequisite is one semester of university parallel chemistry; thus, no previous experience in computing is assumed. The college catalogue description reads:

"General purpose automatic digital computers. Concepts of algorithm, language and flow charts. Programming and numerical methods. Use of FORTRAN to solve problems in Thermodynamics, Kinetics and Structure".

In practice, the BASIC language is also being used.

The three one-hour lectures are designed to teach the students to set up problems so that they are then able to submit their own jobs in their own time to the computer. Students are encouraged to revise, trouble-shoot and add flexibilities to programs. The course may be broken down into:

I. General topics in computing and problem solving; algorithms and flow charts; interactive and batch computing.

II. Programming languages: BASIC and FORTRAN.

III. Individual projects in chemical computing.

We have applied Guided Design to all three of these sections in the form of six projects. These projects are: Problem Solving Techniques; Algorithms and Flow Charts; Design of a Language; Debugging a Program; Gas Law Generalization (to osmotic pressure); Processing Instrumental Data (G.L.C.).

An Example:

This represents a synopsis of one of our G.D. projects, Generalization of Gas Laws.

TIME: The present

PLACE: A biochemical laboratory

PRINCIPAL: Ted Milligan, a newly employed technical graduate with more computer knowledge than most of the other employees.

EPISODES:

A. Goals: These are decided after the problem has been presented to Ted by his supervisor. He is asked to write a program to solve the equation $P = cRT$. He concludes that he must take into consideration potential users' needs.

B. Possible Solutions: Ted realizes that the solutions to the problem depend on the options which he can choose in each of several categories.

To satisfy users he could provide for:

1. solving the equation for any of three variables
2. doing multiple calculations
3. using either batch or interactive mode
4. input and output in standard or optional units
5. output to be printed with or without explicit units
6. designating input by code or explicitly
7. machine dependent or independent coding
8. input or output to be via cards, tape disc, etc.
9. diagnostics to be explicit or in system code
10. ease of modification
11. readability to the casual user

As far as the computer itself is concerned, the program could be:

1. modularized or unitary
2. loaded onto a file or given to the user in source or object form
3. written with or without Computer Department help
4. written in any of a variety of languages

All of these decisions have cost consideration associated with them.

C,D,E. Gathering Information: Ted now formulates questions to ask various personnel to help to make decisions concerning the options in Phase B.

F. A Possible Solution: Answers to the questions formulated in the previous phases are provided, and Ted thereby makes choices of the options generated in Phase B.

G. Preliminary Evaluation; Ted rationalizes his choices on a scale of 1 to 5 for use in the next phase.

H,I,J. Synthesis: This consists of constructing an algorithm, a flow chart, and a program.

Further Plans:

We plan to continue to use G.D. in Chemistry 7. For our one semester Chemistry 7 course, six G.D. projects are the most that there is time for. We have found that the Guided Design approach is readily transportable to other courses, particularly in the laboratory. There are several reasons for this:

1. Laboratory counters provide an adequate alternative to the small tables used for the groups at West Virginia University and elsewhere.
2. The laboratory traditionally has a more "open" learning environment than the lecture hall.
3. Because the laboratory period is longer, it is less critical if a group discussion takes five minutes longer than anticipated.

In addition, we have used G.D. in our basic problem solving skills course, Chemistry 17, and have found that G.D. is appropriate and useful in this course. Also, we would like our Chemical Technolog students to have simulated experience in working within an organizational structure. G.D. is naturally adaptable to case study methods, and it will be appropriate to develop and use such module in the more business-oriented courses in their curriculum.

The self-instructional aspect of G.D. should be made more efficient when we have further developed our Computer Access to Self-Instructional Materials (CASIM)[10]

Conclusions:

We have concluded that the experience is worthwhile both to teachers and students. We have as yet had insufficient time to follow up and test the students' subsequent professional performance.

The method is probably readily adaptable to, in addition to those mentioned above:

1. Graduate seminars
2. Interdisciplinary studies.

Acknowledgment:

We are grateful to the EXXON Education Foundation for a grant to implement Guided Design. We would also like to thank Professors C.E. Wales and G.D'Amour of West Virginia University for their help and encouragement.

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1. C.E. Wales and R. Stager, Eng. Educ. 62, Feb. 1972 and Mar. 1972.
   There have been several subsequent articles and publications by Wales et al.

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3. Film #31864, Guided Design, Film Scheduling Center, Modern Talking Picture Service Inc., 2323 New Hydr Park Rd., New Hydr Park, N.Y. 11040.

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GENERAL CHEMISTRY

MINITIPS: A Non-Punitive Testing Method

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Presented to the Sixty-Second, Two-Year College Chemistry Conference, Brookdale Community College, Lincroft, New Jersey, March 23, 1979.

MINITIPS is a miniature version of the Teaching Information Processing System (TIPS) designed by Allen C. Kelley at Duke University.[1] TIPS has been described as "... a teaching tool that utilizes the computer to provide each student an individualized course of instruction.[2]"

The writing of this smaller version was necessitated by the central memory requirements of TIPS which were greater than those available to Gloucester County College at the time MINITIPS was first written. Of course, the reduction in size results in MINITIPS being able to perform only the more basic tasks of TIPS.

In the operation of MINITIPS, students are first given a survey in the form of a multiple-choice quiz. This survey tests each student's understanding of a group of topics within one unit of educational material. The program takes the student's answers to this survey, grades them, and prints out one or more diagnostic messages based on the student's performance on each topic.

Each student receives a STUDENT'S PROGRESS REPORT containing the student's responses, grade, and one or more messages.

The instructor receives a TEACHER'S REPORT which contains th following:

1. DECISION RULES FOR MESSAGES: The criteria for giving each message, the numbers of the survey questions involved, and the class average on the topic being tested.
2. MESSAGES: A listing of the messages and the number of times each message was given.
3. SUMMARY OF STUDENTS' MESSAGES: The printing of each student's grade on the instructor's copy is optional.
4. The number of students taking the survey and the mean grade.
5. % OF THE RIGHT ANSWER TO EACH QUESTION: The percentage of the class that answered each question correctly.
6. % OF STUDENTS SELECTING EACH ANSWER: For each question, the students selecting each distractor.

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1. Allen C. Kelley, "Individualizing Instruction Through the Use of Technology in Higher Education." Journal of Economic Education 4 (Spring, 1973): 77-89
2. From the brochure "TIPS" distributed by the EXXON Education Foundation through its IMPACT Program: Funds to Implement Educational Innovations.

Strategies Used in Teaching General College Chemistry

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Presented to the Fifty-Ninth, Two-Year College Chemistry Conference, Essex Community College, Maltimore, Maryland, April 8, 1978.

In 1971, the introductory chemistry course, which usually enrolls about 55 students at HCC, began to undergo a systematic and carefully planned development process. As the instructor completed various aspects of in-service professional development, he put these concepts into practice in his course. Instructional taska, learner characteristics and subject content were all analyzed and instructional materials were developed and later revised. In 1976-77, formal try-out data was collected to see how the students reacted to each unit and how successful they were in accomplishing the course goals and objectives. Based on an analysis of this data, specific changes were made and additional data was collected in 1977-78. A few minor revisions were then planned to occur some time in the near future.

STRATEGY OPTIONS

Four strategies were developed to meet the needs of the various types of students who generally enroll in first-year college chemistry. The students were allowed to mix and match the four strategies as they found best met their own needs.

Strategy A:

Strategy one was entitled "Problem Solving Sessions", which basically involves the explanation of a concept by the instructor and the provision of a number of examples by the instructor followed by an interactive period when students attempt to solve similar problems.

Strategy B:

(J. Allen, Burgess Pub. Co.) The "Minicourse" Strategy uses a commercially available set of packaged min-courses and audiotapes for individual student use.

Strategy C:

The "Roadmap" strategy was developed by the instructor and they include detailed directions for solving each type of chemical problem. The Roadmaps include cartoon characters to help guide the students through each step of the problem solution in a highly programmed manner.

Strategy D:

The "Textbook" (General Chemistry, Nebergall) includes reading assignments and problems to be worked.

Laboratory

All students go through each lab activity which includes a pre-lab handout, an audio-tape and in some cases a video-tape to help guide the students through each lab. The labs are set up on an industrial model in that one lab is organized to help the student acquire the skills and techniques needed to analyze an unknown substance. Each "known" lab is followed by an "unknown" lab where the student must apply his skills to a new situation. The instructor predicted the percentage of students who would select each strategy. As it turned out, the percentage were similar but varied somewhat:

(2) Student attitudes toward each strategy includes special comments about each unit.
(3) Student attitudes toward each element in each lab.
(4) Success on identifying lab unknowns were analyzed by the instructor.
(5) Post-test results on each unit were also analyzed including an instructor analysis of each problem (in 1976) to determine the specific problems where less than 70% of the students gets the item correct; in this case the type of errors made were analyzed.
(6) In 1977, the time spent and the options selected were further analyzed by the student's current grade average in chemistry.

Results

(1) Time Spent by Grade Earned

The instructor predicted that the typical student would spend 1 1/2 hours outside of class on chemistry for each hour in class - not including lab time. This would be a total of 157 1/2 hours for the total course for the typical student. The "A" students invested a total of 153 hours, while the "B" students spent 228 hours, which is a considerably greater amount of time than the "A" students. The "C" students spent only 205 hours while the data available from 5 students who did not complete the course indicated they spent a total of 255 hours on the various units. These times are the sum of the mean hours students reported they spent on each unit plus 3 hours for each lab they did.

(2) Attitude Toward Each Strategy

Each of the four components used in the various strategies were evaluated by the students as being well above the mid-point on each scale used. The Road Map and Class are rated most positively (generally above 4.0 on all four scales.) The text is rated least positively in all units and in the overall rating with scale ratings between 3.4 and 3.6 on the various scales.

Attitude Toward Strategies:

Legend (values range from 1 to 5)

Boring/Interesting	Dull/Challenging
1 — 5	1 — 5
Unworkable/Workable	**Good/Bad**
1 — 5	1 — 5

Average mean of questions for eight units:

Class A		Mini B		Roadmap C		Text D	
4.1	4.1	3.8	3.8	4.0	4.0	3.6	3.6
4.1	3.9*	3.8	3.7*	4.2	4.0*	3.6	3.4*

*This scale has been reversed so the direction of the results will be consistent.

All units are rated comparably in terms of overall student attitude.

Average mean attitude for the four scales combined for each unit:

Unit	Mean for each Unit
I	3.82
II	3.95
III	3.94
IV	3.87
V	3.83
VI	3.92
VII	3.81
VIII	3.80

(3) Attitude Toward Labs

A. Overall Attitude Toward Lab:

1. Overall labs are rated very positively -- 3.9 or above on the four scales
2. Lab 1 is rated less positively than other labs. Lab 1 is the check in lab which needs to be jazzed up
3. Lab 15 is rated to be less workable than other labs. This is understandable because this is a difficult and tedious lab. Students have suggested this lab should be placed later in the lab sequence.

B. Various Media are used in the labs to help the students to acquire the skills needed to identify their unknowns. A summary of the students' evaluations of these media indicate:

1. Overall, 88% of the students rated pre-lab materials good to excellent, 80% of the students rated audio tape, good to excellent, and 59% of students rated video-tapes good to excellent.
2. Students rated pre-lab material most positively for 11 of 14 labs.
3. Students rated audio most positively first for 2 of 14 labs.
   Students rated video most positively for 1 of 14 labs.
4. For the pre-lab, lab 15 is rated less favorably than other labs.
5. For the audio, labs 5 and 12 are rated less positively while 10 and 13 are rated extremely positively.
6. For the Video labs 1 and 4 are rated more positively while labs 9, 11 and 12 are rated less positively than the other video presentations. Labs 9, 11 and 12 are unknowns, so students feel the video-tapes are not as helpful.

(4) Lab Unknowns

Evidently the structure of the lab is quite successful because over 90% of the students were successful in their identification of the unknown substances.

(5) Unit Post-Test Results

Of the items selected from the 1976 implementation trial for further investigation:

In Post-test I, success on test item 5 improved from 68% to 84%. Of those still having problems, their inability to work with dimensional analysis seems to be the greatest problem. Additional exercises are planned for next year to provide further practice.

In Post-test III, item 4 did not improve dramatically, but item 5 went up from 45% to 75%. To help improve student success next year, additional time will be planned for small group practice sessions using additional problems which will be prepared.

In Post-test Unit IV, item 1 improved from 60% to 70%. In class, definitions from prior years (one which left out key points) will be presented for the class to critique; this should help them acquire the correct definitions.

In Post-test V, item 3 did not improve (30%) but item 4 went from 63% to 77% correct. Students made errors in the calculating the number of elections involved so a Roadmap will be prepared to detail this process in a programmed manner.

Item 12 in Post-test VI did not move significantly (51%) while item 15 went from 46% to 68%. The method for teaching the isoelectronic concept will be changed to emphasize periods and positions in the periodic chart. Better use of the Periodic Table for ionizational potential trends should help clarify the changes (perhaps ask students to color code blank charts).

Conclusions

In reviewing the results of the major changes which were made in this course during the summer of 1977 based on the data collected during the fall of 1976, it is obvious that student attitudes improved and the course has become more efficient for students since the overall mean time has decreased from 253 1/2 hrs. in 1976 to 209 hours in 1977. Success on lab unknowns (i.e. over 70% correct) increased significantly in most cases; for example, in lab #5 success rose from 65% to 91%.

Since the major changes have occurred and the new implementation data shows them to be successful only a few minor changes are planned to occur in the near future.

Based on the experience gained through this try-out and revision process, it seems obvious that more selective data could be collected to help pinpoint areas needing improvement. By breaking students down by grades earned on each unit, much better and more useful information was obtained; however, a random selection process could reduce the amount of data considerably. In addition, by shifting the emphasis to subjective comments, less objective data would be needed.

The try-out process provides a way to help identify areas where students are having difficulties, it encourages the instructor to review student attitudes and successes and it helps students realize that their input will produce positive changes.

It seems that this process should occur much sooner for the instructor. Instead of waiting for a full and detailed examination, this examination should occur as soon as objectives have been written and changes made immediately.

When CH 101 was analyzed (ALT), it was anticipated that a 70% success rate would indicate the course was working effectivel In both 1976 and in 1977, the percent of students completing the course was 69% (as compared with the official 3rd week roster.). Therefore, the course is achieving its expected success rate.

Cents-ible Media: Some Novel Applications of Effective Low Cost Teaching Aids

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Presented to the Sixty-Second, Two-Year College Chemistry Conference, Brookdale Community College, Lincroft, New Jersey, March 23, 1979.

Budget conscious teachers can profit from use of teaching aids designed to be both cost-effective and learning-effective. With the wide selection of instructional technology now on the market, the principle of accountability requires that a cost-benefit analysis be applied to the selection of teaching aid systems that can have a significant impact on learning while representing a minimum investment of budget funds.

An integral part of the Learning Systems Approach to teaching[7] is the provision of a variety of alternative learning resources in recognition of individual differences in student learning rates and mechanisms. For many students, audiovisual materials can be highly effective supplements to textbook readings lectures, and laboratory work.

Resources Center The extensive use of audiovisual aids in classroom instruction can pose problems for students unable to transfer such material to their notes for review and further study Such problems can be avoided, with increased impact of the AV programming, by providing student access to these materials in a learning resources center. In our center (Figure 1), for example, students can review and study materials employed as lecture aids as well as a large variety of other resources. In its first year of operation, our center recorded nearly 60,000 student check-outs of about 150 different resource materials available. These reflec student interest in such materials, since no student is required to use the center.

Effective use of teaching aids need not be expensive. With appropriate selection of software and hardware systems, any program can employ a variety of learning resources at modest cost. The key is to select the programs and equipment that can be most beneficial to a significant number of students within the constraints of a reasonable budget.

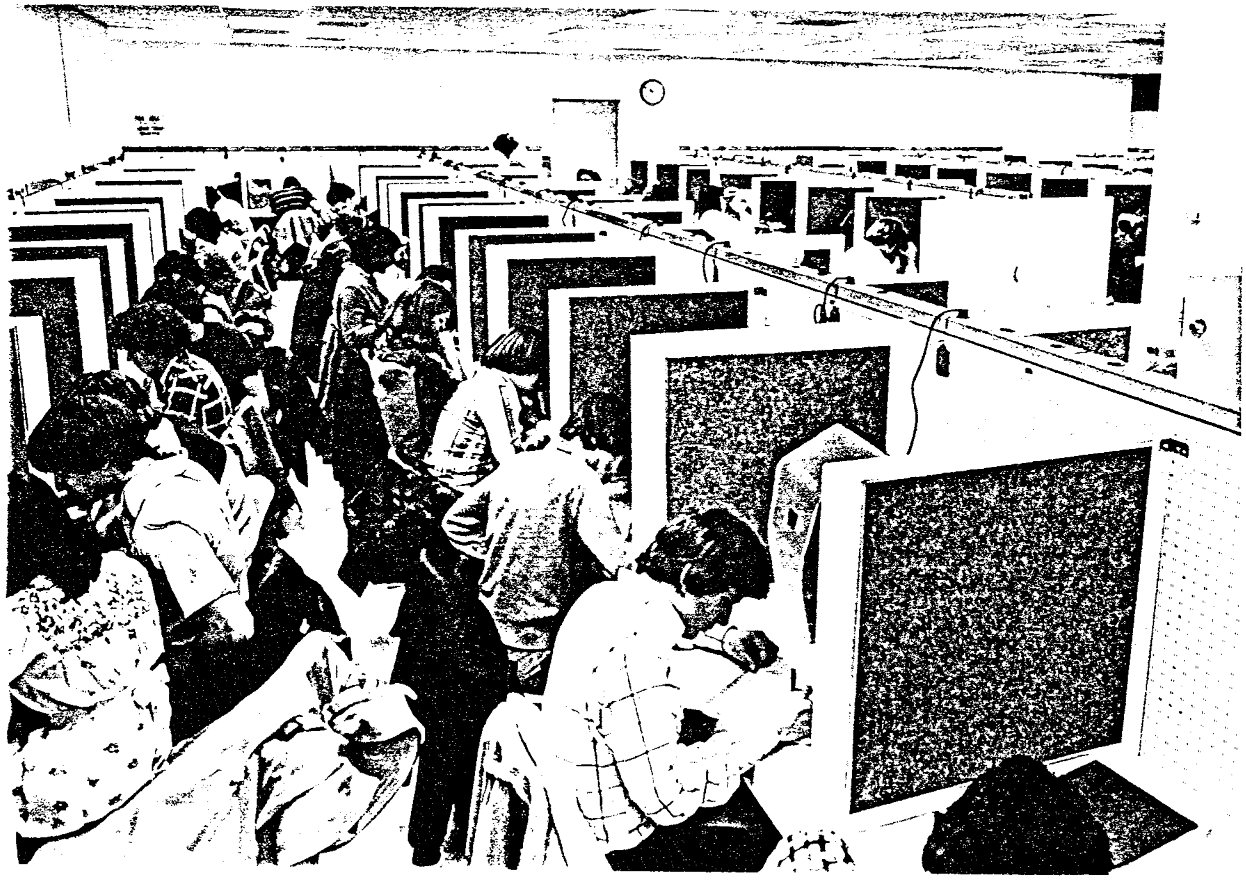
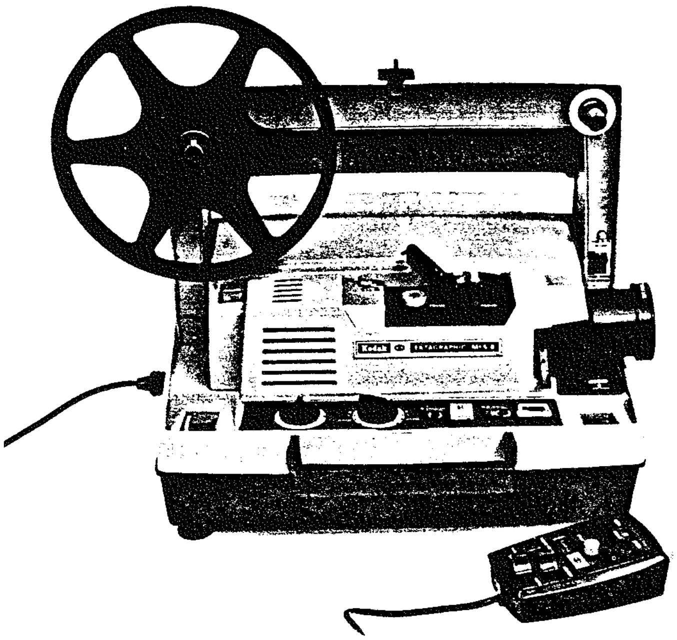


Figure 1. The College of Science Learning Resources Center at Texas A&M University contains 133 carrels built to faculty specifications. Microfiche readers are provided in carrels. Other equipment, as well as an extensive collection of programs, can be checked out at a central station. The Center is used primarily by students in lower division courses in biology, chemistry, and physics.

Super 8 Films Excellent selections of Super 8 films are commercially available for a number of courses in the sciences[1,2,3,6] and many teachers have produced their own films[8]. For the most part, the commercial films have been designed for projection at 18fps with a running time of about 3.5 min, constraints imposed by the design of the most common type of cartridge film projection equipment. As a result, these films have had some very significant limitations, particularly for classroom use with narration, and frequently seem too packed with information for reasonable assimilation during projection time.

In our classrooms, we show Super 8 films with projection equipment (Figure 2, left) designed for variable speed and having a remote control device that permits the lecturer to stop or start the film, switch from "forward" to "reverse" projection, advance it frame-by-frame (as though using slides), or project it at the preselected motion speed (54fps, 18 fps, or 6 fps). A special "image-doubler" lens is added to give a larger picture. By using this equipment, the lecturer can stretch the projection time to coincide with any narration or discussion desired, thus improving the instructional impact of the film significantly. Students have access to copies of classroom films, with simple semi-automatic variable speed projectors (Figure 2, right), in our Learning Resources Center for review or special study. It is our feeling that these uses provide much greater value per film dollar invested than most alternatives.



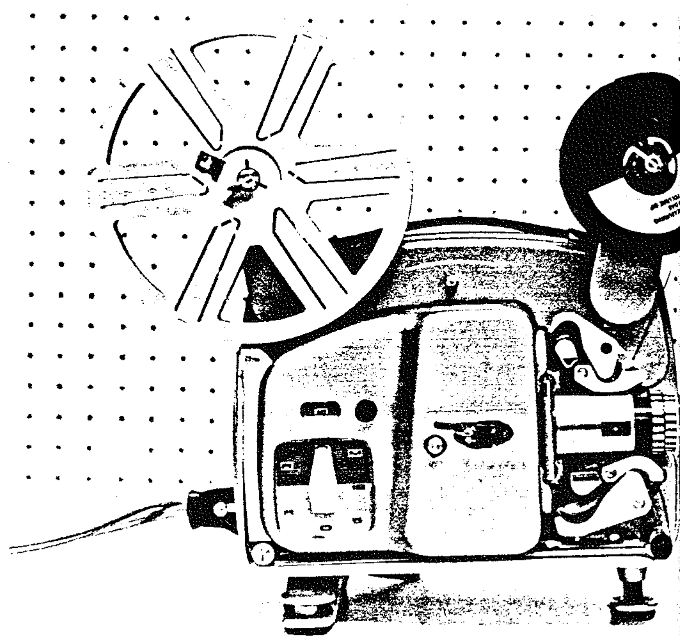
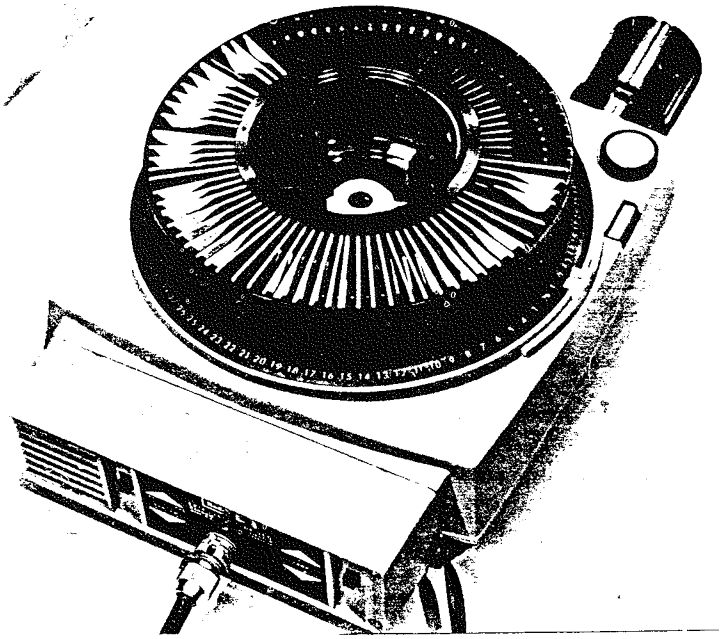


Figure 2 Added versatility and improved instructional impact for Super 8 films are provided by classroom use of the Eastman Kodak MFS-8 projector, with image-doubler (left), and by individual student use with a simple Bolex projector (right).

Slides Although many teachers use 35 mm slides as lecture aids, most current users face three problems. Frequent use of slides can be expensive in staff or faculty time for loading and unloading projectors; the linear sequence of typical projection systems necessitates advance planning of slide sequence and requires showing intermediate slides if it is desired to skip ahead or to go back for review or questions; while a slide may present a concept very well, it is difficult for students to reproduce a complex visual aid in their notes.

Our classrooms are equipped with a random-access projection system (Figure 3, left) that permits the lecturer to dial any one of 80 slides when desired. All of the slides for several days' use of a number of different lecturers can be loaded into a single carousel tray, thus minimizing faculty or staff time for projector loading and unloading. Each participating lecturer is provided with a list of the slides, by number, for use in selecting those needed at appropriate points in the lecture or for immediate accessing as questions or discussion require. The slides are selected by a simple dial control mounted on the lecture table (Figure 3, center.)



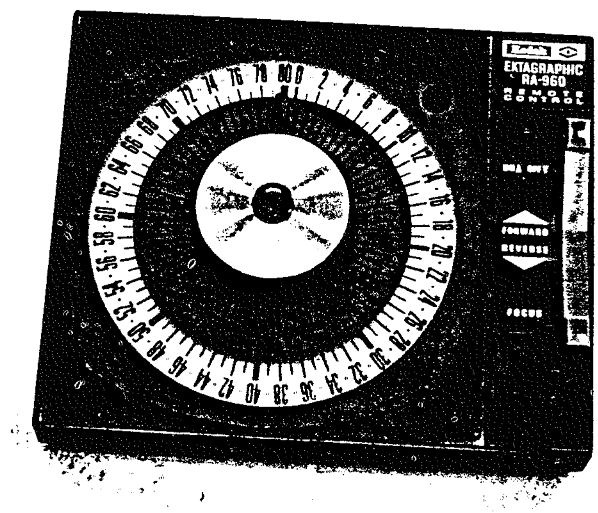


Figure 3 Instant access to any one of up to 80 35 mm slides is provided by classroom use of the Eastman Kodak Random-Access projector (left), with the control dial mounted on the lecture desk (center). Student access to slide-tape presentations in the Texas A&M University College of Science Learning Resources Center involves Eastman Kodak Audioviewers (right).

So that students can readily refer to visuals presented in lecture slides, we employ two approaches. Most of our slides are prepared from illustrations in the textbook used.[5] (These same visuals are also available as overhead transparencies for lecturers preferring to use this format.) Other slides are made available for student use in our Learning Resources Center as slide/tape programs (Figure 3, right). For slides needed by large numbers of individual students, the microfiche format is available at vastly lower cost, as described later in this paper. Many textbooks provide slides of text illustrations and publishers will often grant permission to faculty to duplicate slides or copy illustrations for local use. Text illustration slides are most effective in solving the problem of student access to lecture visual aids.

<u>Microfiche</u> Although microfiche materials have found extensive applications in commerce in areas such as parts lists or merchandise catalogs, it is rare to find microfiche on a college campus except in libraries or records offices. It seems certain that this situation will change in the near future as the low cost and ease of storage of microfiche programming becomes more widely recognized. The instructional value of microfiche has been illustrated by an excellent series produced by the American College of Physicians, in cooperation with the University of Washington Health Sciences Learning Resources Center.

In our own Learning Resources Center, we use a large number of microfiche programs (Figure 4). Inexpensive microfiche readers are readily available and small readers can easily be checked out for student use at home or in dormitories. Teachers can easily design their own microfiche programs from slides, typewritten copy, or graphics.[4] Black-and -white or diazo microfiche can be prepared with up to 84 frames for just a few cents per fiche, while excellent color fiche can be produced for about $2.00 each (at multiple copy rates).

Microfiche may be used with supplementary aids such as audio tapes or workbooks. In addition, the easy accessibility of individual frames makes microfiche an excellent format for branched programs. Several programs for the college sciences have recently become commercially available.[9]

Our records indicate that microfiche resources are extensively used by students. We currently stock several branched programs for review and remedial work, a number of microfiche/tape/workbook programs on single topics, and a set of sample laboratory reports on locally produced black-and-white fiche. The high quality, versatility, and exceptionally low cost make these formats the medium of choice for multiple use materials.

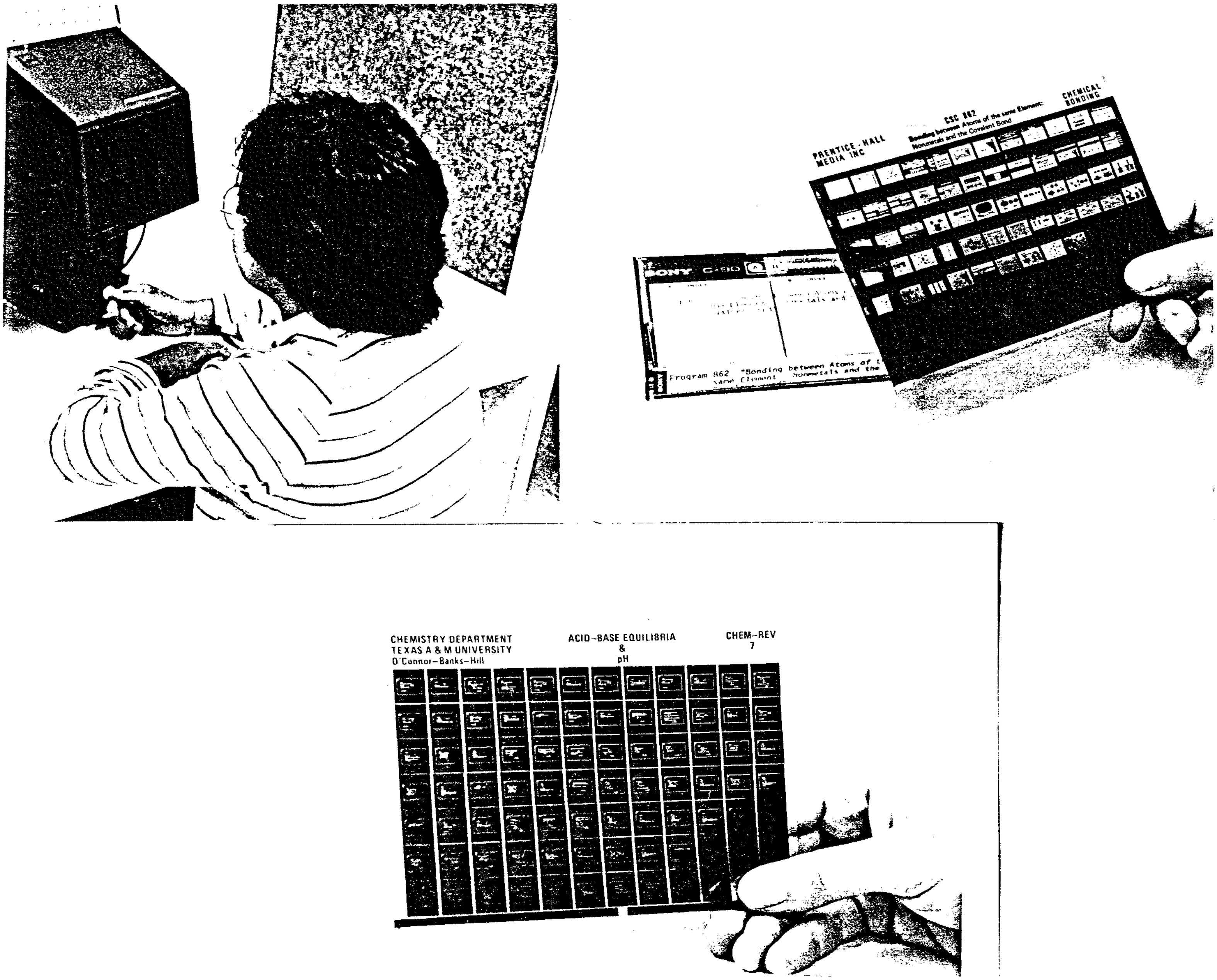


Figure 4. Inexpensive microfiche reader in a Learning Resources Center carrel (left). Branched programs on diazo microfiche (center) or color microfiche with associated audio tapes (right) illustrate the versatility of this most inexpensive type of media.

Laboratory Television Over the past fifteen years, many colleges have adopted closed-circuit television for prelaboratory instruction. The benefits of providing uniform instruction to different laboratory sections, with technique demonstrations optimized for all viewers, have now been widely recognized. We prepare our own color videotapes for this purpose. In addition, we have installed in twelve laboratory rooms an inexpensive black-and-white T.V. monitoring system. Each laboratory contains a simple camera with wide-angle lens and the signals are carried to a bank of monitors in a laboratory supervisors' area (Fig. 5).

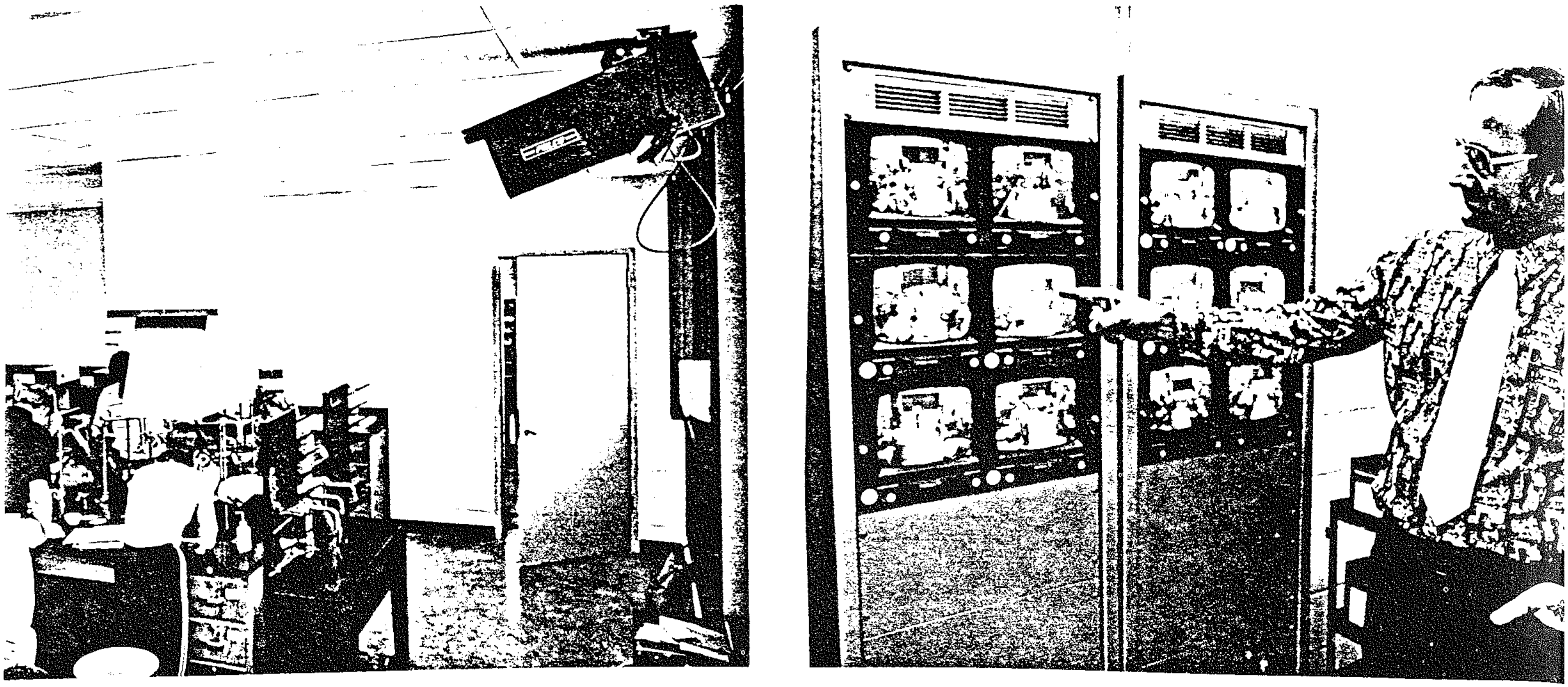


Figure 5 Low cost black-and-white T.V. cameras in laboratories (left) allow the laboratory supervisor to continuously monitor the work in twelve laboratories on a bank of small monitors (right).

Faculty members supervising laboratories can thus check on compliance with safety regulations, pacing of laboratory work, and performance of graduate teaching assistants. The system can be installed for only a few hundred dollars per room, using closed circuit T.V. systems designed as antishoplifting monitors for stores. We have noted significant improvements in laboratory safety, pacing of work, and teaching assistant performance since the installation of this sytem.

Summary Our experience suggests that certain ways of utilizing instructional media can be quite effective in enhancing learning, while representing very economical investments of media dollars. The cost/benefit ratio of Super 8 films is significantly improved by classroom use of the versatile MFS-8 projection system, coupled with availability of the films for further study in a learning resources center. Use of slide sets on a random-access projector increases the teacher's options for slide use, while reducing time and staff costs for slide loading and unloading operations.

Microfiche programming shows the greatest promise for versatility of programming at very low cost. The addition of an inexpensive T.V. monitoring system to a laboratory T.V. instructional network can result in significant improvement of laboratory work. The authors will be pleased to supply details of any of these systems to interested persons.

Acknowledgements: Our sincere appreciation is expressed to Dr. A.E. Martell (Head, Department of Chemistry) for his support of our programs and to Dr. John M. Prescott (Vice President for Academic Affairs) for providing us the opportunity of designing our special instructional facilities.

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Relevance in General College Chemistry

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Presented to the Sixty-First, Two-Year College Chemistry Conference, Phoenix College, Phoenix, Arizona, November 11, 1978.

Relevant is defined in a variety of dictionaries as bearing upon or connected with the matter at hand; to the purpose; pertinent; applicable; germane. What then is the meaning of Relevance in General College Chemistry?

There is no simple answer to this question. Common urgings have been couched in the non-definitive statement "Instruction in chemistry should be relevant." But relevant to what? To all areas of chemistry, to science in general, to industry, to agriculture, to everyday life, to consumer products, to ecology and environment, to medical arts, to legalistics, to government, etc., etc.? It is apparent that no course can have complete relevance, nor can any person be so naive as to presuppose that it can. What is necessary, therefore, is a limited delineation of relevance within the framework of a semester or year of instruction in college chemistry.

Instruction in college chemistry has its broad objectives development of the language of the science, presentation of factual material, elucidation of theory and principle necessary to the understanding and interpretation of factual data and the prediction of yet undetermined facts, indication of practicality _via_ applications and possible applications, relationships to other disciplines, and development of the understanding essential to comprehension of subsequent instruction. It is the author's considered opinion that general college chemistry must fulfill at least all of these objectives. It is also his opinion that within this framework relevance to many of the items indicated in the second paragraph can be achieved in an instructive way by appropriate choice of examples.

To illustrate, let us consider some aspects of the general chemistries of the important non-metals nitrogen, phosphorus, and sulfur. Each element exists in a number of oxidation states; transformations between oxidation states provide opportunities to write and balance equations; the preparation, properties, and uses of compounds are interesting and important, and the subjects of atomic structure, bonding, and variations in properties can be used to exemplify the importance of the periodic table. It is conceivable, and probably highly practicable in enhancing student comprehension and interest, to correlate these discussions with transformations in the natural cycles in which these elements are involved. In a significant way, relevance of the chemistries of these elements and their compounds to important aspects of factual and theoretical chemistry is thus achieved. To a lesser degree, mineral cycles can be used similarly to correlate and render more interesting many aspects of the chemistries of the metallic elements. This approach is emphasized by use of appropriate slides.

SECOND YEAR CHEMISTRY

Microcomputer Applications in Analytical Chemistry

Joe Long
Broome Community College

Presented to the Sixty-Second, Two-Year College Chemistry Conference, Brookdale Community College, Lincroft, New Jersey, March 23, 1979.

In the first half of this paper, I would like to deal with microcomputers in a general way by making comments on the following questions.

1. Why bother with microcomputers at all?
2. What applications are there for microcomputers in analytical chemistry?
3. How much does a usable microcomputer system cost?
4. What are the major systems and subsystems in a microcomputer?
5. Which microcomputer to buy?
6. Where can one get further information on microcomputers?

In the second half of the paper, I would like to briefly describe a microcomputer-controlled automatic titrator which I have assembled, and which is currently being used by students at Broome Community College.

PART I

WHY BOTHER WITH MICROCOMPUTERS?

Microcomputers are not toys. Many of today's microcomputers are more powerful and usable than large-system computers from twenty years ago. Over the past few years, the cost of small-system computers has fallen to the point where it is below the cost of much of the instrumentation within even a very modestly-equipped analytical laboratory. Microcomputers are finally affordable within many community college chemistry departments. Further, industrial laboratories are making heavy use of microcomputers and our students need some familiarity with this sort of equipment if their education is to remain current. Finally, many of the applications which can be made within an analytical lab can not be done on a large-system computer because of problems related to time-sharing on large systems.

WHAT APPLICATIONS ARE THERE FOR MICROCOMPUTERS IN ANALYTICAL CHEMISTRY?

1. They can be used for "off line" data processing. A large-system computer would often (but not always) be a better choice for this application.

2. They can be used for "on line" data processing. Here, data are transferred directly from an instrument to a computer and the data can be processed as the experiment is under way.

3. They can be used for process control. In this case, the computer functions as an executive which, on the basis of a program and perhaps real time data, controls an experiment. The automatic titrator constructed at Broome Community College is an example of this application.

4. They can be used to substitute software (i.e., computer programs) for hardware-electronic components, gears, etc. Examples of this are use of a computer program to generate voltage ramps for use in polarography or to generate pulses to drive a strip chart recorder at different speeds.

HOW MUCH DOES A USABLE MICROCOMPUTER SYSTEM COST?

Complete microcomputers may be purchased for as little as two hundred dollars or for as much money as one might care to spend. Investing around four thousand dollars is required for truly high quality, usable system. This investment would include about two thousand dollars for a video terminal, and a good printing terminal. Careful shopping, and deletion of some desirable but not mandatory features, would permit a system to be implemented for about two thousand dollars.

WHAT ARE THE MAJOR SYSTEMS AND SUBSYSTEMS IN A MICROCOMPUTERS?

A microcomputer, like any computer, must have the following systems; a control processor (CPU), memory, some sort of input/output (I/O) and mass storage. In order to be usable for real time processing and control, two additional systems are required. These are a "Controller" and an Analog-to-digital--Digital-to-Analog converted (AD/DA). The Controller allows relays to be opened or closed in the external world under computer control, and the AD/DA provides a path for analog voltages into and out of the computer.

WHICH MICROCOMPUTER TO BUY?

An important decision which must be made very early is on which of two approaches to take in setting up a microcomputer. This decision is on whether to buy a complete "one-box" computer or to buy a more modular system. This is analogous to the decision facing the purchaser of high fidelity equipment who must decide on whether to opt for a "components" system, or for a console system. Each has its advantages; bu-, because of the versatility and expandability it allows, a modular approach seems to be the best approach where process control and real time computing are involved. We have used this approach at Broome Community College with great success. Our microcomputers are all based on the so-called S-100 Bus. S-100 based computers are available from numerous manufacturers, and dozens of other manufacturers produce scores of different boards which will plug right in. The resulting versatility is almost limitless.

PART II

MICROCOMPUTER CONTROLLED AUTOMATIC TITRATOR

The automatic titrator I will describe here illustrates most of the ways in which microcomputers can be a-plied within the field of analytical chemistry. For that reason, it is a good, concrete example of amny of the principles expressed in Part I of this paper. I will discuss the automatic titrator from the following viewpoints:

1. operation of the titrator
2. it's capabilities and applications
3. special (non-computer) hardware required
4. titrator software
5. student use of the titrator

OPERATION OF THE TITRATOR

The titrator consists of a titrant pump and motor (digital burette), a pH meter and a strip chart recorder interconnected through the microcomputer. It functions, briefly, in the following way; the computer monitors the pH of the solution being titrated.

When the pH reaches a constant value, it is output to the teletype and to the chart recorder. Under computer control, the chart recorder paper is advanced, a titrant increment is added and the cycle begins again as the computer monitors the pH of the solution once more.

TITRATOR CAPABILITIES AND APPLICATIONS

A. It can perform any potentiometric titration which could be done manually using a standard pH/millivolt meter, including acid-base, redox precipitation titrations, etc.

B. As each increment of titrant is added by the computer-controlled pump, the pH (or voltage) can be printed on a teletype. At the same time, the data can be plotted under computer control on a strip chart recorder.

C. Titrating variables, such as the amount of titrant to be delivered, chart recorder format, criteria for stopping the titration, etc, are set by the operator in response to prompts from the titrator program.

D. Changes in the software allow limitless modification and adaptation of the titrator's capabilities. For example, first or second derivative plots can be done, or routines to perform stoichiometric calculations based on the endpoint of the titration could be added. This can be done by changing the titrator <u>programs</u>. The hardware need not be touched. Here is an excellent example of replacement of hardware. Operational amplifiers would be required for derivative plots if the programming power of the computer were not available. This makes the titrator very versatile and in many ways, "intelligent."

SPECIAL HARDWARE REQUIRED

The special hardware for the titrator is of two basic types. The first is computer hardware which consists of two systems -- an AD/DA converter and a controller, both mentioned earlier. The second type of hardware consists of the titrant pump (digital burette), the strip chart recorder and a pH meter.

I would like to make a couple of comments on the AD/DA converter. The one used in the titrator is an eight-bit device, meaning that it can input or output voltages with a precision of one part in 2^8 or about 0.39%. This precision is about the minimum required to produce acceptable results for many measurements in analytical chemistry. Converters with higher resolution are available, but they tend to be quite expensive.

The converter has eight input channels and eight output channels, meaning that, for example, up to eight pH meters and eight strip chart recorders could be connected to it at once. The converter also has a parallel output port, which is used to provide the pulses required to drive the digital burette, the paper advance, and pen up/down functions on the recorder.

The digital burette consists of a peristaltic-type pump which is belt-driven by a digital stepping motor. The stepping motor is driven through a set of drive transistors by a special stepper motor intengrated circuit. The integrated circuit is driven by pulses from the computer, which are output through the AD/DA parallel output port, as mentioned above. Timing belt drive is used between the stepper and the pump because the motor does not have sufficient power to drive the pump directly. The main components of the digital burette can be purchased for about one hundred twenty five dollars.

The strip chart recorder used, while not really special or expensive, does have several features for successful interfacing to a computer. It must have a stepper motor driven paper advance, and external control must be possible of the pen up/down position and chart drive. The recorder used in the titrator is a Heath EV-205 which has all of these features. The chart drive and pen up/down control signals are provided through the AD/DA parallel output port.

The pH meter used in the titrator is a Corning Model 7. Any pH meter could be used, but a problem could arise over interfacing the pH meter to the analog input of the computer. The AD/DA accepts inputs in the range of ± 2.5 volts. The pH meter must therefore be modified to produce output over this range. In the Corning meter, the required modification is very simple and consists of installing a single potentiometer. The modification could be more difficult for other meters. An operational amplifier, connected to the recorder output of the meter could also be used to do the scaling. This approach would require no modification at all to the pH meter.

SOFTWARE

All of the titrator programs have been written in a language called Control Basic. Anyone familiar with a large system would be able to use the language very easily. There are several features which make the language so suitable for control-type applications. The first of these is that control basic has the commands "IN" and "OUT". These commands input or output data directly through the computer's ports. They are the commands used to get data into and out of the AD/DA converter and other peripheral devices. Another useful feature of the language is that data may be entered in ASCII or hexadecimal format as well as in decimal. This is often very helpful in control-type programming. Control Basic is integer only and is limited in range to ± 32,767. This ia an inconvenience whic can usually be sidestepped through clever programming techniques. The language is not suitable for "number crunching". Another basic, called BASIC ETCS is currently being added to the Imsai to make it possible to process titration data. ("Imsai" refers to the Imsai 8080 microcomputer used in this project.)

The titrator program which I have chosen to show here has been stripped of many features and functions in order that the basic ideas can be seen clearly.

Although the flow diagram of the titrator program is, for the most part, self-explanatory, a few comments are necessary. First, notice that the pH is read twice, with a delay between the readings The reason for the successive reads is to detect changes in pH. The reason for the delay between the reads is that the response of electrodes is very slow compared to the speed of the computer. Without the delay loop, the successive reads would occur only a few hundred microseconds apart, in which time the electrode potential could not have shifted significantly. The delay loop puts about one half a second between the reads.

Second, a discussion on the conversion of the electrode signal (Y) into pH would be helpful. The algebraic form of the conversions is a bit complicated because of the fact that Control Basic is an integer-only language. The algebraic relation of Y and pH in the program is:

$$P = (127-Y)*\frac{256}{480}$$

The fraction 256/480 is used because its decimal equivalent (0.533) is not usable in an integer language. This illustrates how proper programming can work around the integer-only limitation. This problem also shows in the pH (P) itself. It must be scaled to vary from 0 to 140 so that pH's can be output to the nearest 0.1 pH unit. (P = 104 indicates a pH of 10.4.)

Finally, it should be noted that the program has been written in a very modular format. This is very important in programs used in processing and control, so that the programs can be modified easily. Addition or deletion of features in the titrator program can be done, in amny cases, in just a few minutes. A non-modular program would often necessitate complete rewriting for even small changes.

STUDENT USE

Students using the titrator are second-year Chemical Technology students. These students have taken, as freshmen, a computer programming course. After a brief lecture on operating microcomputers and using the titrator, the students are able to operate the equipment independently. The students working in groups of two typically do several acid-base titrations, such as HCl, HOAc and H_3PO_4 vs NaOH. The computer-plotted titration curves and data tables are immediately available for inclusion in the student's notebooks. Students then use the curves in the same way they would manually-plotted titration curves -- for determining endpoints, pK_a values, etc.

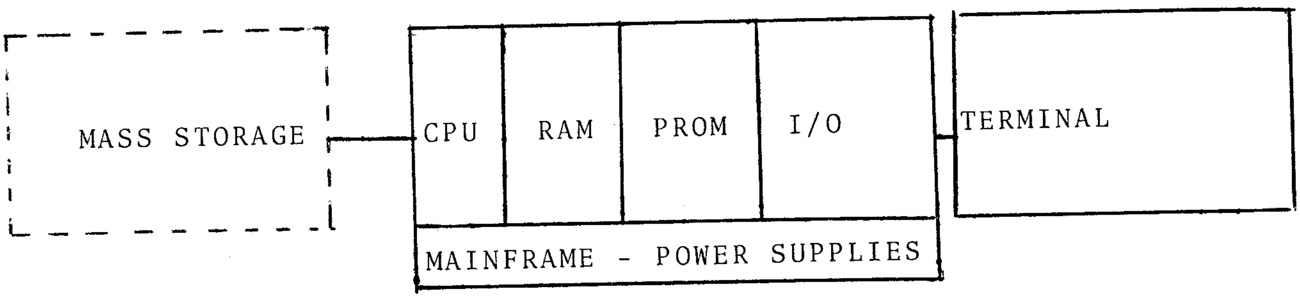
Students with the ability and the interest are encouraged to go a bit further with this equipment. This involves modification of the titrator routines in any of several ways -- addition of derivative curve plot routines, titration stop at a preset pH, etc.

The use of the titrator from our point of view, benefits the students in two general ways. First, it can help them make more efficient use of their laboratory time. When a student has mastered the technique of doing a potentiometric titration manually, there is nothing left to learn from the process itself. The titrator can give the student more free time in the laboratory, which can be put to use, for example, on the chemistry behind the titration. Second, the titrator introduces the student to the world of small system computers and how they can be used within a laboratory. With the direction that laboratory instrumentation is taking, this should prove to be a very important part of their chemical education.

WHY BOTHER WITH MICROCOMPUTERS?

1. STUDENT BENEFITS
   - A. KEEPS STUDENT ABREAST OF DEVELOPMENTS IN INSTRUMENTATION.
   - B. AUTOMATION OF LABORATORY PROCESSES CAN RESULT IN MORE EFFICIENT USE OF LAB TIME BY STUDENTS.
2. PRICE OF HIGHLY USEFUL MICROCOMPUTER SYSTEMS HAS DROPPED TO VERY LOW LEVELS.
3. MANY APPLICATIONS FOR MICROCOMPUTERS WHICH CAN NOT BE HANDLED BY LARGE SYSTEM COMPUTERS.

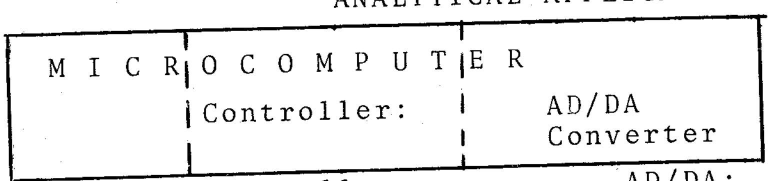
MINIMUM SYSTEM MICROCOMPUTER HARDWARE



CPU - Central Processing Unit
RAM - "Core" Memory - For temporary programs, data
PROM - "Permanent" Memory - For compilers, intertreters, permanent programs
I/O - Terminal Interface

TERMINAL - Teletype of Video Terminal
MASS STORAGE - Cassette Floppy Disk

MICROCOMPUTER HARDWARE FOR ANALYTICAL APPLICATIONS

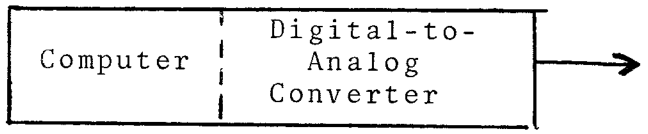


Controller:
Output:
8 Relays
Input:
8 Switch Sensors

AD/DA:
Analog to Digital
Digital to Analog Converter
(8 Bit)
Output: 8 Analog 1 Digital
Input: 8 Analog 1 Digital

MICROCOMPUTER APPLICATIONS

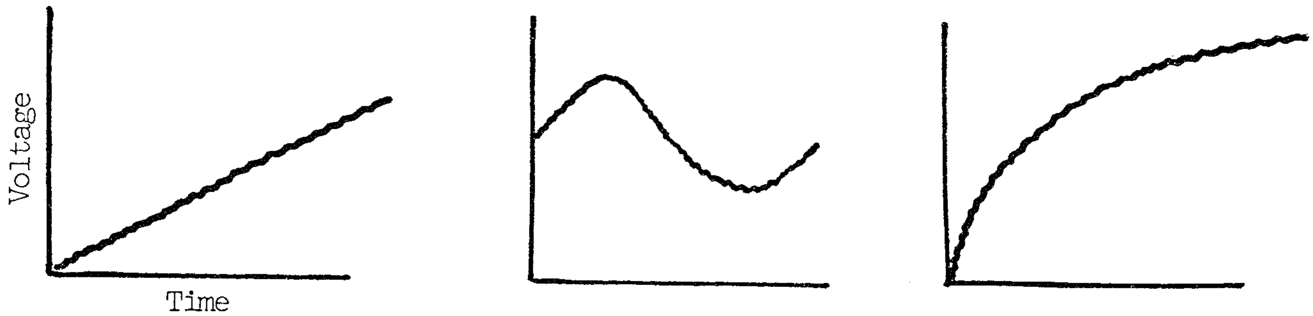
SUBSTITUTION OF SOFTWARE FOR HARDWARE-GENERATION OF VOLTAGE RAMPS



A.
```
10 FOR J=Ø TO 100
20 OUT( ) = J
30 NEXT J
```

B.
```
10 FOR J=Ø to
   2*3.14 STEP .01
20 Y=SIN(J)
30 OUT()=Y
```

C.
```
10 FOR J=1 to 100
20 Y=LOG(J)
30 OUT()=J
```



AUTOMATIC TITRATOR

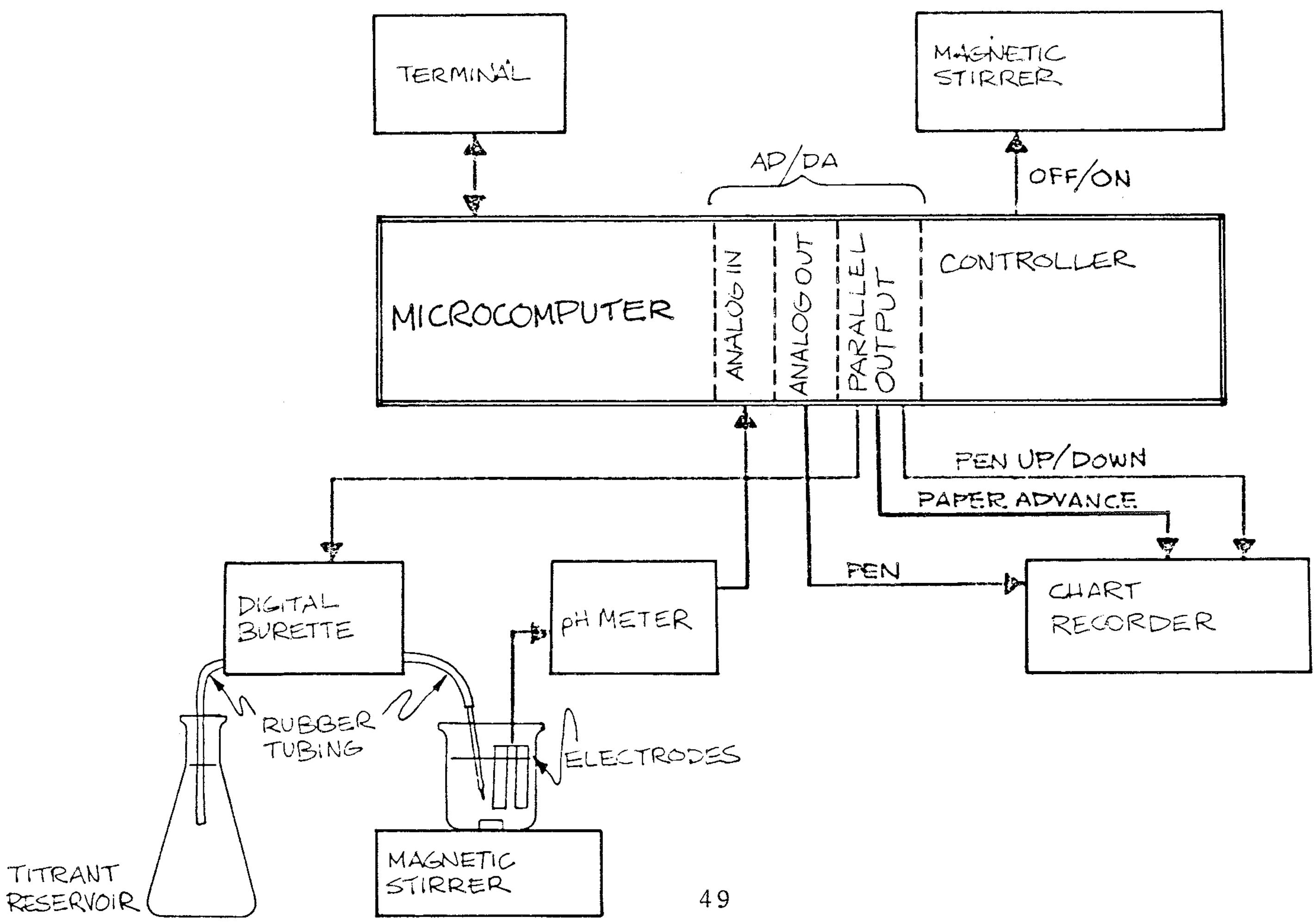
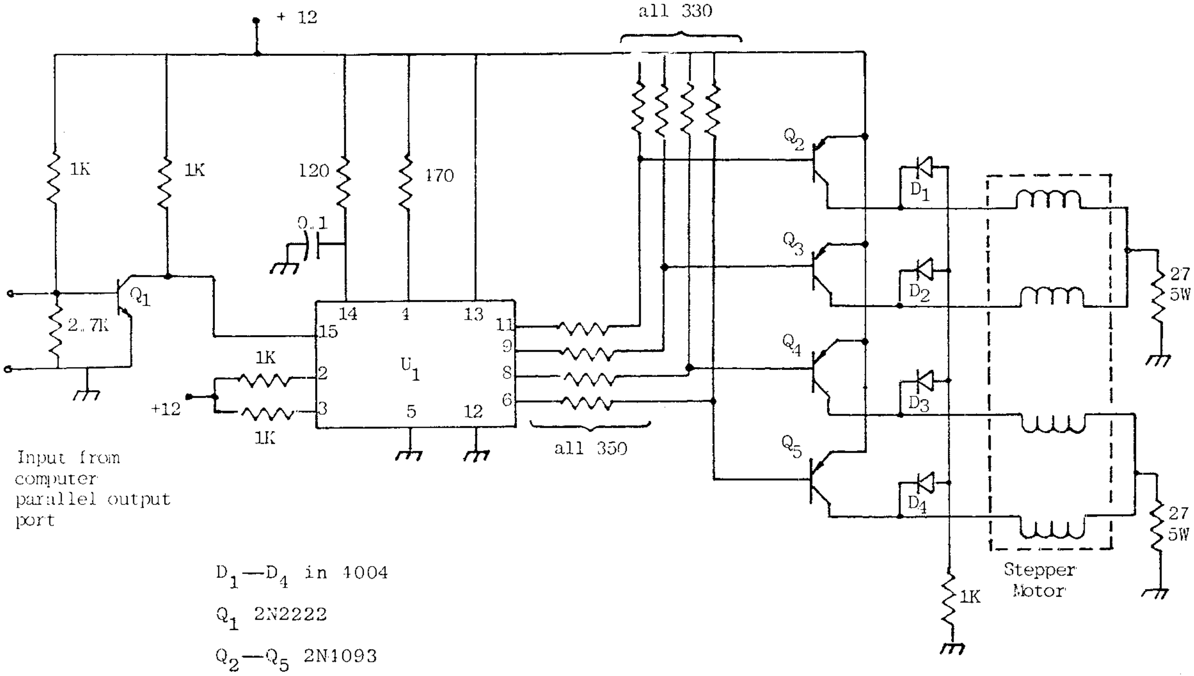


FIGURE 3
DIGITAL BURETTE

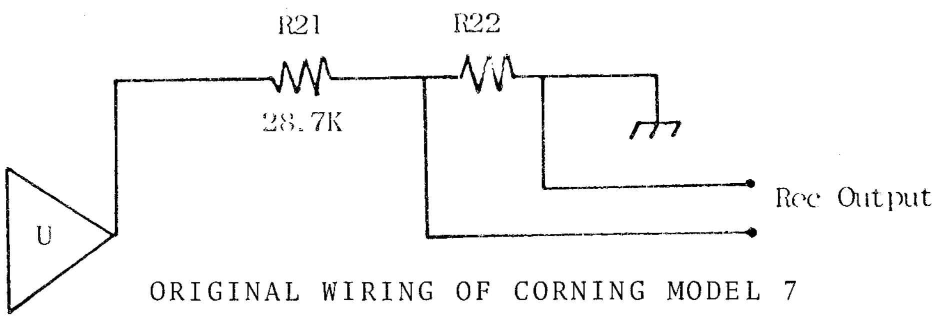


D_1—D_4 in 4004

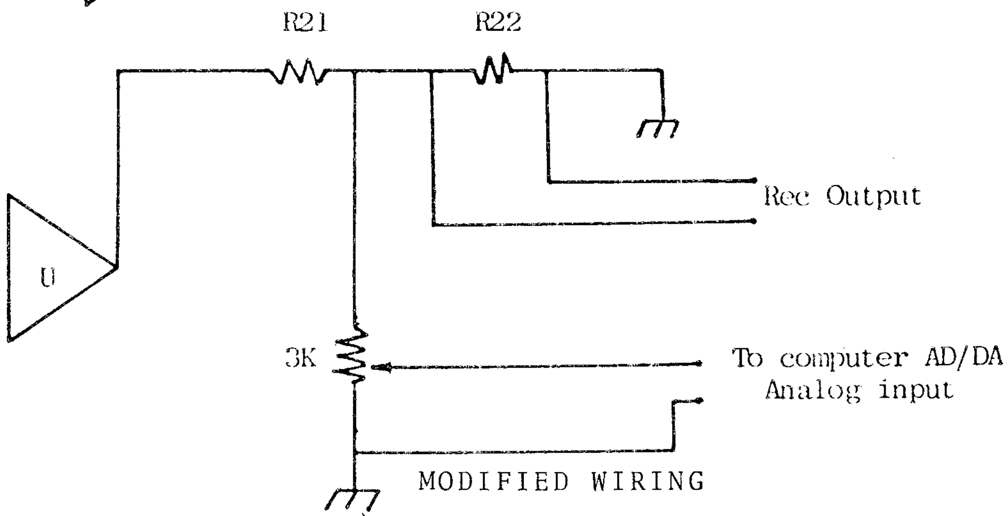
Q_1 2N2222

Q_2—Q_5 2N4093

U_1 SAA 1027 (North American Phillips)



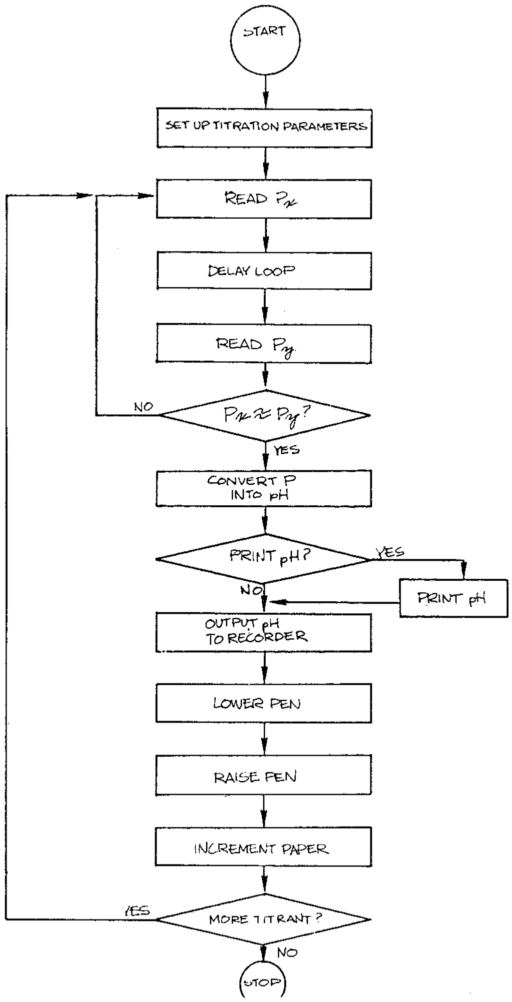
ORIGINAL WIRING OF CORNING MODEL 7



MODIFIED WIRING

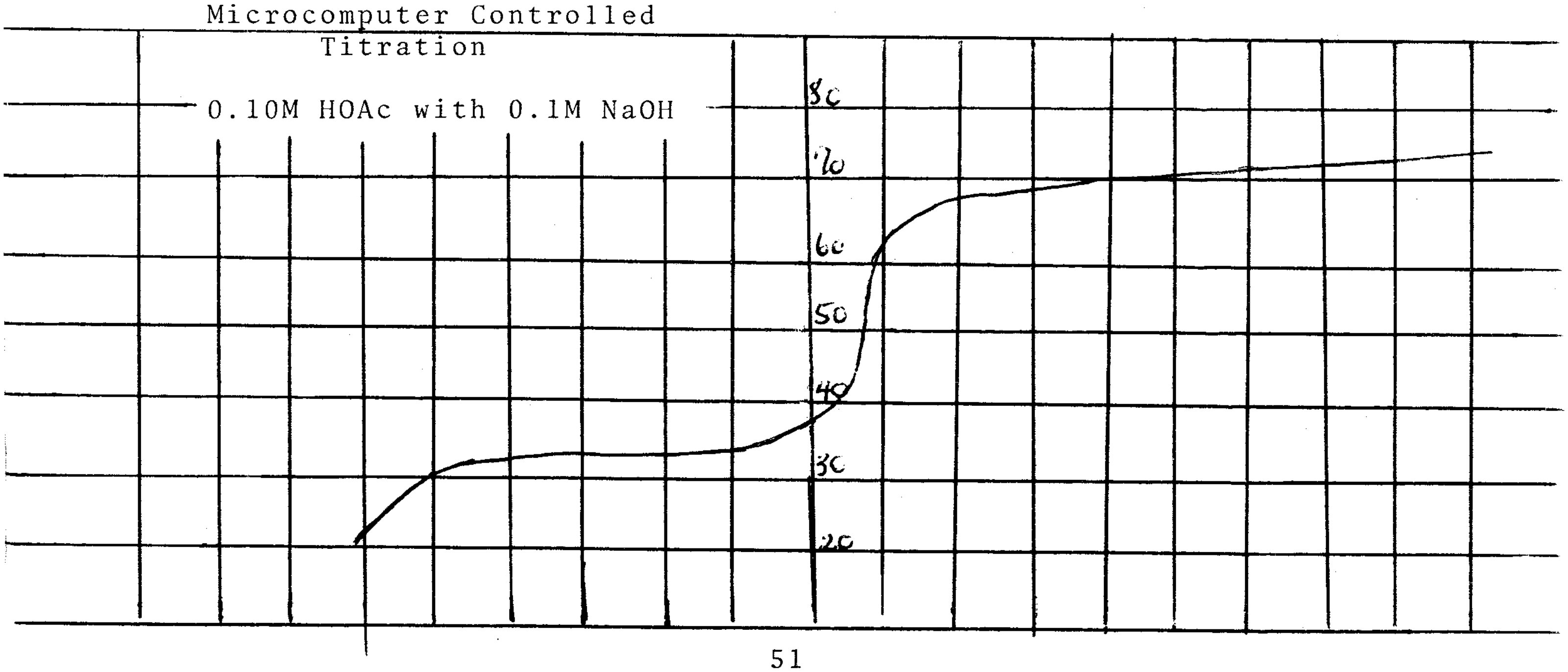
Adjust 3K potentiometer to give output range of-2.5 to +2.5V as pH varies from 0 to 14

TITRATOR SOFTWARE



Microcomputer Controlled Titration

0.10M HOAc with 0.1M NaOH



TITRATOR PROGRAM

```
OK
>LIST
 10 REM TITRATOR USING SUBROUTINES. SUBROUTINES IN
 15 REM REVISION 1
 40 REM REVISION 0
 45 REM AUGUST 21, 1978
 50 REM COPYWRITE J.W. LONG
100 INPUT"TYPE 1 FOR HELP,OR A 0  ",H
120 IF H=0 INPUT N,W,J,T
130 IF H=0 GOTO 170
135 INPUT " # OF TITRANT INCREMENTS  ",N
140 INPUT " WIDTH OF CHART PAPER STEP  ",W
150 INPUT " PH READ DELAY. 0=LONG, 99=NONE.   ",J
160 INPUT " TELETYPE OUTPUT ? TYPE 1 FOR YES 0 FOR NO ",T
170 W0=100;N0=0
210 IF T=1 PRINT "        N0     PH(*10)
220 GOSUB 1210
240 V=Y; GOSUB 4110; REM RECORDS POINT ON ST. CH. REC.
260 IF T=1 PRINT N0,P;REM PRINTS PH
270 N0=N0+1; IF N0=N GOTO 500
280 GOSUB 2100;REM ADDS TITRANT
290 GOSUB 3100; REM ADVANCES CHART PAPER
300 GOTO 220
500 INPUT "MORE TITRATING ? 1 FOR YES 0 FOR NO ",M
510 IF M=1 GOTO 100
520 STOP
1210 REM PH READ WITH DELAY.  P=PH TIMES 10.  Y=OUTPUT TO
1220 REM CHART RECORDER.  MAIN PROGRAM MUST INITIALIZE J.
1240 REM REVISION 0. AUGUST 21, 1978. COPYWRITE J.W. LONG
1310 X=IN(25);REM READS FIRST PH
1315 K=J; REM RESETS DELAY TIME
1320 IF X>126 GOTO 1340
1330 Z=(127-X)*256; P=Z/480
1340 C=255-X; P=(127*C/226)+63
1410 Y=IN(25); REM REREAD PH
1419 REM 1420 IS A DELAY LOOP
1420 K=K+1; IF K<100 GOTO 1310
1430 IF ABS(X-Y)>1 GOTO 1310
1440 RETURN
2100 REM PUMP STEPPER SUBROUTINE . MAIN PROGRAM MUST INITIALIZE
2110 REM W0.  PUMP WILLBE STEPPED THRU W0 INCREMENTS
2120 REM REVISION 0.  AUGUST 21, 1978. COPYWRITE J.W. LONG
2200 FOR S=0 TO W0
2220 OUT(24)=00;OUT(24)=02;REM PULSE TO STEPPER
2240 NEXT S
2260 RETURN
3100 REM STRIP CHART RECORDER PAPER ADVANCE ROUTINE.  MAIN
3110 REM PROGRAM MUST INITIALIZE W
3120 REM REVISION 0. AUGUST 21, 1978.  COPYWRITE J.W. LONG
3200 FOR S=0 TO W
3220 OUT(24)=00; OUT(24)=01
3240 NEXT S
3260 RETURN
4110 REM SUBROUTINE FOR ST CH TEC. POINT PLOT.
4120 REMMAIN PROGRAM MUST DEFINE V.
4130 REM REVISION 0. AUGUST 21, 1978. COPYWRITE J.W. LONG
4200 OUT(25)=V
4240 OUT(24)=08; REM LOWERS PEN
4250 OUT(24)=00; REM RAISES PEN
4260 RETURN
```

Current Approach to Organic Chemistry

Robert Bates
University of Arizona
Tempe, Arizona

Presented to the Sixty-First, Two-Year College Chemistry Conference, Phoenix College, Phoenix, Arizona, November 11, 1978.

The most important change in two-semester elementary organic courses in the last decade has been the increased emphasis on structure determination by spectral techniques, especially nuclear magnetic resonance (NMR). This topic is usually introduced during the latter part of the first semester and driven home through frequent usage thereafter.

An organic course usually begins with a few lectures on bonding and then launches into a survey of the main classes of organic compounds, starting with alkanes. For each class, names, physical properties, methods of preparation, and reactions are discussed. Problems involving design of multistep synthesis are introduced as soon as possible and used throughout. Mechanisms for many of the reactions are included for better understanding. Temporary relief from the onslaught of new reactions is given first by a discussion of stereochemistry (often after alkenes) and later by the material on spectroscopy.

Once this most fundamental material has been covered (about 1.5 semesters), biomolecules (especially carbohydrates and proteins) are discussed at length, and topics such as polymers, heterocycles, and pericyclic reactions are covered to the extent that time permits.

Use of Color Video-Tapes for Teaching Organic Chemistry Concepts and Mechanisms

Cecelia M. Jorgensen

Presented to the Sixty-Second, Two-Year College Chemistry Conference, Brookdale Community College, Lincroft, New Jersey, March 23, 1979.

Excerpts from 5 color videotapes covering the concepts listed below were shown. Each videotape (about 9-14 minutes long), was made incorporating the Lap-Dissolve Projection technique which uses 35 mm slides. The videotape allows a voice narration coinciding with the visual image, which enables its use in the Media Center by students.

Excerpts from the following programs were shown:

1. Mechanism of SN^1 Reaction - Shows the abstraction of the nucleophile from a carbonium ion (carbocation), changing meanwhile from SP_3 to SP_2 hybridization. A discussion of the transition state and its reaction with a nucleophile yields the substituted product.

2. Mechanism of the SN^2 Reaction - Shows the incoming nucleophile approaching from the backside while the hybridization changes

until finally a 5-membered transition state results. Includes a discussion of the nature of the transition state, factors effecting it, and some stereochemistry.

3. Dehydration of a Primary Alcohol - E^1 Elimination - The mechanism of dehydration of n-butanol is shown to form 2-butene. The protonation and abstraction of the water molecule (including all electrons) is shown to yield a primary carbonium, including hybridization. A hydride shift is shown together with formation of a 2° carbonium ion. Abstraction of a proton yields the alkene.

4. Aldol Condensation - Two acetaldehyde molecules are used to show with appropriate explanation and visual images how one acetaldehyde molecule becomes the electrophile and the second molecule the nucleophile in the system. The condensation of these yields the -hydroxy aldehyde.

5. Stereochemistry of Tartaric Acid - The structure of tartaric acid is used to demonstrate Fischer projections, chiral carbon atoms, and the predicted number of stereoisomers. The 4 structures are shown together with their models. Rotation of the models shows that one pair is superimposable while the other pair is not. The concepts of meso, enantiomers, and optical rotation are developed.

These color videotapes are available for preview and for purchase at cost.

Inexpensive Computer Graphics for Science Education

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Presented to the Sixty-Second, Two-Year College Chemistry Conference, Brookdale Community College, Lincroft, New Jersey, March 23, 1979.

There are primarily three types of computer Graphics technology-storage tube, vector generation, and raster scan. In storage tube graphics terminals the line patterns are stored on a secondary screen and thus do not need to be continually refreshed by the computer. This technique allows for high resolution (1024 horizontal x 780 vertical in a Tektronix terminal) and a very high line density. Thus, very complex figures can be drawn using these terminals. A disadvantage to this method is no selective erasure, i.e. to change any part of the screen the entire screen must be erased and redrawn. A second disadvantage is the lack of color. A typical cost of a storage tube terminal is \$3000 and up. A stand alone unit, e.g., Tektronix 4051, costs about \$7000.

A second type of graphics technology is vector generation (or random vectoring) as illustrated by the Digital Equipment Corporation GT-40 series. In these terminals the cathode continually refreshes the screen but scans only the illuminated points. This allows for high resolution (1024 x 1024), light pen interaction, selective erasure and animation effects, and multiple intensity levels. These terminals cannot have the high line density of storage tube terminals (at high line densities the refresh flicker becomes visible), do not have color, and require a dedicated minicomputer. Typical cost of one of these systems is $20,000 (includes a PDP 11/04 minicomputer).

The third type of graphics terminals, i.e., raster scan, uses television technology. In these terminals the screen refresh is accomplished by the cathode scanning the entire screen. The maximum resolution of raster scan terminals is of the order of 640 x 480 (Tektronix 4025 - $6000 (no color) and Tektronix 4027 - $12,000 (with color)). Raster scan terminals require dedicated computer memory for the screen refresh (although the Tektronix terminals have their own memors). Microcomputer graphics systems are of the raster scan type.

There are many different microcomputer graphics systems, but I shall only discuss four of the most popular, the PET, Radio Shack TRS-80, Apple II, and Compucolor II. Table I gives some pertinent information about all of these systems. Several things should be noted about these systems. First, a disk based system makes a computer a computer and not a toy. The ease of program development, program and data storage and retrieval and general increased power and flexibility make a disk well worth the extra cost. The second item is the amount of actual user RAM available. The minimum is 16 K bytes user RAM for any kind of serious application. This amount of memory space would allow one to write a BASIC program of about 200 lines with about 2000 variables. A third consideration is execution speed. The different systems were given two benchmark programs, one which tested general execution speed and the other was more of a number cruncher. As can be seen, the TRS-80 is rather slow compared to the other systems.

A fourth consideration is graphics capability. Only the Apple and the Compucolor have color graphics, a medium amount of resolution, and well developed graphics software. Finally, there is the true system cost. It can be seen that the PET is by far the cheapest but because of the lack of a disk and the limited amount of user memory it is not really as viable a system as the others. Also, the TRS-80 is not really a graphics system. Thus, my two favorites are the Apple and Compucolor. For 16 K bytes user RAM the cost of a Compucolor is about $1700, whereas the next smaller Apple (at $1200) only has 6 K bytes user space (this is assuming that one is using the Apple high resolution graphics). Thus, the Compucolor is substantially cheaper and this includes an RS232-C interface which is an extra $180 for the Apple, but the Apple has some abilities lacking in the Compucolor. These include the following: ability to drive a large TV monitor for classroom demonstrations (the Compucolor comes with a built in color monitor), a speaker, and 2 game paddles. Both of these are excellent inexpensive graphics systems and one should choose based on one's particular needs.

TABLE I

REPRESENTATIVE MICROCOMPUTER SYSTEMS

	PET	TRS-80 (LEVEL II)	APPLE II	COMPUCOLOR II
PROCESSOR	6502	Z-80	6502	8080A
ROM (bytes)	14K	8K	10K	17K
MAX. RAM (bytes)	8K	48K	48K	32K
GRAPHICS (h x v)		128 x 48	LR-40 x 40 HR-280 x 160	128 x 128
COLOR	No	No	LR-16 HR-6	8
DISK (bytes)	None	80K	100K	51K
ACTUAL USER RAM (bytes)	8K	38K	22K	32K
LANGUAGE	BASIC	BASIC/FORTRAN	BASIC/PASCAL	BASIC
SPEED Gen. Exec.	51 SEC.	83 SEC.	43 SEC.	55 SEC.
NO. CRUN.		17 1/2 MIN (7 Digits)	14 1/2 MIN (9 Digits)	15 1/3MIN (7Digits)
SYSTEM PRICE	$800	$2000	$2200 + TV	$2000

Chemistry Sequencing in an Environmental Curriculum

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Presented to the Fifty-Ninth, Two-Year College Chemistry Conference, Essex Community College, Baltimore, Maryland, April 7, 1978.

The curriculum in an environmental program should be specific. Experience has shown that the best product is produced from a special curriculum. This means that the institution should decide on the environmental area to pursue, i.e., air, solid waste, noise, water/wastewater, pesticides, etc. Once this is established, the objectives must be identified and outlined. The needs of the curriculum can then be satisfied by having the appropriate courses implemented into the system. The objective of this presentation is to present the sequencing of Chemistry Courses in one such environmental curriculum.

At the present time, there are two Environmental Curricula at the Charles County Community College - Estuarine Resource Technology and Pollution Abatement Technology. The primary goals of the Pollution Abatement Technology program are to produce a graduate who is capable of operating a water of wastewater treatment facility at the Class "D" Certification level, and perform the appropriate laboratory analyses at the facility.

The curriculum in the program is organized in a fashion which allows a harmonious mix of all courses involved. The remaining part of the discussion will focus entirely on the Pollution Abatement Technology curriculum.

Because of the aforementioned objectives, the Chemistry Courses are considered to be an integral part of the program. In addition, graduates of the Pollution Abatement Technology Two-Year Program are capable of performing nearly every test as outlined in _Standard Methods for the Examination of Water and Wastewater_. With the passage of the Water Pollution Control Act of 1972 and the Clean Water Bill of 1977, the reporting of effluent quality is of prime importance, consequently, laboratory analytical procedures must be thoroughly covered.

The entering student begins with CHE 150-151 Technical Chemistry, or CHE 120-121 General Chemistry, depending on the student's mathematical background. (It should be noted that the Technical Chemistry Course is currently under review, and is slated for revision or abolishment, in lieu of the feasibility of a preparatory chemistry course).

The laboratory portion of Tecynical Chemistry prepares the student for the upcoming Analytical Course by presenting a mixture of practical chemistry, and quantitative and qualitative analysis. It is critical that a solid foundation be established with the first semester courses.

In the third semester, CHE 252 Analytical Techniques of Water Chemistry is presented. This course deals with the performance of selected analysis from the _Environmental Protection Agency Methods_

Manual and the previously mentioned, Standard Methods. The student is given a short introduction into the topic of the day and then performs the associated experiments. A report, prepared in standard format, is written up in a laboratory notebook and turned in for evaluation.

The Instrumentation Course (CHE 255), stresses "hands-on" operation of the Gas Chromatograph, Atomic Absorption Spectrophotometer, Total Carbon Analyzer, Ultraviolet Spectrophotometer, and Nuclear Magnetic Resonance. Again, the student is allowed to use the instruments and become familiar with their operation, so that they have a good working knowledge of the techniques involved.

At this point, it is necessary to emphasize the fact that "actual hands-on" laboratory work is a necessity for the success of the program. One of the major stumbling blocks to successful passing of state certification examinations for example, is the lack of adequate coverage of laboratory analytical procedures. In order for the student to understand a parameter, he/she must perform the analysis, interpret the results, and write the report.

To have a successful program, it is necessary to implement good communication and coordination with all departments involved in the program.

The Life Science Program for Allied Health Students at ECC

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Presented to a General Session of the Fifty-Ninth, Two-Year College Chemistry Conference, Essex Community College, Baltimore, Maryland, April 7, 1978.

History and Development of the Life Science Program

The Life Science program at ECC is designed to serve three of the Allied Health Career Programs, i.e., Nursing, Physician's Assistant and Dental Assisting. Before 1972, the science requirements for these programs included the following courses:

Physical Science for Nurses (4 credits) Anatomy and Physiology (4 credits) and Microbiology (4 credits)

Each of these courses were standard college courses involving three lectures and one lab per week. Many schools had similar courses so that an advantage for the students was that these courses were all transferable. If a student decided to continue his education at a four year school usually the biology courses were transferable as science courses. However, there were several disadvantages which far outweighted the advantage of transferability. Many students enrolled in the Nursing program were apprehensive of the physical science course, which was mostly chemistry, and chose to take microbiology and physiology first. This meant they did not have an adequate chemistry background for the biology courses. When these students finally did take the physical science course they usually felt it was then irrelevant since they had already passed the biology courses; but they also admitted that the physical science course explained much of what they had been unable to grasp in the biology courses and realized it would have been better to take physical science first.

Another problem with the original science courses was that the students were not given any formal training in math. Dosages and solutions were taught solely by the Nursing faculty who felt this would be better handled by the math faculty. In addition, the Nursing faculty found that very often their students did not get enough anatomy early enough to prepare them for their nursing courses.

It seemed that it would not be possible to reorganize the existing courses sufficiently to solve these problems so it was decided instead to introduce three new courses specifically designed for the Nursing and Physician's Assistant students. All Nursing and Physician's Assistant students beginning in the Fall of 1972 were advised to take the New Life Science courses in the order specified in Figure 1 below:

LIFE SCIENCE COURSES AS OFFERED FROM 1972-1975

First Semester:	LS 111	(5 credits) lectures only 2 hours math 3 hours chemistry (inorganic and organic) 3 hours Biology (anatomy & elementary physiology)
Second Semester:	LS 112	(5 credits) lectures and lab 4 1/2 hours Biochemistry 4 1/2 hours Microbiology
Third Semester:	LS 211	(4 credits) lecture and lab 8 hours Physiology

FIGURE 1

Dental Assisting students were only required to take LS 111 and LS 112 since theirs was only a one year program.

EVALUATION AND MODIFICATION OF THE ORIGINAL LIFE SCIENCE PROGRAM

The sequence of life science courses remained unaltered for three years to provide time for evaluation. Students were now taking their science courses in the correct order and were better prepared for each course as a result ot developing the appropriate background. The Nursing faculty were very pleased with the increased mathematical preparation given their students and the anatomy section of LS 111 was also well received.

However, by 1975, it was apparent that the program needed modification. One reason for this was that the number of part-time students wishing to take the life science courses was steadily increasing and many of these students were less well prepared than those already accepted into the professional programs. Such students found a 5 credit science course too much to take on at one time. Another problem was that students could pass LS 111 and LS 112 in spite of being weak in one area and consequently were not as well prepared for the physiology course as they should have been. It was also found that quite a number of students had great difficulty with the lab work in LS 112 which was obviously due to having no lab experience in LS 111. Finally, most Dental Assisting students were very hard pressed in their second and last semester and had great difficulty keeping up with the demands of LS 112.

In 1975 it was decided to modify the life science program to make it more flexible in an attempt to alleviate the problems. To enable students to procede more slowly if they wished and to make sure students gained proficiency in each area, LS 111 was split into 3 courses and LS 112 was split into 2 courses as shown in Figure 2.

1975 MODIFICATION OF THE LS PROGRAM

First Semester:	LSMA 104	(1 credit) 2 hours Math
	LSCH 106	(2 credits) 3 hours Chemistry (inorganic & organic)
	LSBI 108	(2 credits) 3 hours Biology (Anatomy & elem. physiology)
	These 3 courses equivalent to LS 111	
Second Semester:	LSCH 114	(3 credits) 5 hours Biochemistry
	LSCH 116	(2 credits) 4 hours Microbiology
	These 2 courses equivalent to LS 112	
Third Semester:	LSBI 216	(4 credits) 8 hours Physiology
	This course equivalent to LS 211	

FIGURE 2

A student can now take one of these courses at a time in the order listed or he can take 104, 106 and 108 together followed by 114 and 116, etc. Well prepared students and those who are accepted in their first year into one of the Allied Health Programs are advised to take the courses as listed in their first, second and third semesters in order to graduate on schedule.

In addition to these modifications, two minicourses have been introduced. A one credit minicourse in Biochemistry is offered during the winter break as an alternative to LSCH 114 for Dental Assisting students only. Since these students do not take LSBI 126 they do not require such an extensive background in biochemistry as the Nursing and Physician's Assistant students need. Those who take advantage of this minicourse are able to lighten their second semester load considerably. Another one credit minicourse is also offered during the winter break which is designed to train students in lab techniques. Those who have taken this course have found they were then very well prepared for the lab work in Biochemistry and Microbiology. Both these minicourses have been very well received and appreciated by the students.

STUDENT PROFILES

Approximately 150 students have been admitted each year since 1972 into the three Allied Health Programs. The selection process is not the same resulting in quite different student profiles as summarized in Figure 3.

STUDENT PROFILES			
	Nursing (2 yrs.)	Physician's Assistant (2 yr)	Dental Assisting (1 year)
Source of Students	Initially most were new ECC students from Maryland. Currently most are admitted in their 2nd yr. at ECC	Initially most were new ECC students from out of state. Currently most are admitted in their 1st. yr at ECC and are Maryland residents.	Most have always been admitted in their first yr at ECC and are Maryland residents.
Number admitted per year	Appr. 100	Appr. 18	30
Number graduating per year	Appr. 65	Appr. 16	Appr. 25
Average age of graduates	28	28	19

FIGURE 3

The average numbers of students registered in LS courses per year is summarized in Figure 4. These numbers have not changed significantly over the past 5 years.

AVERAGE NUMBER OF STUDENTS REGISTERED IN LS COURSES PER YEAR		
LS 111, LSMA 104 LSCH 106 & LSBI 108	LS 112, LSCH 114 & LSBI 116	LS 211 & LS 216
220	150	80

FIGURE 4

The number of students enrolled in the first semester LS courses per year (approximately 220) has always been greater than the number of students admitted into the Allied Health Programs (approx. 150). This is due to the large number of students who are not admitted into a program in their first year who wish to take some of their required courses before they begin the rigorous professional training. Many students also hope to show their ability in these courses as a means of getting into one of the professional programs.

STUDENT PERFORMANCE IN LIFE SCIENCE COURSES

Figure 5 summarizes the grades earned by all students taking LS courses. The figures represent % of students each year earning the grades shown. Students withdrawing early in the semesters are not included.

GRADE ANALYSIS I

% of students earning grade	A	B	C	D	NC*
Fall, 1972	7	17	27	12	37
Spring, 1973	13	35	25	5	22
Fall, 1973	18	30	27	6	20
Spring, 1974	15	39	27	5	13
Fall, 1974	20	24	24	4	29
Spring, 1975	16	27	28	4	24
Fall, 1975	23	25	20	3	30
Spring, 1976	21	21	25	7	26
Fall, 1976	24	24	17	5	15
Spring, 1977	26	28	16	5	18
Fall, 1977	25	28	17	4	20

*NC grade now replaced by F

FIGURE 5

It can be seen from this grade analysis data that the % of students earning an A grade was very low initially, but has increased and now seems to have stabilized at about 25%. It is impossible to attach any significance to the NC grades as the college policy in recording these has changed numerous times during this time period.

Figure 6 summarizes the grades earned by students in a typical semester in the separate LS courses. The figures represent % of students in each course earning the grades listed during one semester.

A very high % of the students are able to attain an A grade in the math course and students find it most difficult to earn an A grade in the anatomy and physiology courses. As expected, the failure and withdrawal rates are highest in the first semester courses and very low in the third semester when most of the students are also pursuing their professional careers.

GRADE ANALYSIS II						
% of students earning grade	A	B	C	D	F	W
LSMA 104	37	18	12	4	14	13
LSCH 106	25	17	16	6	20	17
LSBI 108	17	15	15	2	37	13
LSBI 114	22	27	33	4	8	6
LSBI 116	22	34	17	2	7	12
LSBI 216	17	56	0	0	0	0

FIGURE 6

METHODS OF INSTRUCTION USED IN LS COURSES

The students who take LS courses have immensely different backgrounds making it very difficult to teach the courses without boring some and others finding themselves out of their depth. There are challenge exams for any student who feels he has already covered the material but very few students take advantage of these. The only prerequisite a student must fulfill before taking LS courses is in the math area. Before taking LSMA 104 a student must have taken one year of High School Algebra with a C grade of better or make a satisfactory grade on the math placement test. Those who do not qualify for LSMA 104 cannot take any of the courses until they improve their math backgrounds in the ECC math lab which is designed to prepare students for all levels of college math.

No attempt is made to standardize teaching methods although all instructors are expected to adhere to the course outlines recommended by each department for each course. These outlines are constantly being updated and frequent changes have been made in the texts adopted. The Mathematics Department has prepared a text solely for LSMA 104. Students in this course are allowed to take tests over several times until a C grade is earned. Many other instructors also have a liberal make-up policy.

Dr. Patricia Daron has prepared a self-pacing package for the LSBI 108 course. This includes tapes and study guides and is currently being published by Burgess. Other LSBI 108 instructors may use Dr. Daron's materials or a text if they wish. Most of the other courses are taught with the aid of a standard text, however, there is a set of lecture notes available for LSCH 106 prepared by the author and many of the lab experiments used have been developed by ECC faculty.

FUTURE PLANS FOR THE LS PROGRAM

The LS Program could be greatly improved if more hours and credit were available. In particular, the two first semester chemistry and biology courses would be infinitely better if a lab period could be added to each. Every instructor who has taught a LS course feels that he is pushing the students to their limit within the time allowed. However, as long as the programs must fit into a 2-year span, it is unlikely that more time and credit will be available for science courses.

If there were more Dental Assisting students, they could be better served with special LS courses designed for them to fit into their one-year program. However, at the moment this would not be practical as the sections would be too small.

To summarize, the LS Program at ECC has been designed to serve the three Allied Health programs. It is now a very flexible program which has been modified already and will probably be modified in the future. As the needs of the ECC students change and these needs are recognized, then the LS courses will be modified or replaced by more suitable courses.

Chemistry for Layman

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Presented at the Sixty-First Meeting of the Two-Year College Chemistry Conference, Phoenix College, Phoenix, Arizona, November 10, 1978.

Dr. Judd gave a slide presentation describing a new type of course in chemistry. The name of the course: "Chemistry for the Layman" was recently changed from the initial title: "Modern Aspects of Chemistry". The course originated in 1970 in the Phoenix College Chemistry department, and the usual enrollment has been about 20 students. There is a laboratory with the lecture. The text was written by Dr. Judd and is currently under revision for possible publication.

<u>Purposes of the course are</u>:

1. To introduce the student to an array of chemical armament in life.
2. Permit the student to get the feel of his abilities in chemistry without the onus of failure. This is possible, because the course is not in the usual "hierarchy" of flunkers for which chemistry is so noted.
3. Provide a general background for specific courses in the sciences.
4. Permit the student to go on field trips and get other visual experience (films, slides, tapes, etc.) relating to the practice of chemistry.

<u>The content of the course is broken down into 10 main sections:</u>

1. The Earth and its Composition
2. The Petroleum Industry and the Products we receive from it

3. Fertilization of Soils and the Growing of Plants
4. Insecticides, their action and use.
5. Adhesives and Adhesion
6. Nutrition
7. Chemotherapy
8. Air Pollution. Clean Air and How to Bring it Back to Urban Areas
9. Water. Clean Water and How to Clean up our Sources and Insure a Water Supply
10. Solar Energy. Solar Energy for the Home. Home Insulation

The various subjects are treated from a viewpoint of usefulness of chemistry. If the chemistry is unnecessary or unrelated, it is not introduced, and the course thus treats only the subject at hand.

Some of the action is described below:

THE EARTH AND ITS COMPOSITION

1. Verbalize 106 elements
2. Write symbols of 106 elements
3. Discuss the uses of several of the elements and their compounds
4. Discuss the overall composition of the earth
5. See some outstanding mineral samples
6. Go on a field trip to an oxygen plant
7. Learn the simple shell structure of the atoms and how it related to the periodic table
8. Learn the magic number of 8 and how it applies to reactions
9. Learn what the ions are and be able to write types of reactions
10. Carry out some exchange reactions in laboratory
11. Learn hot to use the Mettler balance
12. Learn how to use a centrifuge

PETROLEUM

1. History--where it started
2. Theory of origin from marine plants and animals
3. The processing plants--diagram and explanation
4. The chemicals in the gases and liquid deposits
5. The nomenclature of organic chemistry
6. Additives in gasoline
7. Products made from petroleum; rugs, plastics
8. Demand for products (tables)
9. Cracking the hydrocarbons
10. Visit to a refinery

FERTILIZATION OF PLANT SOILS

1. Controversy: "organic" or "chemical" gardening
2. The elements necessary in plant nutrition
3. Commercial labeling of a fertilizer mix (4,2,2,1, etc.)

4. Importance of recycling to soil
5. Pore space in various types (importance for CO_2): sands, silt, loams, clays, peats, vermiculite
6. Building the compost pile
7. Loss of elements in alkaline soil. Acidification for release
8. Microbiological reactions in soil:

$$N_2 \xrightarrow[\text{red.}]{H_2} NH_3 \qquad N_2 \xrightarrow[\text{oxid}]{H_2O} (HNO)_2$$

9. Normal, deficient and toxic amounts of N, P, K, S, Mg, Fe, Mn, B, Cu, Mo, Cl, Na, Zn and function in plants. Chelates and additives
10. Sheep muscle disease in New Zealand and selenium
11. Field trip to a garden
12. Raise a plant, using correct nutrients

INSECTICIDES, THEIR ACTION AND USE: HOW TO KILL BUGS AROUND THE HOUSE

1. Use as little as possible, applying by a windex bottle
2. Insecticide must penetrate the anatomy. Use water or oil base
3. Insecticide acts at proper site:
   a. Anticholinesterase
   b. Nerve toxicant
   c. Antimetabolite
   d. Enzyme complexer
   e. Enzyme inhibitor
4. Judiciously combine properties for paralysis and death
5. Add a residual
6. Insure safety to man and animals
7. Present specialties, for example, chemosterilization
8. Stability of insecticides
9. Specific suggestions; soft-bodies insects, weevils, cockroaches, flies, mosquitos, moths, millars; diazinon, pyrethrin
10. A short course in organics
    a. Compounds of carbon
    b. Fluoro and silicone organics
    c. Cyclic and heterocyclic structures and how they are drawn
    d. Naming and numering the chains, C_1 - C_{100}
11. Insecticides, their names and structures
12. Toxicity chart
13. Kill bugs in laboratory with a variety of insecticides
14. Tour an insecticide analysis laboratory
15. Visit a garden to observe bugs

ADHESIVES AND ADHESION

1. The adherent-adherend and adhesive
2. Polar versus non-polar concept, the setting angle - "like bonds to like"

3. Weak forces (short molecules) versus strong forces (long molecules)
4. Similar structures give strnegth
5. Thin layer, flexibility, water resistance
6. Wetting and adhesion
7. Penetration into surface and chemical reaction
8. Protein glues. Animal hide, hoof, and blood glues. Casein, soyabean
9. Dextrin, urea-formaldehyde, melamine and phenolic 3-dimensional glues
10. Epoxy, nitrile rubber, polysulfide, polyisobutylene, polyisocyanate adhesives
11. Trimellitic anhydride-propylene oxide, high temperature polyimide and ceramic resins
12. How to glue furniture, plastics, vinyls, nylon, metals and rock to each other in laboratory. Practical applications
13. Tables of wetting, protein composition, adhesive chemical structures and bonding abilities

NUTRITION

1. Man is from the earth and his elemental composition is similar to that of the earth and seas
2. Concentration of the elements in differentiated body tissues
3. What the body needs to exist; energy, provision and dissipation, cell-replacement, 28 elements and enzymes
4. Specifically known functions of essential elements, with minimum daily requirement and toxic amount
5. Amino-acids, requirements and deprivation effects
6. 19 vitamins, positive effects, requirements and deficiency symptoms
7. Tables on weight loss, elemental content of tissues, structures of ehmoglobin and other molecules
8. Hormones, lubrication, elimination
9. Field trip to food stores
10. Field trips to University Libraries

CHEMOTHERAPY - HOW TO GET WELL AND STAY WELL

1. Where chemotherapy armament came from
2. Statistics, deaths and injuries, a profile
3. Prevention of illness and injury. Bacteria vs viruses
4. Specificity and structures of bacteriocides and modes of action (12 antibiotics and sulfonamides).
5. Serious life and health threateners, prevention and treatment.

    a. Home accidents
    b. Car accidents
    c. Work accidents
    d. Colds
    e. Sore throat, streptococcus, tonsillitis and other
    f. Heart and vascular conditions
    g. Cancer, non-leukemia

h. Leukemia
i. Asthma
j. Dysentery
k. Coccidioidomycosis
l. Viral hepatitis
m. Canker
n. Trench mouth
o. Rickettsiosis
p. Cystic fibrosis
q. Warts
r. Shingles, latent chicken-pox herpes zoster
s. Suicides
t. Mononucleosis, college kissing disease, Burkitt's Lymphoma
u. Tuberculosis
v. Arthritis
w. Leprosy
x. Trachoma (pink eye)
y. Stomach ulcers
z. Gingivitis or anus itch

6. Structures of chemotherapeutic agents are given as treatment is described
7. Structure of Virazole (first broad-spectrum virocide) is given
8. Non-conventional approach to the control of cancer is described (laetrile, nutrition, etc).
9. Field trip to the Contreras cancer clinic in Tijuana
10. Field trips to orthodox clinics should become more easily arranged in the future

AIR POLLUTION. CLEAN AIR AND HOW TO BRING IT BACK TO URBAN AREAS

1. What's in the air

   a. Pollen, allergens and radioactive dust
   b. Uncontaminated urban air (N_2, O_2, rare gases)
   c. Names and amounts of chemicals in urban air from the automobiles
   d. SO_2 and SO_3 from the smelters, power plants and cars
   e. The smaze composite of water, polymers, dust and NO_2

2. How to reduce CO and hydrocarbons in urban air; standards of air quality

   a. Efficient carburetion
   b. Switch to other modes
   c. Change over to hydrogen fuel
   d. Scrubbing SO_2-SO_3 with water or reducing SO_2 to sulfur
   e. Smog is function of gallons of gasoline burned annually

3. Health hazards from various contaminants. Critical levels for health effects

   a. Pollen and allergens
   b. Lead
   c. Carbon monoxide
   d. Tables of blood versus ambient concentrations
   e. The nature of inversions; radiation of heat and cooling
   f. The effect of wind velocity on pollution
   g. Methods of analysis for CO. Collecting and analysis of samples
   h. The function of lead in gasoline. Low temperature combustion and wall poison
   i. Trips to the edge of the city to observe smog
   j. Trips to County and State air-pollution bureaus

SOLAR ENERGY FOR THE HOME: INSULATION OF THE HOME

1. Where does our energy come from?

	kwh/100 g		kwh/100 g
1. Cellulose	.59	5. Fission	2.23×10^6
2. Coal	.82	6. Fusion	9.52×10^6
3. Gasoline	1.33		
4. Natural gas	1.77		

2. How much energy do we use?

	kwh/day
1. Body maintenance	3
2. Vigorous work	6
3. Home heat	15
4. Home cooling & electrical	30
5. Car	72
6. Other	86
Daily	212 kwh

3. Fossil fuels and depletion times.
4. Becoming energy self-sufficient.
5. Heat supplements (water systems).
6. Solar cells for electric power.
7. Hydrogen production and use.
    1. Electrolysis systems.
    2. Operation of cars, buses, etc.
    3. The "hydrogen" home.
8. Power from the wind
9. Fuel cells and hydrogen
10. Solar cell demonstration.
11. Field trip to solar displays and Billings Energy Corporation (hydrogen cars)

New Aproaches in the Chemistry-for-Everybody Laboratory

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Presented to the Sixty-First, Two-Year College Chemistry Conference, Phoenix College, Phoenix, Arizona, November 10, 1978.

This paper describes the laboratory portion of the chemistry-for-everybody course at the University of Wisconsin-River Falls. Emphasis is on new experiments and on revisions of some of our old ones.

Before getting into a description of our laboratory, though, perhaps we should decide whether there should be a laboratory for those students not going into the sciences. Laboratories are expensive in a time of tight budgets and demanding of staff time when we teachers already have more than we can do.

We at UW-RF have felt those constraints just like everyone else. Yet we still believe, now more firmly than ever, that non-science students should have laboratory experience. We just as firmly believe that the experience should not be the traditional one in which students test laws that are already well-proven, redetermine physical constants which are more easily found in a handbook, and analyze "made-up" unknowns. The main goal of our course is to get the students involved in investigating the real world. We use made-up samples only to show what a positive test looks like or to calibrate our apparatus.

Students obviously cannot reverify all the chemical principles in one term. Nor can they necessarily understand all the chemical reactions and principles involved in the investigations undertaken in our course. We have found, however, that students are quite willing to accept our standardized solutions, comparative samples, etc. They also recognize and respect our expertise as chemists. We feel that is as it should be. We all depend upon the work of others and build upon it without repeating every experiment or calculation.

We feel that the role of chemists is changing. Indeed, it must change if chemistry is to survive as a profession. In the past, most chemists have concentrated on making new products -- "better <u>things</u> for better living". While we will continue to need new and improved materials, more and more chemists will have to become involved in designing "better <u>processes</u> for a more livable world". Chemists will also become more involved in monitoring air and water quality and other aspects of our chemical environment. It is these changing roles that we emphasize in our laboratory.

Before going further, I'd like to acknowledge the creative contributions of my colleagues, Lawrence Scott, Leon Zaborowski, and Peter Muto, to whom much credit for the success of the laboratory is due. Also, I'd like to emphasize the four guiding principles in our revision. First, we have moved toward shorter experiments. We have tried to limit them to those that can be finished in one hour -- or, at most, two hours. That makes lab easier to schedule, and it is easier to maintain student interest.

Second, we've tried to keep them cheap. We use everyday materials as much as possible, often asking the students to bring in their own from home or the store. Our purchase of chemicals is kept to a minimum.

Third, we avoid as many of the more hazardous chemicals as possible. Total avoidance of hazard is impossible. And even if it weren't, it would be unwise. We try to teach them how to handle dangerous substances safely, a practice that we hope will carry over into their everyday lives.

And fourth, we've tried to devise more interesting experiments, yet ones which still illustrate important principles. Let's now look at some of our new experiments to see how we have tried to accomplish these goals.

We still start off with a section or measurement. We make metric mayonnaise or Si salad dressing. Students may also prepare "Sterno" or "Canned Heat". Next we do any experiment to illustrate chemical change. We grow crystals of iron (II) sulfate, potassium ferricyanide, potassium ferrocyanide, etc. Then we mix various solutions and look for new colors and shapes of crystals. (One product is Prussian blue.)

In electrochemistry we now use glacial acetic acid in toluene -- safer, cheaper, and easier to prepare -- in place of hydrogen chloride in benzene.

We have added a new agricultural chemical experiment on antibiotics in animal feeds. Chlorotetracycline and oxytetracycline give different colors when treated with certain chemical reagents. The text is simple and dramatic. And it illustrates one minor role that chemists play in modern agriculture.

Several new foods experiments have been added. We have modified the old Baeyer test so that it works as a test for unsaturated fats. (The usual Baeyer test doesn't work; fats are immiscible with water). We have the test working well on a qualitative basis. We have hopes that it be made quantitative and thus replace the iodine number as a test for unsaturation. Another experiment evaluates a variety of organic acids and salts as mold inhibitors in foods.

One of the most interesting -- and original experiments that we have developed is making a copper mirror. They said it couldn't be done, but we plate copper on glass to make a mirror. With our copper mirror, everyone appears to have an Arizona suntan.

We can make an infinite variety of soaps -- hard, soft, transparent, and with varying solubilities. Just neutralize any of several fatty acids -- lauric, myristic, palmitic, steavic, or oleic -- with sodium or potassium carbonate (or hydroxide) or with triethanolamine. Or we can make soap the way Grandma did, using lard and lye. Like colored soap? Just add a piece of crayon to the fat.

A new cosmetic unit has added a great deal of interest to our course. We can make toothpaste, cologne or aftershave, and a lovely vanishing analgesic balm. We can make shampoo, but it isn't worth it. Just buy the cheapest stuff you can find and add your own conditioner -- an egg or a tablespoon of gelatin.

Student response to the new experiments -- and to the lab in general -- has been quite favorable. "Why can't we do more lab?" is a common question. Well, why not?

New Directions in the Chemistry-for-Everybody Laboratory

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Presented to the Sixty-First meeting of the Two-Year College Chemistry Conference, Phoenix College, Phoenix, Arizona, November 11, 1978.

Recurring reports reach me that enrollment is declining in the chemistry-for-everybody courses. Perhaps a part of the reason is that more students are choosing the hard sciences. Perhaps another part is that we teachers have lost some of our initial enthusiasm for such courses. The purposes of this paper are (first) to make a case for renewed and expanded efforts in our attempts to reach the nonscience people with our vital message, and (second) to share with you some of the things we are doing at the University of Wisconsin-River Falls to attract students to the course -- and to teach them something when we get them there.

It is somewhat surprising that this decline in enrollment comes at a time when the "back to basics" cry is heard throughout the land. No one would argue with the essentiality of reading, 'riting, and 'rithmetic, but what could be more basic than science? We live in a technological society. Our only defense against technological tyranny is information and the ability to evaluate it. Pollution, overpopulation, shortages of useful energy and of materials will continue to plague us for years -- perhaps for generations. An understanding and appreciation of chemistry is central to defining our problems, let alone to solving them.

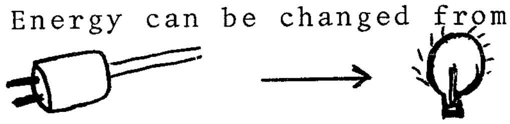
I'm sure we all agree to importance of chemistry. But how can we get our message across to the nonscientist? First, you've got to get them to take the course. Also how can you teach them anything? How do you do that? The course must be interesting. More importantly, it must be useful to the students in their daily lives. It may be useful to their survival, that of their children, and of civilization.

Any meaningful course must be based on chemical principles. Matter is conserved. Energy is conserved. The composition and properties of a compound are invariant. How simple those ideas, yet how often we see them ignored by otherwise intelligent people.

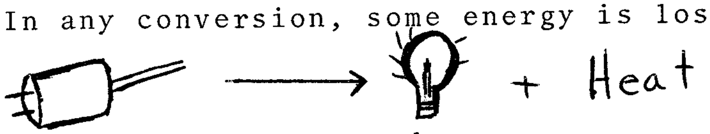
Where are we headed? I see students coming to us a little better prepared and a lot more willing to work. I think (hope?) the trend has already begun. My students are now introduced to names, formulas, and equations. We even tackle a little simple stoichiometry -- handled very carefully, of course. Acid-base and oxidation-reduction are introduced in a qualitative fashion. These concepts enable us to take a more scientific approach to the topics that follow.

The laws of thermodynamics seem particularly appropriate for consideration of those who wish to be survivors. There are several important facets.

1. Energy can be changed from one form to another.



2. In any conversion, some energy is lost as heat.



3. High grade Low grade

STEAM ⟶ HOT WATER

4. Mechanical ⟶ Heat

5. Hot $\longrightarrow$ Cold Refrigerator?

6. Order $\longrightarrow$ Disorder   Life?   Nuclear wastes.

7. You can't even break even.

Perhaps of greater immediate interest is food. And the need for knowledge is perhaps even greater. Quackery is rampant. Scientific findings are often equivocal; but food laws are absolute. (Consider the Delaney Amendment and the saccharin and cyclamates controversies). You can buy sassafras tea (containing safrole, a carcinogen) in a natural foods store, but a diabetic can't buy food sweetened with cyclamates. It boggles the mind!

Consider the business of dieting. There are thousands of books with magic methods for losing weight. All weight loss diets work if (and only if) the caloric intake is reduced to less than the calories used up. Will exercise help you to lose weight? Consider taking off one pound of fat.

$$1 \text{ lb fat} \times \frac{454 \text{ g fat}}{1 \text{ lb fat}} \times \frac{9 \text{ kcal}}{1 \text{ g fat}} = 4{,}086 \text{ kcal}$$

<u>Running</u>: $$19.4 \frac{\text{kcal}}{\text{min}} \times \frac{8 \text{ min}}{1 \text{ mile}} = 155.2 \frac{\text{kcal}}{\text{mile}}$$

$$\frac{4{,}086 \text{ kcal}}{155.2 \frac{\text{kcal}}{\text{mile}}} - 26.33 \text{ miles (for 1 lb fat)}$$

<u>Walking</u>: $$5.2 \frac{\text{kcal}}{\text{min}} \times \frac{17 \text{ min}}{1 \text{ mile}} = 88 \frac{\text{kcal}}{\text{mile}}$$

$$\frac{4{,}086 \text{ kcal}}{99 \frac{\text{kcal}}{\text{mi}}} = 46 \text{ miles (for 1 lb fat)}$$

<u>Dieting</u>:

```
  2500 (normal)
  1500 (diet)
  1000  kcal/day (deficit)
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$$\frac{4{,}086 \text{ kcal}}{1000 \text{ kcal/day}} = 4.086 \text{ day (for 1 lb fat)}$$

When considering food additives and drugs, one of the most important concepts is the constant composition and properties of compounds. Properties of a given chemical substance are invariant. Synthetic Vitamin C is the same as natural Vitamin C. An aspirin is an aspirin. And, as far as five-grain aspirin tablets are concerned, no significant differences have ever been found.

Why teach chemistry to nonscience students? Chemistry is a physical science which deals in an objective way with nature and with the workings of our material universe. Chemistry is more than that, however. I believe that is also an important part of the humanities, which explore what is thought of as being distinctive of humans. Certainly there is nothing more distinctive about the people of the 20th Century than their scientific enterprises. And chemistry is central to all the sciences.

Chemistry is an important intellectual activity in its own right, but we don't have to justify chemistry for nonscience students on philosophical grounds. There are some rather practical reasons. We need citizens who are better informed, more interested in science, and more supportive of science, especially of basic research.. We have accomplished a great deal if we can convince our students that the world, for all its bewildering complexity, is comprehensible and is potentially subject to the control of the human mind. Knowledge gives power, and chemistry is an important way to gain knowledge about the world in which we live.

Innovative Approaches to Teaching Allied Health Students

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Presented at the Sixty-Second, Two-Year College Chemistry Conference, Brookdale Community College, Lincroft, New Jersey, March 24, 1979

The solubility product principle can be related to the dissolution and deposition of bone and teeth. The mineral of these tissues consists mainly of tricalcium phosphate which precipitates from solution. Therefore, concentrations of participating ions must exceed certain values in the immediate environment in order for precipitation to take place. Even at equilibrium surface ions from the crystal lattice structure of the mineral exchange with like ions from solution.

If we take the basic event in calcification to be the precipitation of $Ca_3(PO_4)_2$, we can write for the reaction:

Equation 1 $$3\ Ca^{++} + 2\ PO_4^{\equiv} \longrightarrow Ca_3(PO_4)_2$$

the solubility product expression

Equation 2 $$[Ca^{++}]^3 \times [PO_4^{\equiv}]^2 = K_{sp}$$

Using buffered solutions at pH 7.4 + 37°C (pH of normal blood and normal body temperatures) and allowing sufficient time for equilibrium to be reached, the experimental value for the K_{sp} is $10^{-26.4}$. Are the calcium and phosphate ions in blood serum present in sufficient concentration to be just saturated with respect to crystalline $Ca_3(PO_4)_2$? The actual value for free unbound ionic calcium in blood at pH 7.4 is approximately 1.2×10^{-3}M. For tertiary phosphate ion it is about 1.6×10^{-8}M. Substituting these values in Equation 2 $(1.2 \times 10^{-3})^3 \times (1.6 \times 10^{-8})^2$ we get an ion-product of 4.4×10^{-25} or $10^{-24.4}$. This value is one hundred times greater than the solubility-product constant $10^{-26.4}$ and we would expect bone precipitation to occur. However, while serum at pH 7.4 is supersaturated with respect to $Ca_3(PO_4)_2$, in the <u>immediate vicinity</u> of bone formation the pH is lower. This is due to metabolic reactions taking place in the bone cells. Organic anions produced by these cells in the metabolism of glucose are destroyed elsewhere in the body, and the excess hydrogen ions released lower the pH in the internal environment of the bone. The $PO_4^{\equiv}$ concentration which is strongly pH dependent is consequently reduced.

$$PO_4^{\equiv} + H^+ \longrightarrow HPO_4^{=}$$

$$HPO_4^{=} + H^+ \longrightarrow H_2PO_4^{-}$$

Apparently under normal conditions, when the pH of blood is 7.4 the pH in the <u>immediate</u> vicinity of bone formation and dissolution is sufficiently lowered to depress the $[PO_4^{\equiv}]$ to a point where the ion-product $[Ca^{++}]^3[PO_4^{\equiv}]^2$ falls very close to $10^{-26.4}$ and normal bone tissue maintenance exists. In the case of children suffering from chronic acidosis, the pH of blood is below normal, 7.1, and indeed bone growth is greatly impaired. In this situation the pH at the site of bone formation is below 7.1 which has the effect of depressing the $[PO_4^{\equiv}]$ to a value which is too low to produce an ion-product that will equal the K_{sp} for $Ca_3(PO_4)_2$. Children with this congenital defect form improper skeletons.

Another K_{sp} dependent situation exists in the mouth with respect to tooth formation and dissolution. Here, at ordinary pH values of saliva, which constantly bathes the teeth, are Ca^{++} and $PO_4^{\equiv}$ in sufficient concentration to prevent erosion of tooth tissue. In cases where salivary glands, which produce the saliva, are removed - the teeth, if not removed, will deteriorate rapidly because the ion-product of Ca^{++} and $PO_4^{\equiv}$ is below the K_{sp} for $Ca_3(PO_4)_2$.

How can carie formation be explained in teeth which are constantly being bathed by saliva? A combination of carbohydrate and protein known as mucin is precipitated from saliva and forms a film or plaque on the tooth. If this is not removed by brushing and flossing it thickens as entrapped bacteria and food becomes embedded. This becomes firmly attached to the enamel or root surfaces of the tooth. It is beneath these plaques that carious lesions occur. Acid decalcification is the essential step in the process and the requisite acids are produced by the microbial fermentation of the carbohydrates entrapped in the plaque. Saliva which bathes the area cannot reach under the plaque, therefore the buffering action normally provided by the $PO_4^{\equiv}$ + $HPO_4^{=}$ ions in saliva is blocked. At the site of human carious lesions pH's have been found to be as low as 4.5-6, which is acid enough for decalcification to take place. The $PO_4^{\equiv}$ from the mineral of tooth tissue promptly neutralizes the excess acid forming a more soluble $HPO_4^{=}$.

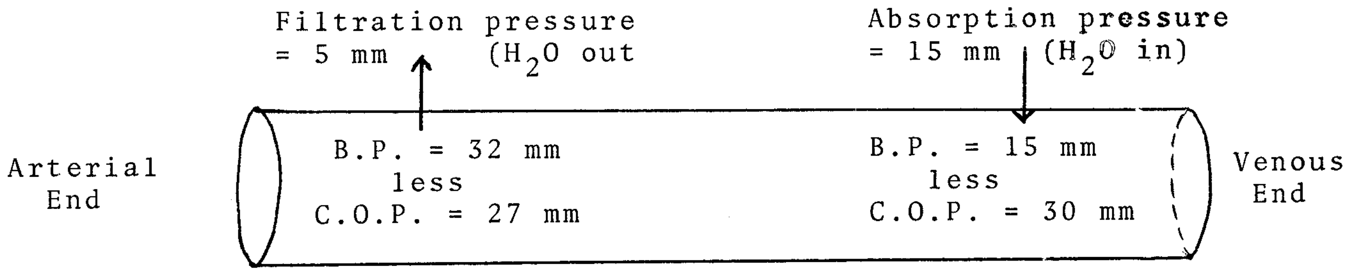
Two units of great importance to students in the health sciences involve the study of water and solutions and the maintenance of water, electrolyte and acid-base balance of the body. All the processes of dialysis, diffusion, osmosis and filtration can be taught as they contribute to tissue fluid formation and the movement of molecules through membranes. What are the factors that promote the exchange of food molecules from the blood to the tissues, of the waste products of metabolism from the cells to the capillaries?

Fluid passes from the capillaries and into the tissue spaces by the process of ultrafiltration. It is in this manner that water and solutes flow through the capillary wall. The chief factor promoting filtration is the blood pressure (B.P.) or hydrostatic pressure pushing fluid out of the capillaries. Opposing this is the colloid osmotic pressure (C.O.P.) or the oncotic pressure of the plasma protein pulling water in.

Filtration pressure = Capillary blood pressure minus plasma colloid osmotic pressure.

The colloid osmotic pressure will vary with the concentration of the plasma proteins. A loss of plasma protein will increase the filtration pressure and increase tissue fluid formation. An increase in blood pressure also increases the filtration pressure.

Although values for blood pressure and colloid osmotic pressure varies from time to time and from place to place the following values may be used as an example.



Capillary

Arterial end

B.P. = 32 mm = (pressure forcing H_2O out)

less

C.O.P. = 27 mm = (o.p. drawing H_2O in)

Effective filtration pressure = 5 mm (H_2O goes out)

Venous end

B.P. = 15 mm = (H_2O out)

less

C.O.P. = 30 mm=(H_2O in)

Absorption pressure = 15 mm (H_2O enters)

B.P. falls at venous end due to increased resistance to flow and loss of fluid.

C.O.P. rises at venous end due to greater concentration of plasma proteins.

The kidneys in a fantastic filtration reabsorption process regulate the amount of water that will be excreted in the urine and rid the blood of waste products of metabolism such as urea, uric acid and creatine. Hormones assist the kidneys in regulating the electrolyte and acid-base balance. When the kidneys fail to function hemodialysis can be carried out with an artificial kidney machine. Without the aid of hormones the health professionals must study the blood profile of the patient and select a dialipate solution for bathing the blood (i.e. normal Na^+/K^+ or K^+ free) that will correct conditions through the simple process of dialysis.

These few examples, enhanced through the use of slides or other audio-visual aids where possible, demonstrate a sensible approach for teaching chemistry to students in the health professions. Find applications of chemical principles as they occur in the hospital, the laboratory, or in the body and teach the concept relating it to the practical situation. When teaching gas laws, draw examples from gas exchange as it occurs at the cells and at the lungs. The absolute necessity of knowing the pH, pCO_2 and pO_2 relationships in order to properly ventilate a patient furnishes numerous practical applications for the Henderson-Hasselbach equation. Nuclear medicine is a rich source of application illustrations for lecture and laboratory material. Problems can be drawn directly from hospital situations, i.e., 3 liters of 5% glucose given intravenously over a 24 hour period provides the patient with only 570 kcal.

If a self-motivated visit to one of your cooperating hospitals is not a simple matter, then a chat with a clinical staff colleague or with a physiology instructor and a look in his text book will suggest still more applications of the chemical concepts you teach. Relevence in our teaching is still a major concern.

An Innovative Approach for Beginning College Chemistry

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Presented to the Sixty-Second, Two Year College Chemistry Conference, Brookdale Community College, March 24, 1979.

At Merritt College, one year of high school chemistry or its equivalent is a prerequisite for General College Chemistry. To provide for students who have not had high school chemistry, we offer a one semester Beginning Chemistry course which is designed to bring these students to the same level as those with high school chemistry. Our experience with this "college prep" course has been that there is an extremely high rate of withdrawal by students in the first four to five weeks of the semester.

It has been our experience that the early withdrawals are due to the students entering intimidated by the idea of science in general, with the preconception that chemistry is "too abstract" and, most important, poorly prepared in and frightened by mathematics. They are certain that chemistry will involve too much math for them. In actuality, the mathematics involved in General Chemistry is very basic and only a minimal amount of even algebra is required.

The solution to this dilemma which I have worked out is to make the students first essays into chemistry very real and tied in with their own observations or with what they have heard about and to delay <u>any and all</u> mathematics sufficiently far into the semester so that the students' self-confidence has been built up.

This delay in the introduction of chemical calculations is totally different with what is found in the sequence of the most popular texts for Beginning Chemistry. Table 1 shows the pages where five selected types of mathematical operations are treated in five common texts.

TABLE I

MATHEMATICS PRESENTATION IN VARIOUS TEXTS

	Exponential Notation	Metric System	Significant Figures	Dimensional Analysis	Density
Hein	appendix	p. 8	p. 8	p. 12	p. 12
Seese & Daub	appendix	p. 21	p. 12	p. 22	p. 34
Peters	appendix	p. 19	p. 33	p. 9	p. 28
Cherim & Kallim	p. 6	p. 16	p. 12	p. 33	p. 32
McCurdy	p. 17	p. 18	p. 13	p. 29	p. 31
Sherman, Sherman & Russikoff	p. 22	p. 11	p. 18	p. 12	p. 17

In all of these texts the student is faced with at least four different types of calculations in the first two chapters which normally will be taught in the first and second week. This precedes any mention of chemistry. It is hardly surprising that timid or poorly prepared students elect to withdraw at this point.

Obviously, students completing a Chem Prep or a high school chemistry course must have a certain facility in problem solving before entering General Chemistry. The question was would it be possible to delay the starting of calculations roughly one-third into the semester and still have adequate time to cover those calculations which are vital. It felt if this could be done then it would be possible to keep the students, build their self-confidence and let their momentum carry them through the problem solving.

The first thing was to determine exactly which types of calculations the students must be able to handle. Table 2 lists these.

TABLE 2

CALCULATIONS NEEDED FOR FIRST SEMESTER COLLEGE CHEMISTRY

- Exponential Notation
- Metric System
- Significant Figures
- Densities
- Percentages
- Moles
  - Molecular Weight
  - Percent Composition
  - Empirical Formula
- Stoichiometry
- Gas Laws
- Solutions
  - Concentration
  - Stoichiometry
- (Logarithms)

I have omitted calculations dealing with thermodynamics, equilibria, Bohr-Rydberg, physicists' energy calculations, etc. feeling that these can be picked up in General Chemistry. Logarithms might be included to allow pH calculations. Except for significant figures and exponential notation, all of these calculations are amenable to dimensional analysis (unit analysis or factor-unit) solutions. This is an incredible tool and once students are trained to use it they are usually amazed at their own ability in solving problems.

Actually there are fewer mathematical topics than there are theoretical and descriptive topics which we feel must be covered. Table 3 lists these topics.

TABLE 3

DESCRIPTIVE TOPICS NEEDED FOR FIRST
SEMESTER COLLEGE CHEMISTRY

Matter - Properties and State
Element and Compounds
Atoms and Molecules
Periodic Table
Dalton's Atom - Electronic Structure
Bonding
Formula Writing and Nomenclature
Chemical Reactions and Balanced Equations
Classes of Compounds
Gases, Liquids and Solids
Solutions
(Optional)
Organic Chemistry
Nuclear Chemistry

Examination of the topics shows that there is no real need for any quantitiative treatment until after formula writing and the balanced chemical equation are covered. I therefore designed a syllabus in which none of the calculation topics is treated until the fifth week. At that point non-chemical dimensional analysis technique is introduced. The success - and gratification - the students find in this procedure provides the impetus to carry them on to more detailed calculations. Then, after the sixth week when the balanced equation is introduced, the students start a sequence ofalternating calculation and theoretical (descriptive) topics.

Furthermore, I have carefully separated the calculations from the theoretical topics. This was done so that the students' understanding of the theoretical topics is not hindered or interrupted by the presence of possibly unmanageable mathematics and also to show that the calculations are merely supportive to the chemistry. Of course, whenever possible those calculations related to a theoretical topic immediately follow that particular topic. Thus gas calculations immediately follow gas law theory and solution calculations immediately follow solution theory. I feel that significant figures are related only to laboratory work and, in the text, Chemistry: Concepts and Calculations (Canfield Press), which I have written to follow this sequencing of topics, they are relegated to an appendix.

Starting with the plan to start actual calculations in the sixth week of a fifteen week semester and from that point on to have alternating calculation and theoretical topics, it was only necessary to examine how all the desired calculations could be fit into the necessary theory. It actually works out very well as can be seen in Table 4.

TABLE 4

SYLLABUS FOR DELAYED MATH CHEM PREP COURSE

Weeks	Topics
1,2,3,4	General Aspects of Science, Nature of Matter, Classification of the Elements, Periodic Table, Dal-on Theory, Structure of Atoms, Electronic Structure Related to Periodic Table, Bonding (Ionic, Covalent), Formula Writing, Dimensional Analysis as a Method of Problem Solving
5	Oxidation Number, Binary Nomenclature, Balanced Equations
6	Exponential Notation, Metric System, Density, Types of Chemical Reactions, Equilibrium in Chemical Reactions
7	Calculations Involving the Mole, Percent Composition, Simplest and Molar Formulas
8	Water-Hydrogen Bonding, Solvent Properties, Equilibrium, Acids, Bases, pH, Oxides in Water, Neutralization, Oxy-acid Nomenclature
9	Balancing Redox Equations, Stoichiometry
10	Gas Laws - Kinetic Theory, Ideality, Equation of State
11	Gas Calculations, Gas Stoichiometry, Liquids-Evaporation, Equilibrium Vapor Pressure, Boiling Point
12	Liquids - Effects of Molecular Interactions, Solids-Particles Present and Properties
13	Solutions - Saturation Equilibrium, Factors Affecting Solubility, Vapor Pressure Lowering by Non-volatile solutes
14	Solution Calculations - Concentrations, Stoichiometry
15	Organic Chemistry - Hydrocarbons, Functional Groups or Nuclear Chemistry

*Underlined topics are calculations

The question immediately comes to mind, "What can we do in the laboratory during these first five or six weeks when the students cannot even handle metric system?" We are all conditioned to starting our laboratory with some experiment like determining the density of a metal cylinder by length measurement and also by water displacement and then discussing the reliability of the measurements. There is no doubt that chemistry is an experimental science and the students should have a laboratory experience which instills this idea. Actually there are a great many non-quantitative experiments which are extremely instructive, serve to support the textual materials and are interesting for the students. Some of these are listed in Table 5.

TABLE 5

NON-QUANTITATIVE EXPERIMENTS FOR FIRST SIX WEEKS

Setting Up Flow Diagram (Classification)
Glassworking
Separation of Mixtures
Physical Properties
Chemical Properties
Scientific Models - Emission Spectra
Effect of Type of Bonding on Physical Properties
Relation of Location in Periodic Table to Elements' Chemical and Physical Properties

Once past the initial one-third of the semester, it is possible to match the laboratory experiments easily into the syllabus. The density determination, mentioned previously is a good introduction to metric measurements and significant figures. The usual Boyles' and Charles Law experiments and molar weights by vapor desntiy fit with the gas law coverage. Stoichiometry can be experimentally examined as can percent composition.

We have found that using this approach to teaching our Chem Prep course has (1) almost eliminated student withdrawals in the first four weeks of the semester and (2) increased the number of students completing the semester with a C or better grade (a prerequisite for General Chemistry) and able to pass the Toledo Chemistry Qualifying Examination (another General Chemistry prerequisite). The students entering General Chemistry fare as well or somewhat better than those students with one year of high school chemistry in the theoretical aspects and considerably better in the calculations. We are now considering using my text, Chemistry: Concepts and Calculations, for our terminal beginning chemistry course (mainly for paramedical students) by eliminating some of the calculations chapters.

SYLLABUS FOR BEGINNING CHEMISTRY WITH DELAYED MATHEMATICS PRESENTATION

The following is based on a 15 week semester with three hours lecture and two hours laboratory per week. Text following this syllabus: Chemistry: Concepts and Calculations, Loebel (Canfield Press)

Week	Topics	Possible Experiments
1	Scientific Method, Fields of Chemistry, States of Matter, Heterogeneous and Homogeneous Matter, Pure vs Impure Substances, Elements, Compounds, Atoms, Molecules, Elements and Symbols, State of Elements at Room Temperature	Setting Up Flow Diagram; or Glassworking
2	Metallic vs Non-Metallic Elements, Families of Elements, Periodic Table, History of Chemistry, Chemistry as Science, Laws of Conservation of Mass, Constant Composition, Multiple Proportions	Separation of Mixtures; or Physical Properties
3	Dalton's Atomic Theory, Atomic Weights, Electrons, Protons, Neutrons, Nuclear Atom, Isotopes, Electronic Energy Levels, Relationship of Electronic Structure to Periodic Table	Chemical Properties; or Scientific Models (Spectra)
4	Ionization and Its Relationship to Location in Periodic Table and Metallic or Non-metallic Character, Ionic Bonding, Formulas of Ionic Compound, Covalent Bonding, Electronegativity, Formulas of (Binary) Covalent Compounds	Effect of Type of Bonding on Physical Properties (or in 5th week)
5	Metallic Bond, Dimensional Analysis as Method of Problem Solving, Oxidation Number, Nomenclature of Binary Compounds, Balanced Equation	Relation of Element's Location in Periodic Table to Its Chemical Reactions
6	Exponential Notation, Metric System, Significant Figures, Density, Types of Chemical Reactions, Equilibrium in Chemical Reactions	Density Determination
7	Calculations Involving the Mole, Percent Composition, Simplest Formula, Molar Formula	Types of Chemical Reactions; or Formula from Percent Composition (MgO) or % Cu in $CuSO_4 \cdot 5H_2O$

8	Water - Its Polarity, Hydrogen Bonding, Solvent Properties, and Equilibrium, Acids, Bases, pH, Nature of Oxides in Water, Neutralization	Electrolytes; or Acids and Bases; or Saponification
9	Balancing Redox Equations, Stoichiometry	Stoichiometry; or Redox Reactions
10	Gas Laws - Kinetic Theory, Ideality, Equation of State, Gas Constant	Boyle's Law; or Charles' Law
11	Gas Law Calculations - Change Conditions, Equation of State, Stoichiometry - Liquid Phase - Evaporation, Vapor Pressure Equilibrium, Boiling	Molecular Weight by Vapor Density
12	Liquid Phase - Effects of Molecular Interactions on Properties, Solids - Particles in Crystalline Solids, Properties of Crystalline Solids	Heat of Fusion
13	Solutions - Saturation Equilibrium, Energetics of Solution Process, Factors Affecting Solubility, Lowering of Vapor Pressure by Nonvolatile Solute	Solubility of Salts
14	Solution Calculations - Concentration - Molarity, Molality, Normality - Stoichiometry	Standardization of HaOH; or Acid Base Titration
15	Organic Chemistry - Hydrocarbons, Functional Groups or Nuclear Chemistry - Common Nuclear Reactions	Reactions of Hydrocarbons; or Radioactivity

Demonstrations for Allied Health Chemistry

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Presented to the Sixty-Third, Two Year College Chemistry Conference, Columbus Technical Institute, Columbus, Ohio May, 1979.

Considered in a broad sense, demonstrations provide visual aids to understanding. Demonstrations take a variety of forms, and may involve active participation by the instructor, the student, or both. My comments are not limited to allied health chemistry, but specific examples will be drawn from this course.

"Show-type" demonstrations. This type of demonstration is a useful attention-getter, such as on the first day of class or at a science fair. It is meant to be spectacular, and the effect is more important than the illustration of chemical principles. A recent compilation of such demonstrations[1] divides them into those involving color changes, emission of heat (combustion), light, and sound. They are often presented as "chemical magic". This type of demonstration is not especially useful for allied health chemistry and will not be discussed further.

"Standard" demonstrations. This category includes the usual type of presentation generally thought of as a demonstration. Many excellent examples are collected from the Journal of Chemical Education in the book edited by Alyea and Dutton.[2] They can illustrate both physical and chemical principles relevant to allied health courses. For example, the "drinking bird" toy shows the greater tendency of alcohols to evaporate than water if the bird's cup is filled with an alcohol. This principle, of course, can then be related to alcohol rubs or the use of alcohols as solvents. A chemical example is the illustration of enzyme catalysis by decomposing peroxides with blood. Appendix A is a detailed list of mainly "standard" demonstrations taken primarily from the Alyea/Dutton book. The demonstrations are organized by topic for allied health chemistry courses, in contrast to Tested Demonstrations, in which related demonstrations are scattered throughout the book.

Examples and samples. This category consists of "real" things that are shown to or passed around the class. They may include an IV bottle whose label illustrates concentration units, Clinistix for measuring glucose, x-rays and organ scans, or biological specimens. A useful method for creating permanent mini-displays is the technique of embedments with polyester casting resin. Appendix B describes how such embedments may be prepared. Commercially available chemistry embedments[3] contain examples of elements, crystals, models of atomic and ionic size, and a comparison of solutions, colloids, and suspensions. These materials are easily passed around and handled without damage. Embedments that could be prepared oneself might include gallstones, examples of drugs, or vials containing Benedict's solution with varying concentrations of glucose.

Audiovisual materials. A wide variety of commercial materials are available for demonstration purposes. Examples of slides, filmstrips, 8 mm and 16 mm films are presented in a handy form by Rod O'Connor in Topics-Aids.[4] Photographs are often invaluable, such as the electron micrograph of a red blood cell trapped in the fibrin fibers of a blood clot[5] or the photo of a space-filling model of lysozyme that clearly shows the active-site cleft.[6]

Models. Simple ball-and-stick models are ideal for illustrating small organic and biological molecules like monosaccharides, especially if put together by the student. They immediately reveal the difference between two-dimensional structural formulas and the actual spatial configuration within the molecule. Although more complex molecules may be purchased or put together by the instructor, they do not provide the experience of model-building by the student.

Cut-outs and games. Activities can be designed that demonstrate various types of chemical processes. Cut-outs are available that illustrate chemical bonding and the synthesis of a tetrapeptide.[7] Games are also available, such as involving cards with formulas of ions; players eliminate cards from their hand by forming ionic compounds with a card shown from the deck.

Individual projects. Projects carried out by the student may be considered "personal" demonstrations. For example, the student may be requested to keep an accurate record of the approximate amounts of each type of food they eat in one 24-hour period. They may then be asked to determine their intake in calories, the relative amounts of carbohydrates, lipids, and proteins, and the quantity of vitamins ingested using literature values.[7] Such a project, which may be carried out in several stages as the course progresses, brings home abstract biochemical concepts.

The types of demonstrations described here range from activities performed excelusively by the instructor to those carried out individually by the student, with varying mixtures in between. They all share the common characteristic of helping reveal to the student a new way of looking at chemistry.

References

1. Philip S. Chen, Entertaining and Educational Chemical Demonstrations, Chemical Elements Publishing Company, Camarillo, California, 1974.

2. Hubert N. Alyea and Frederic B. Dutton (eds.), Tested Demonstrations in Chemistry, 6th ed., American Chemical Society, Easton, Pennsylvania, 1965.

3. Educational Modules, Inc., 1665 Buffalo Road, Rochester, NY 14624.

4. Rod O'Connor, Topics Aids: A Guide to Instructional Resources for General Chemistry, American Chemical Society, 1975.

5. David A. Ucko, Living Chemistry, Academic Press, New York, 1977, p. 359.

6. Ucko, p. 369.

7. David A. Ucko, Experiments for Living Chemistry, Academic Press, New York, 1977, experiments 3A and 20C.

APPENDIX A

Suggested Demonstrations

Note: Numbers in parentheses refer to pages in Tested Demonstrations in Chemistry (6th ed.).

Unit	Demonstration
1 - Matter and Measurement	States of Matter (13) Density (128, 155) Examples of measurement Decimeter cube (10 cm on edge)
2 - The Composition of Matter	Examples of elements - metals and nonmetals (5) Different forms of periodic table (123-124) Element bingo game ("Elemento")
3 - Chemical Bonding	Formulas (72) Reaction of Na and Cl_2(146, 201, 212) Ionic Reactions in slow motion (202) Chemical bingo game ("Chemgo")
4 - Compounds and Chemical Change	Mixtures vs compounds; electrolysis of H_2O (5) Fe + S / FeS (5), I_2 + Sb (53) Chemical Changes (5, 53-54) Energy transfer in reactions (17-18, 150, 154) Rates of reaction (19, 85) Reversibility of reactions (19-20, 86) Redox reactions (20, 87-89) Conservation of mass (54) Agovadro's number (71, 129, 197) Determination of molecular weight (72-74) Calorimetry (79) Separation of a mixture - tooth powder (170)
5 - Gases and Respiration	Preparations of O_2 (7, 55) Reactions of O_2 (7) Atmospheric pressure (23) Kinetic theory (63, 153, 160 204, 220) Gas laws (64-65, 128, 156, 195)

	Lung demonstration model (bell jar with 2 balloons on "Y" tube) Barometer 22.4 liter box (28.2 cm cube)
6 - Water	Water purification (11) Vapor pressure (11, 65, 180) Water of hydration (11) Properties of water (60,128) Motion in liquids (63) Boiling (66) Specific gravity (67) Surface tension (68, 69, 189) Oil of water (68) Heat of vaporization (69) Changes of state (79, 187) Ion exchange resin (87, 219) Hydrogen bonding (132, 143) Razor blade or needle floating on water Rise of water or blood in capillary tube
7 - Solutions	Colloids (13, 49-50, 113-115, 206) Tyndall effect (13, 169) Solubility (14, 67, 189, 211, 223) Conductivity (15, 75-76, 129, 148) Osmosis (16, 66, 136)
8 - Acids, bases and salts	Reactions of acids with metals (11) Indicators (11, 61, 147, 167) Titration (11, 62) Naturally-occurring acids (60) pH of solutions (62) Buffer action (62, 155) Reactions of acids and bases (128) Antacids (135) pH meter
9 - Nuclear Chemistry and Radiation	Radioactivity (21-22, 89-91) Photography (28, 83, 130, 141) Radioisotopes (131-132) Cloud chamber (sources - alpha: Po-210, beta Tl-204, gamma: Co-60
10 - Organic Chemistry - Hydrocarbons	Combustion of alkanes (47) Petroleum distillation (104) Aromatic compounds (112) Tars in cigarette smoke (178) Cis-trans isomers (190) Molecular models

11- Oxygen Derivatives of Hydrocarbons	Substitution products (47, 112) Oxygen in organic compounds (55) Comparison of alcohols (105) Reactions of alcohols (106) Idoform test (134)
12 - Other Organic Derivatives and Polymers	Reactions of amines (106) Reactivity of halides (106,112) Isolation of caffeine (107) Preparation of plastics (110) Nylon (111-112, 136, 164) Preparation of polymers (135, 157) Bromination of hexane (191)
13 - Carbohydrates	Fehling's test (28) Reactions of carbohydrates (48) Isolation of starch and cellulose (106) Fermentation (107, 120) Isolation of beet sugar (107) Preparation of cellophane (135--136) Optical rotation (224)
14 - Lipids	Hydrogenation of oils (59) Isolation of vegetable oil (106) Reactions of castor oil (107,110) Properties of detergents (108, 203) Soaps (110, 111)
15 - Proteins	"Permanent" hair wave (102) Denaturation (107) Kjeldahl determination (107-108) Amino acids (108) Chromatography of amino acids (119-120)
16 - Enzymes and Digestion	Catalysis of peroxide decomposition using blood (55) Enzymes in yeast (120) Enzyme catalysis (130)
17 - Energy and Carbohydrate Metabolism	Exothermic vs endothermic processes (17) Glucose tests
18 - Metabolism of Lipids	Ketone body tests in urine
19 - Metabolism of Proteins	Test for porphyrin in blood (108) Reversion of urea synthesis (152)
20 - Heredity and Protein Synthesis	Molecular model of DNA Protein synthesis model

21 - Vitamins and Hormones	Isolation of Vitamin C (108)
22 - Chemistry of the Body Fluids	Separation of milk (107) Blood test (108) Blood typing Blood clotting Commercial urine tests
23 - Drugs and Poisons	DDT (112) Analysis of medicines (135) Pollution test kits (Hach, LaMotte, etc.)

APPENDIX B

Embedment Procedure

The mold, consisting either of glass, metal, or wood, must be greased with margarine or paste wax on the inside. Mix enough resin, after preheating, if necessary, to form the base; about 5 to 10 drops of hardener (catalyst) are added per ounce of resin, less for thick pieces. Stir with a stick for about 30 seconds to remove bubbles, and pour the mixture into the mold. After it hardens, place the objects to be embedded into position on the base. Mix another batch of resin with hardener and pour on top, filling the corners and cavities.

Initial hardening requires 30 minutes or more (complete hardening may take a week or two). Place the mold on its side when hard and allow to cool before removing the embedment. Surface imperfections can be removed with sandpaper; use damp fine paper for the final sanding.

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1570 East Colorado Blvd
Pasadena, CA 91106

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3201 SW Trafficway
Kansas City, Missouri 64111

Phoenix College
1202 W. Thomas Rd
Phoenix, AZ 85013

Pikes Peak Comm. College
5675 S. Academy Blvd.
Colorado, Springs, CO 80906

Pima Co. Comm. College
Tuscon, AZ 85710

Polk Community College
999 Ave. H N.E.
Winter Haven, FL 33880

Prairie State College
Chicago Heights, IL 60411

Prince Georges Comm. College
301 Largo Rd.
Largo, MD 20870

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Ponce, Puerto Rico 00731

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9555 Plainfield Rd.
Cincinnati, OH 45236

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995 N. Reed Ave.
Reedley, CA 93654

Rhode Island Jr. College
400 East Ave.
Warwick, RI 02886

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4800 Magnolia Ave.
Riverside, CA 92506

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Harriman, TN 37748

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28000 Marguerite Pkwy
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17th @ Bristol
Santa Ana, CA 92706

Scottsdale Comm. College
9000 E. Chaparral Rd.
Scottsdale, AZ 85252

Seminole Jr. College
Box 351
Seminole, OK 74868

Skyline College
3300 Skyline Dr.
San Bruno, CA 94066

Sierra College
5000 Rocklin Rd.
Ricklin, CA 95677

Southern Arkansas Univ.
El Dorado Branch
El Dorado, AR 71730

Southerwestern College
900 Otay Lakes Rd.
Chula Vista, CA 92010

Spring Garden College
102 E. Mermaid Lane
Chestnut Hill, PA 19118

Tarrant Co. Comm. College
828 Harwood Rd.
Hurst, TX 76053

Three Rivers Comm. College
507 Vine St.
Poplar Bluff, MO 63901

Triton College
River Grove, IL 60171

Tulsa Jr. College
Tenth and Boston
Tulsa, OK 74119

Vincennes University
1002 N. First
Vincennes, Indiana 47591

Virginia Western Comm. College
3095 Colonial Ave SW
Roanoke, VA 24015

Washtenaw Comm. College
P.O. Box 345
Ann Arbor, MI 48107

Wesley College
College Square
Dover DE 19901

Westark Community College
P.O. Box 3649
Fort Smith, AR 72901

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Algonquin & Roselle Rds.
Palatine, IL 60067

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1100 E. Sheldon
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