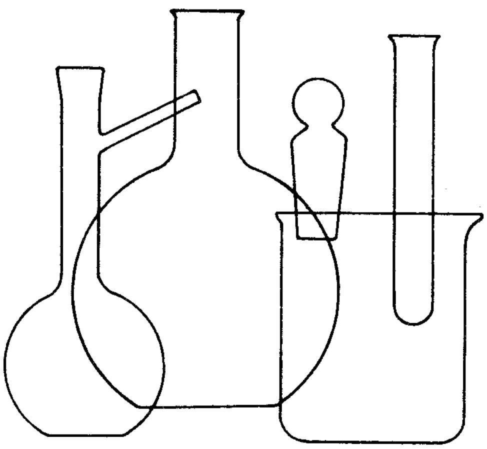


CHEMISTRY IN THE TWO-YEAR COLLEGE

VOLUME XIX, FALL 1979

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

Foreword

The Two-Year College Chemistry Conferences make invaluable contributions to chemical education in a number of ways. Visiting other campuses, meeting and exchanging ideas and experiences with colleagues from across the nation, learning from papers presented by talented speakers on a variety of topics particularly pertinent to the interests and needs of two year college chemistry teachers, having an opportunity to question and discuss papers in greater detail directly with the speakers, and having an opportunity to see exhibits and talk to exhibitors offers two-year college chemistry teachers unparalled opportunities for professional development.

All too often it is only the participants at conferences who have an opportunity to learn from the papers presented. Fortunately, the *Journal of Chemistry in the Two-Year Colleges* makes all papers presented at the conferences available to a much larger audience. So, the contributions of the conferences are not limited and short-lived, but, through the journal, extend far beyond the conferences and become a permanent source of professional growth for many.

The papers in this journal were presented at the 1977 and 1978 conferences. During 1977 Curt Dhonau was Chairman of $2YC_3$. Woodie Sink was program chairman for the New Orleans meeting held on Delgado Community College campus on Mar. 18 and 19. The fall meeting was chaired by Dean Elkins and held on the Vincennes University campus. Bill Cheek was program chairman of the Morrow Georgia meeting held on the Clayton Junior College campus on December 9 and 10. Bill Griffin was Chairman of $2YC_3$ in 1978 and the first meeting was held on the Santa Ana College campus. Douglas Bond was program chairman for the Santa Ana meeting.

John Mitchell
Chairman

Industrial Sponsors

Addison-Wesley
Jacob Way
Reading, MA 01845

Alltech Associates, Inc.
202 Campus Dr.
Arlington Heights, IL 60004

Allyn & Bacon, Inc.
470 Atlantic Ave.
Boston, MA 02210

Beckman Instruments, Inc.
Campus Dr. at Jamboree
Irvine, CA 92714

Burgess Publishing Co.
7108 Ohms Lane
Minneapolis, MN 55435

W. H. Freeman & Co.
660 Market St.
San Francisco, CA 94104

Gow-Mac Instrument Co.
P.O. Box 32
Bound Brook, NJ 08805

Harper & Row
10 East 53rd St.
New York, NY 10022

D. C. Heath & Co.
125 Spring St.
Lexington, MA 02173

Houghton Mifflin Co.
1 Beacon St.
Boston, MA 02107

Kontes
P.O. Box 729
Vineland, NJ 08356

Lab Aids, Inc.
130 Wilbur Place
Bohemia, NY 11716

McGraw-Hill Book Co.
8171 Redwood Highway
Novato, CA 94947

Perkin-Elmer Corp.
328 Eisenhower Lane
Lombard, IL 60148

P.P.C. Books
P.O. Box 1260
Tulsa, OK 74101

Prentice-Hall, Inc.
Sylvan Ave.
Englewood Clif, NJ 07632

Prentice-Hall Media, Inc.
150 White Plains Rd.
Tarrytown, NY 10591

Princeton Applied Research
P.O. Box 2565
Princeton, NJ 08540

Program-Media Associates
15612 Claretta Ave.
Norwalk, CA 90650

Reliance Glass Works, Inc.
17 Gateway Road
Bensenville, IL 60106

Sargent-Welch Scientific
35 Stern Ave.
Springfield, NJ 07091

W. B. Saunders Co.
W. Washington Square
Philadelphia, PA 19105

Scientific Products
1210 Waulegan Rd
McGaw Park, IL 60085

Scott Foresman & Co.
1900 E. Lake Ave.
Glenview, IL 60025

Serco, Inc.
P.O. Box 511
Deerfield, IL 60015

Spectrex
3594 Haven Ave.
Redwood City, CA 94063

Technicon Instruments Corp.
511 Benedict Ave.
Tarrytown, NY 10591

Tel-Atomic
180 W. Michigan Ave.
Harris Bldg. Suite 1207
Jackson, MI 49201

The Torsion Balance Co.
125 Ellsworth St.
Clifton, NJ 07012

D. Van Nostrand Co.
135 W. 50th St.
New York, NY 10020

Varian Associates
611 Hansen Way
Palo Alto, CA 94303

VWR Scientific Inc.
2335 E. University Drive
Phoenix, AZ 85034

Wadsworth Publishing Co.
10 Davis Dr.
Belmont, CA 94002

John Wiley & Sons
605 Third Ave.
New York, NY 10016

Willard Grant Press
20 Newbury St.
Boston, MA 02116

Wilmad Glass Co., Inc.
Buena, NJ 08310

College Sponsors

Aims Community College
P.O. Box 69
Greeley, Colorado 80631

Area Board of Vocational Tech
211 N. Carrol St.
Madison, WI 53703

Arizona West College
P.O. Box 929
Yuma, AZ 85364

Atlantic Community College
Black Horse Pike
Mays Landing, NJ 08330

Community College of Baltimore
2901 Liberty Heights Ave.
Baltimore, MD 21202

Brasosport College
500 College Drive
Lake Jackson, TX 77566

Brevard Community College
1519 Clearlake Rd.
Cocoa, FL 32922

Broward Community College
225 E. Las Olas Blvd.
Fort Lauderdale, FL 33301

Burlington County College
Pemberton-Browns Mill Rd.
Pemberton, NJ 08068

Canada College
4200 Farmhill Blvd.
Redwood City, CA 94061

Canton Ag & Tech College
Canton, NY 13617

Cedar Valley College
3030 N. Dallas
Lancaster, TX 75134

Centralia College
P.O. Box 639
Centralia, WA 98531

Charles County Comm. College
P.O. Box 910 Mitchell Road
La Plato, MD 20646

Chipola Jr. College
College Street
Marianna, FL 32446

Citrus College
18224 E. Foothill Blvd.
Azusa, CA 91702

Clackamas Community College
19600 S. Molalla Ave.
Oregon City, OR 97045

Clatsop Community College
16th & Jerome St.
Astoria, OR 97103

Colorado Mt. College West
P.O. Box 1367
Glenwood Spring, CO 81601

Corning Community College
87 E. Third St.
Corning, NY 14830

Cuesta College
Box J
San Luis Obispo, CA 93406

Cuyahoga Community College West
11000 Pleasant Valley Rd.
Parma, OH 44111

Dawson College
Box 421
Glendive, MT 59330

Del Tech and Community College
P.O. Box 610
Georgetown, DE 19947

Denmark Tech Ed. Center
P.O. Box 327
Denmark, SC 29042

Des Moines Area Community College
2006 Ankeny Blvd.
Ankeny, IA 50021

Dodge City Community College
Dodge City, KS 67801

El Camino College
16007 Crenshaw Blvd.
Via Torrance, CA 90506

El Centro College
Main & Lamar
Dallas, TX 75202

Elgin Community College
1700 Spartan Drive
Elgin, IL 60120

Erie Community College
4140 Southwestern Blvd.
Orchard Park, NY 14127

Essex Community College
7201 Rossville Blvd.
Baltimore MD 21237

Foothill College
12345 El Monte Road
Los Altos Hills, CA 94022

Gainesville Jr. College
Gainesville, GA 30501

Garden City Community College
Box 977
Garden City, KS 67846

Gloucester County College
Deptford, NJ 08080

Golden West College
15744 Golden West Street
Huntington Beach, CA 92647

Grand Rapids Jr. College
143 Bostwich St.
Grand Rapids, MI 49502

Green River Community College
12401 S. E. 320th St.
Auburn, WA 98002

Hagerstown Junior College
751 Robinwood Dr.
Hagerstown, MD 21740

Harford Community College
401 Thomas Run Rd
Bel Air, MD 21014

Hartnell College
156 Homestead
Salinas, CA 93910

Holyoke Community College
303 Homestead Ave.
Holyoke, MA 01040

Jackson Community College
2111 Emmons Road
Jackson, Michigan 14701

Jones County Junior College
Ellisville, Mississippi 39437

Kettering College of Med Art
3737 S. Blvd.
Kettering, OH 45429

Keystone Junior College
La Plume, PA 18443

Kishwaukee College
Malta, IL 60150

College of Lake County
19351 W. Washington St.
Grayslake, IL 60030

Laramie County Community College
1400 E. College Drive
Cheyenne, WY 82001

Lewis & Clark Community College
Godfrey Rd.
Godfrey, IL 62035

Linn-Benton Community College
6500 SW Pacific Blvd.
Albany, Oregon 97321

Madison Area Tech College
211 N. Carroll St.
Madison, Wisconsin 53703

Manatee Junior College
P.O. Box 1849
Bradenton, FL 33506

Prairie State College
Chicago Heights, IL 60411

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

Catholic University of Puerto Rico
Ponce, Puerto Rico 00731

Raymond Walters College
9555 Plainfield Rd.
Cincinnati, OH 45236

Reedley College
995 N. Reed Ave.
Reedley, CA 93654

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

Riverside City College
4800 Magnolia Ave.
Rive-side, CA 92506

Roanne State Community College
Harriman, TN 37748

St. Marys College
200 N. Main
O'Fallon MO 63366

St. Petersburg Jr. College
6700 7th Ave. North
St. Petersburg, FL 33710

Santa Ana College
17th Street at Bristol
Santa Ana, CA 92706

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

Seminole Jr. College
Box 351
Seminole, OK 74868

Skyline College
3300 Skyline Drive
San Bruno, CA 94066

Sierra College
5000 Rocklin Rd.
Rocklin, CA 95677

Southern Arkansas University
El Dorado Branch
El Dorado, AR 71730

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

Sweetwater Community College
900 Otay Lakes Rd.
Chula Vista, CA 92010

Tarrant County Community College
828 Harwood Rd.
Hurst, TX 76053

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

Triton College
2000 Fifth Ave.
River Grove, IL 60171

Tulsa Junior College
Tenth and Boston
Tulsa, OK 74119

Vincennes University
1002 N. First
Vincennes, IN 45791

Virginia Western Community College
3095 Colonial Ave SW
Roanoke, VA 24015

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

Wesley College
College Square
Dover, DE 19901

COLLEGE SPONSORS (con'd.)

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

Will Rainey Harp College
Algonquin & Roselle Rds.
Palatine, IL 60067

Yavapai College
1100 E. Sheldon
Prescott, AZ 86301

Marin Community College District
San Rafael, CA 94902

McHenry County College
Crystal Lake, IL 60014

Mesa Community College
1833 W. Southern Ave.
Mesa, AZ 85201

Miami Dade Community College
North
11380 N. W. 27th Ave.
Miami, FL 33167

Miami-Dade Community College
South
11011 S. W. 104th St.
Miami, FL 33176

Middle Georgia College
3rd Street
Cochran, GA 31014

Midlands Technical College
P.O. Drawer Q
Columbia SC 29250

Mohegan Community College
Mahan Drive
Norwich, CT 06360

Monroe Community College
1000 E. Henrietta Rd.
Rochester, NY 14623

Mountain View College
4849 W. Illinois Ave.
Dallas, TX 75211

Nash Technical Institution
R. 5 Box 255
Rocky Mount, NC 27801

Nashville State Technical Inst.
120 White Bridge Rd.
Nashville, TN 37209

New Mexico State University-
Alamogordo
North Scenic Dr. Box 477
Alamogordo, NM 88310

New Mexico University - Carlsbad
2900 W. Church St.
Carlsbad, NM 88220

New York City Community College
300 Jay St.
Brooklyn, NY 11201

Normandale Community College
9700 France Ave. S
Bloomington, MN 55431

North Idaho College
1000 W. Garden Ave.
Coeur D Alene, ID 83814

North Shore Community College
3 Essex Street
Beverly, Mass. 01915

Norwalk Community College
333 Wilson Ave.
Norwalk, CT 06854

Oakland Community College
Bloomfield Hills, MI 48013

Oakton Community College
7900 North Nagle
Morton Grove, IL 60053

Olympic College
16th and Chester
Bremerton, WA 98310

Pasadena City College
1570 East Colorado Blve.
Pasadena, CA 91106

Penn Valley Community College
3201 SW Trafficway
Kansas City, Missouri 64111

Phoenix College
1202 W. Thomas Rd.
Phoenix, AZ 85013

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

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

TABLE OF CONTENTS

APPROACHES TO TEACHING CHEMISTRY

USE OF THE COMPUTER IN CHEMICAL EDUCATION

Computer In Chemistry

John W. Moore
Eastern Michigan University
Ypsilanti, MI 48197

Presented to the Fifty-Sixth, Two Year College Chemistry Conference, Vincennes University, Vincennes, Indiana, October 7, 1977.

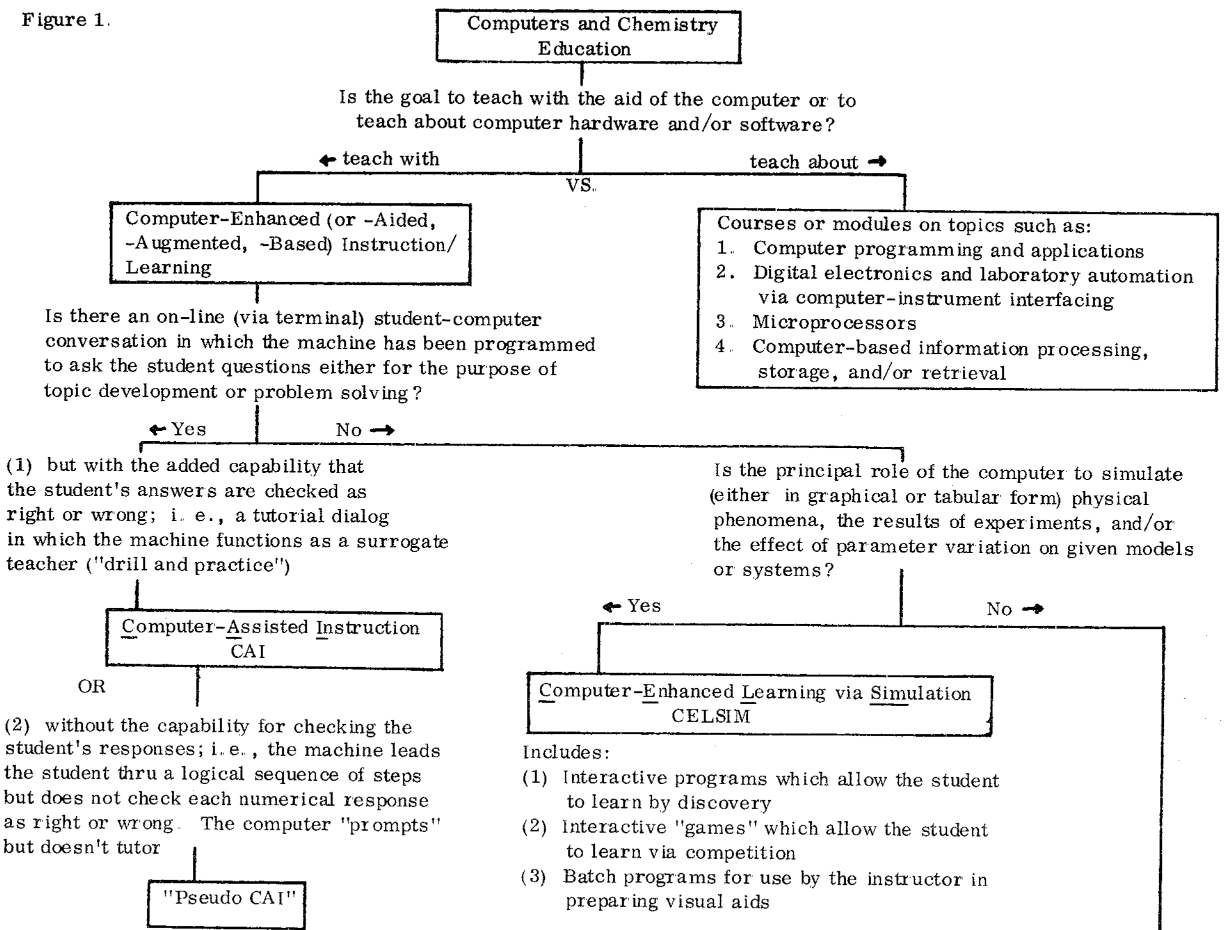
In writing and presenting this paper I find myself playing a dual role. On the one hand, as chairman of the Committee on the Role of Computers in Chemical Education of the ACS Division of Chemical Education, I am concerned with all types of computer applications in chemistry. On the other hand, as a college teacher who has found the computer to be a very useful pedagogical tool, I have specific personal experience and a considerable store of materials which may be useful to specific persons in the audience. In the time and space available I shall try to provide you with as much useful information as I can, pursuant to each of these two roles.

ACS-CHED-CRCCE

The ACS-CHED Committee on the Role of Computers in Chemical Education was founded five years ago when Bob Parry (who was chairman of the Division of Chemical Education) appointed Ron Collins of Eastern Michigan University to suggest members and chair the committee. The committee was (and still is) primarily concerned with making available to chemical educators information and curricular materials relating to the many uses of computers in chemical education. In support of this goal the CRCCE publishes a bimonthly newsletter (available free of charge to members of CHED), sponsors numerous national and regional workshops on computers in chemical education (there will be one at the Joint Great Lakes and Central Regional ACS Meeting in Indianapolis next May), and maintains a membership which includes first-hand expertise on all aspects of computer applications in chemical education. As an appendix to this paper I have attached a list of CRCCE subcommittees and their activities as well as a roster of CRCCE members' names and addresses. Persons who are interested in specific applications of computers in chemical education are welcome to contact me as committee chairman or any of the subcommittee chairmen with requests for information. New members are appointed to CRCCE each year, and any persons who might be interested in working on the committee are also urged to contact me.

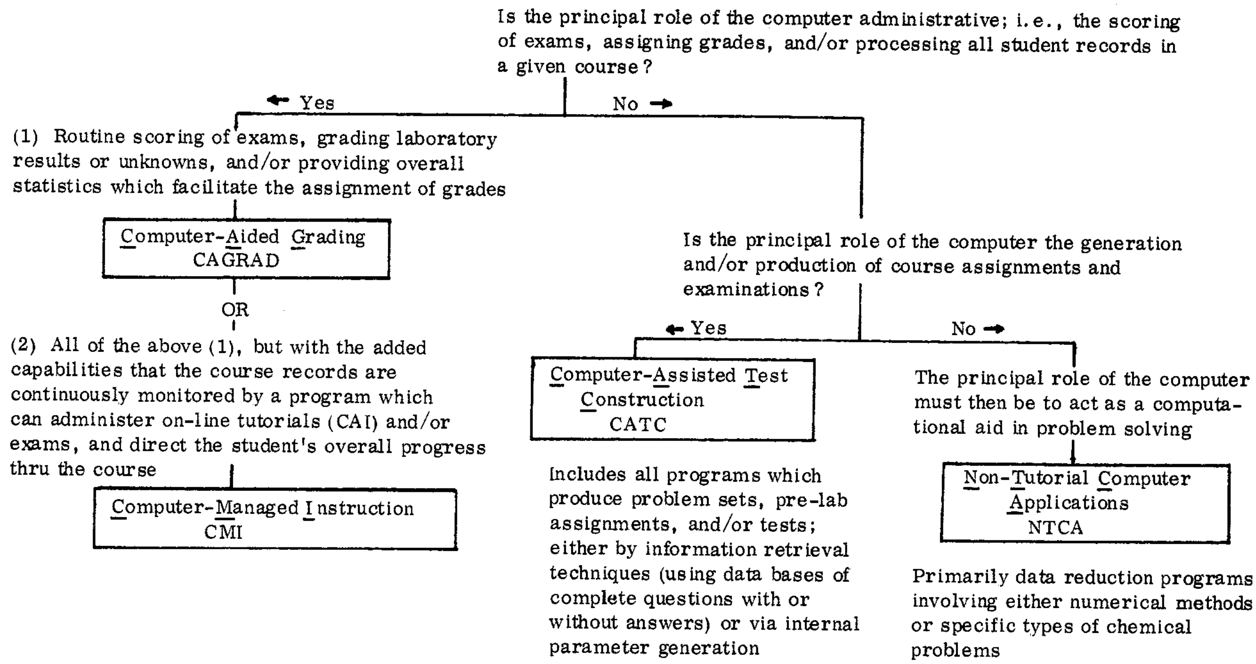
One major result of CRCCE's efforts has been to classify the many different aspects of computer involvement in chemical education. Our current solution to this classification problem is shown in Figure 1. The first division in the flow chart reflects a duality of roles that the computer can play in the classroom. The computer is an important tool or instrument which modern chemists (and many other persons as well) must learn to use if their education is to prepare them adequately. At the same time the computer provides a medium for teaching nearly all aspects of chemistry (not just those related to the computer as instrument). The flowchart in Figure 1 concentrates on this second aspect of computer usage, showing four more major divisions. Stan Smith, whose paper will follow mine, will demonstrate the state of the art in Computer-Assisted Instruction (CAI), and I will concentrate on the other aspects of computers as instructional tools, since that is where my personal experience lies.

Figure 1.



(Continued)

Figure 1 (Continued)



Simulation and Graphics

There are a variety of reasons for using a computer to simulate a physical or chemical system instead of having students investigate the system experimentally. Some of them are: time, cost, scope of system to be investigated, danger, theory better than experiment. The first two of these constraints would apply, for example to qualitative analysis, and a few years ago almost everybody in educational computing was doing simulations of inorganic or organic qual schemes.

The third and fourth constraints apply to environmental problems (and to many other chemical problems as well). In the process of teaching a course and writing a textbook titled Environmental Chemistry (Academic Press, New York, 1976), I have collected a number of examples of simulations of air pollution (see Barry J. Huebert, J. Chem. Educ., 51, 644(1974), water pollution, and environmental degradation in general. Many of these involve a methodology called Systems Dynamics which was developed at MIT by Jay W. Forrester and has been applied by the Club of Rome in their best-selling study of world environmental problems, The Limits to Growth (Universe Books, New York, 1972). I have neither time nor space to discuss Systems Dynamics or the computer language, DYNAMO, in which Systems Dynamics simulations may be implemented. However, a version of DYNAMO which will run on minicomputers is available from Dr. William Davisson of the University of Notre Dame, Department of Economics, making Systems Dynamics available to a much wider audience. Use of the same system for simulating chemical kinetics has been described by CRCCE member Jay Martin Anderson in J. Chem. Educ., **53**, 561 (1976).

Turning now to the last of my reasons for using simulation, we come to atomic and molecular electronic structure, where indeed quantum mechanical theory can be better than experiment, at least for small molecules and certain properties. Certainly there are few experiments which can actually give us a picture of what an atom looks like, and the pictures that have been obtained from high-powered electron microscopes give far fewer details than does quantum mechanics. Furthermore, it is not an easy task for a teacher to use mathematical wave functions, radial distribution functions, sines and cosines, electron screening, and other quantum mechanical jargon to explain to students the rules of atomic and eventually molecular structure.

In an attempt to solve this pedagogical problem, Bill Davies and I at Eastern Michigan combined the techniques of computer simulation and computer graphics. Using a Monte Carlo method we represent electron density in a planar slice through an atom or molecule by means of the density of dots on a planar sheet of paper. The dots are drawn by a Calcomp plotter attached to the computer, and the computer is programmed to use recent, highly accurate, self-consistent field atomic and molecular wavefunctions to calculate the electron density function, ψ^2. The algorithm governing the calculation is:

1. Choose an appropriate planar slice through the atom or molecule.

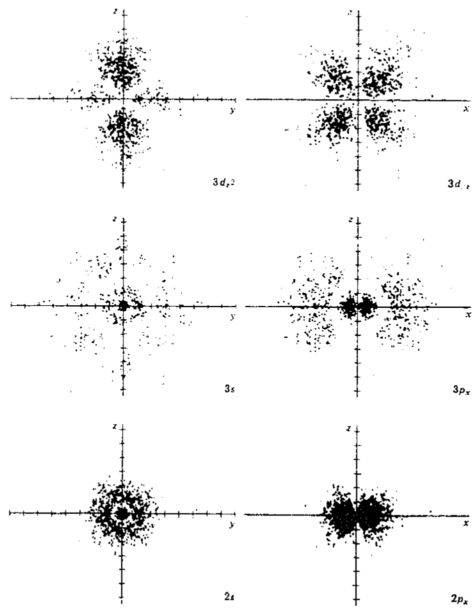
2. Use random numbers to select appropriate x and y coordinate values within that plane.

3. Evaluate the wavefunction, ψ, at the selected point in a 3-d space.

4. Plot a dot if and only if ψ^2 exceeds an appropriately scaled random number.

5. Iterate steps 2 through 4 until enough dots have been plotted.

Step 4 is the most important. Here the calculated ψ^2 is compared with a random number between zero and the maximum possible value of ψ^2, and a dot is plotted only if ψ^2 exceeds the random number. Thus an element of chance is introduced into the diagram--the probability of plotting a dot is proportional to ψ^2, but there is no guarantee that a dot will be plotted except when $\psi^2 = \psi^2_{max}$. The diagrams produced in this way are in conformity with the uncertainty principle and the idea of a distribution of electron probability density in the vicinity of an atomic nucleus. An example is shown in Figure 2.



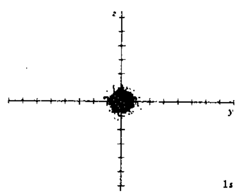


Figure 2 Dot-density diagrams of electron clouds for the 1*s* 2*s*, 2*p*, 3*s*, 3*p*, and 3*d* orbitals of a hydrogen atom (computer-generated) Note carefully the labeling of the axes. Markers along the *y* and *z* axes are at intervals of 200 pm (2.00 Å). A three-dimensional view of each electron cloud is given by the boundary-surface diagrams of Fig 3 (*Copyright © 1975 by W G Davies and J W Moore*)

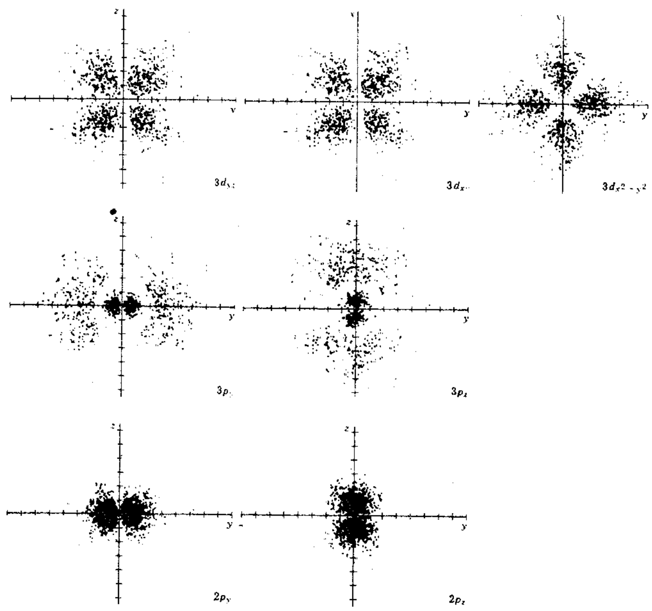


Figure 2 (continued). Copyright © 1975 by W. G. Davies and J. W. Moore.

Computer programs for producing electron dot-density diagrams are available at Eastern Michign University, and we are happy to send them to anyone who asks for them. However, since the programs involve large data files on disk storage and plotter sub-routines unique to our DEC system-10, they are relatively hard to transport to other computers. Moreover, the diagrams are most conveniently used in the classroom as over-ly overhead transparencies. In this format each electron cloud of a multi-electron atom and be color-coded and the total electron density can be built up by overlaying one electron cloud on another. The Aufbau principle can thus be shown very clearly. The relative sizes of electron clouds are also immediately apparent to students, permitting readily understandable presentations of the shell structure of the atom, atomic sizes, and relative ionization energies. More complex quantum mechanical results can also be illustrated (see J.Chem. Educ., 53, 426 (1976)), but time and space do not permit their description here. To provide wider dissemination of these overlay overhead transparencies, Dr. Davies and I have arranged for their publication by Science Related Materials, Inc. of Janesville, Wisconsin. Two sets, Introduction to Atomic Structure and Essentials of Bonding, are available.

Dot-density diagrams are very realistic in illustrating the probabilistic nature of the behavior of electrons in atoms, but they do not provide a three-dimensional picture of orbital shapes. To serve this latter function, Dr. Davies and I turned to boundary surface diagrams of the type shown in Figure 3. In such diagrams the computer draws a surface which encloses a certain percentage, say 75% or 90% of the electron density of an atom or molecule. Although boundary surface diagrams imply (incorrectly) that an electron density distribution has a boundary, they provide a three-dimensional aspect which nicely complements the probabilistic picture provided by dot-density diagrams.

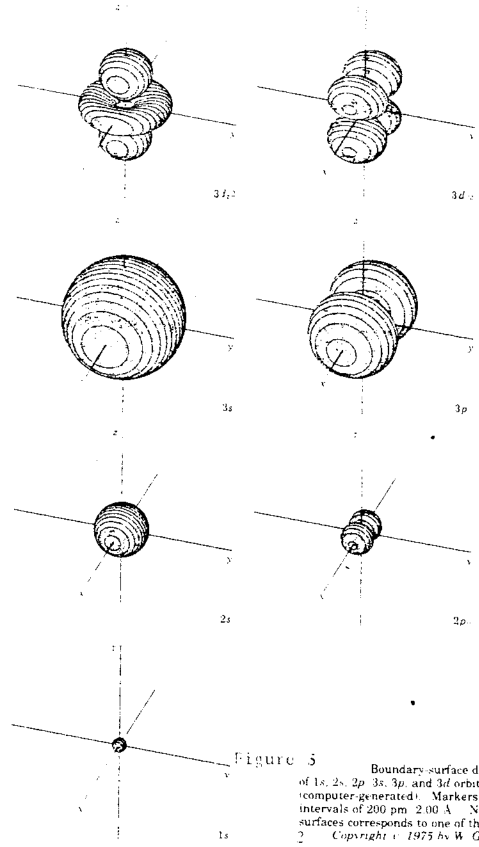


Figure 3 Boundary-surface diagrams for electron densities of 1*s*, 2*s*, 2*p* 3*s*, 3*p*, and 3*d* orbitals of a hydrogen atom (computer-generated). Markers along the *y* and *z* axes are at intervals of 200 pm 2.00 Å. Note that each of these boundary surfaces corresponds to one of the dot-density diagrams in Fig 2. *Copyright © 1975 by W. G. Davies and J. W. Moore*

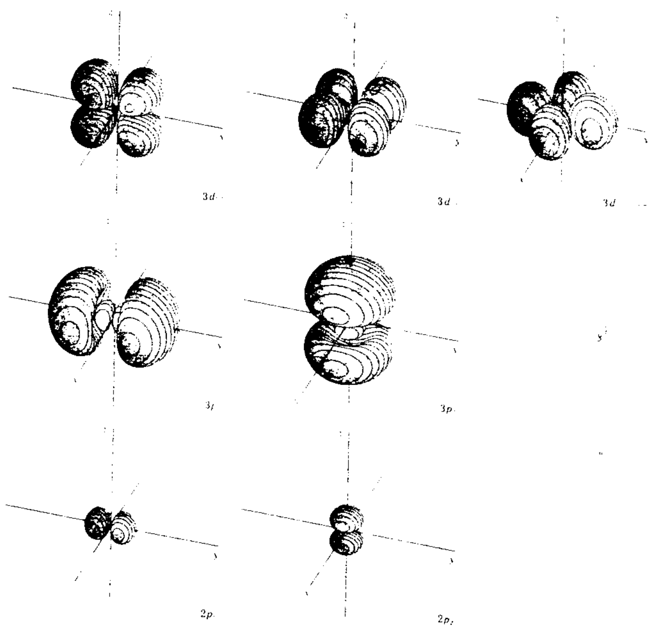


Figure 3 (continued). Copyright © 1975 by W. G. Davies and J. W. Moore.

Having solved the computer problem of eliminating lines from our drawings which should be hidden from view by three-dimensional boundary surfaces, Dr. Davies and I decided that it would be well worthwhile to adapt our computer programs to draw ball-and-stick molecular structures. This was particularly true since we were entering into a contract with the McGraw-Hill Book Company to author a general chemistry textbook. We felt that having a computer draw molecular structures directly from x-ray crystallographic data giving atomic coordinates would yield far more accurate diagrams than would having a human artist draw them. An example of the results we obtained is shown in Figure 4.

This shows the structure of ice in a side view, rather than the more usual view from the top. The channels of empty space which are a result of the ridig, hydrogen-bonded structure are quite apparent. Note that the computer shows perspective and eliminates hidden lines, giving a very effective three-dimensionality without using stereo pairs.

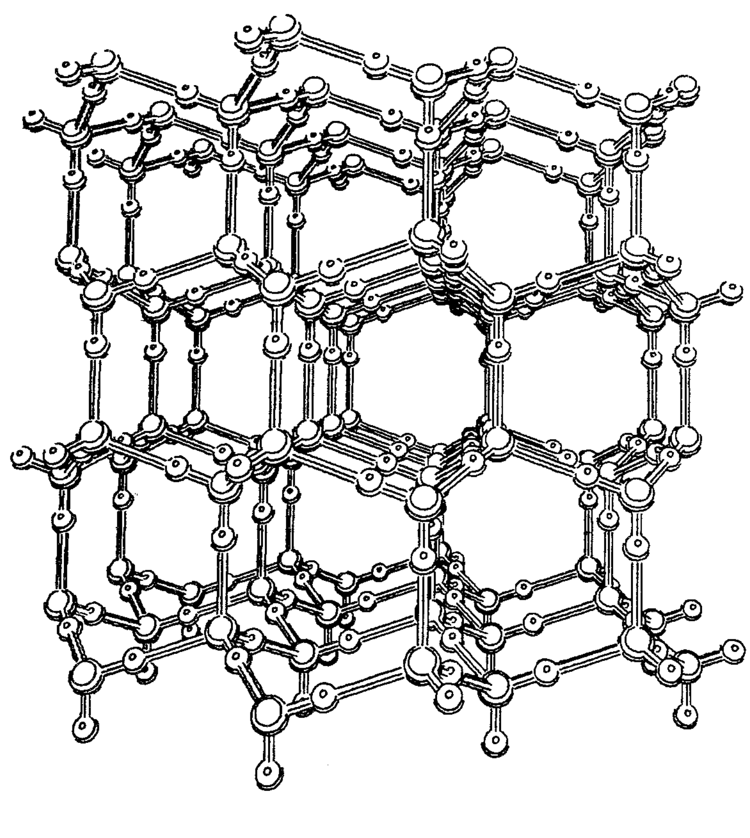


Figure 4. Ball-and-stick, structural model of ice. Copyright © 1976 by W. G. Davies and J. W. Moore.

Both my coauthors and I feel that computer-generated illustrations such as this one are important pedagogical tools in our textbook. We hope that student and faculty users will agree after the book is published in February 1978.

Turning from simulation and graphics to the perhaps more mundane topic of evaluating student progress, there are a number of computer applications listed toward the end of the computers and chemistry education flowchart (Figure 1) which apply to testing. My experience in this area has been mainly with computer-assisted test construction (CATC), especially with the idea of computer-generated repeatable tests (CGRT). In any CATC system the computer is provided with a source of questions from which it can generate a test by random selection. If a sufficiently large number of questions is available, the random selection procedure can generate a large number of unique but nearly equivalent tests, each of which evaluates the student over the same objectives.

Since the tests are unique, the same student can take more than one of them without being asked the same question twice. This is especially valuable in mastery learning situations such as the Keller plan, because a student can repeat tests over the same material until mastery at a pre-specified level is achieved. Computer-generated tests may also be used to replace ordinary quizzes or tests, as pre-lab quizzes, as individualized homework assignments, as make-up exams, and as diagnostic and/or remedial tools. Computer-generated gests are especially valuable for teaching material at lower cognitive levels where rote learning and drill and practice are essential. The factor or repeatability allows a student to find out what has not been learned, study it, and come back later to try again.

The CTRT system currently in use at Eastern Michigan University consists of three computer programs and a data base of some 7500 test questions. The questions are divided into groups called sets, each set containing questions of similar form and/or which test for similar objectives. Using program REQUEST a user of the system can select from a master magnetic tape those sets of questions needed to construct a test. Unwanted questions within a set can be edited out. Then program BUILDR constructs the desired number of tests by selecting a set and selecting from that set a question. When this first question has been printed on the first test BUILDR selects a different set and from it a question. This question is printed, another is selected, and so on, until the desired number one. BUILDR then proceeds to test number two and continues until the desired number of tests has been constructed. Both the order of sets and the selection of questions from each set on a test are governed by random numbers, making each test unique. The test questions and the correct answers are printed in a convenient format so that they can be separated before the questions are given to students. The answer key can be used by the instructor for hand grading or it can be given to the student to to provide immediate feedback at the end of the test. If multiple-choice or other questions which permit a single character response are used and machine-readable answer forms are provided, tests can be graded by program GRADER. The result is a complete roster of student scores which can be used for computer-managed instruction.

Programs and test questions for the Eastern Michigan University CGRT system are available on 9-track magnetic tape in E BCDIC, 80 character records, 800 character blocks, odd parity, unlabeled. (If you do not understand this computer jargon, fear not--it is really intended for computer center staff.) There is a charge of $15 for postage and handling of the computer tape. If you want a copy of the CGRT system, please send me your blank tape, allow about a month, and I will return it with the programs and questions. The program BUILDR requires 15 to 20 k 36-bit words of core memory to run normally, although it can be modified to run on less. The other programs have considerably smaller core requirements. If you are undecided about whether you can use the system, write to me for more details. In particular you may want a list of all question sets so that you can see what subjects are covered. Right now they are mainly in general chemistry.

Summary

I have attempted to do two things in this paper. First, as chairman of the ACS-CHED Committee on the Role of Computers in Chemical Education, I have given a brief overview of the many ways that chemical educators are using computers in instruction. Second, as a chemical educator who has made extensive use of computers in a variety of areas, I have related some of the specific things that I have done with computers. I hope that each of these approaches has provided you with useful information and with some incentive to initiate or to expand the use of computers in the chemistry classroom and laboratory.

Individualized Instruction. The Use of Computers in the Teaching of Chemistry

Stanley Smith
Carolynn Moore
University of Illinois
Urbana, Illinois 61801

Presented to the Fifty-Sixth, Two Year College Chemistry Conference, Vincennes University, Vincennes, Indiana, October 7, 1977.

Individualized, self-paced instruction which is responsive to the needs of each student can be provided by the use of the PLATO computer-based teaching system.[1] The PLATO system is used as a required part of the chemistry courses for about

1,000 students per semester at the University of Illinois in courses ranging from introductory general chemistry through graduate level organic chemistry.

Students gain access to the PLATO system by typing their name on a keyset which closely resembles a standard typewriter, the name of their course, and a unique password made up by the student. The instructor specifies the work which is to be done by the students by selecting programs by descriptive title from a catalog of lessons. Usually programs are selected for the entire class; however, the instructor can specify a different course of study for each student.

Lesson material is displayed on a screen which is 22 cm square and may consist of text, drawings, graphs, and color photographs.

The instructional material is written in a variety of styles which includes tutorial dialogs between the computer and the student, animations of reaction mechanisms, simulated experiments, open-ended multistep synthesis problems, drills and chemical games[2,3]. The programs are used to reinforce concepts developed in the lecture and to extend the objectives of the traditional course through simulated experiments and tutorial dialogs. In addition, PLATO programs are used to provide pre-laboratory instruction which can include simulations so that the student can practice key features of the experiment before going to the laboratory.

Some of these features are illustrated in Figures 1-4, which are abstracted from a lesson which introduces students to some of the properties of an ideal gas. This lesson requires about an hour to complete. The lesson index, Figure 1, gives students easy access to any section of the material. In section 3, the student explores the relationship between volume and pressure at constant temperature with a simulated experiment, Figure 2, in which the student must adjust the volume of the gas and record the pressure at constant temperature.

INDEX: Properties of Ideal Gases

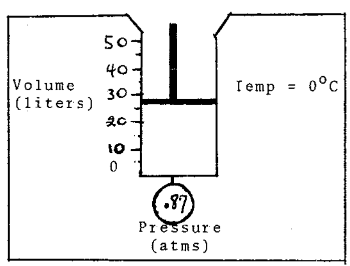
Press the number corresponding to the topic you wish to see.

1. Introduction
2. Pressure Measurement
3. Pressure-Volume Relationships*
4. Pressure-Temperature*
5. Volume-Temperature*
6. Ideal Gas Laws*
7. Review Problems*

Press SHIFT-DATA to return to this index
SHIFT-STOP when you are ready to leave
Sections marked* are required for credit.

Fig. 1. Index to lesson on ideal gases.

Adjust the volume by moving the piston (↓,↑).
Press DATA to record a pressure and volume.
What is the volume?



V(liters)	P(atm)
11.0	2.00

Fig. 2. Part of a simulated experiment in a lesson on ideal gases. The student moves the piston and records pressure-volume data.

After plotting the data by touching the screen the computer engages the student in a dialog about the relationship between pressure and volume, Fig. 3.

Here is a summary of the experiments you did

	Exp	P (atm)	V (liters)
	1	2.00	11
	2	0.87	26
	3	0.51	43
Plot	4	0.49	46

In this plot, as P increases does V increase or decrease?

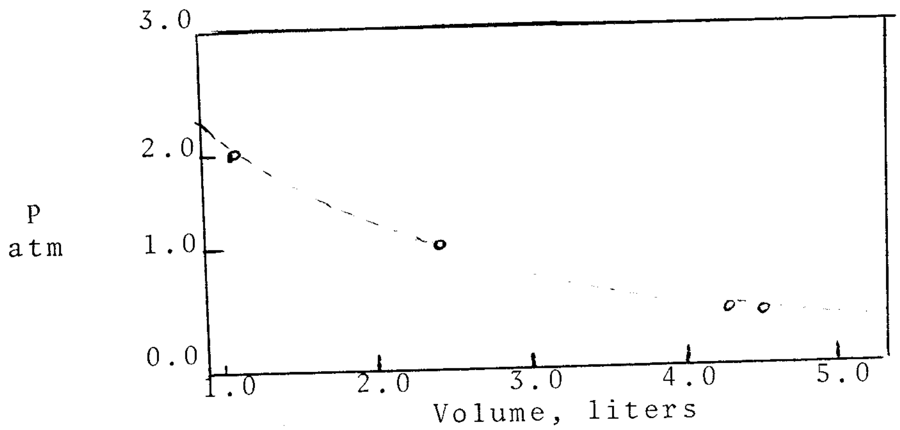


Fig. 3. Plot of pressure vs. volume from the student's experiment.

In subsequent sections of the program, the ideal gas law is derived from data obtained by the student in simulated experiments. Practice in rearranging the ideal gas law, Fig. 4, is also provided along with numerical problems.

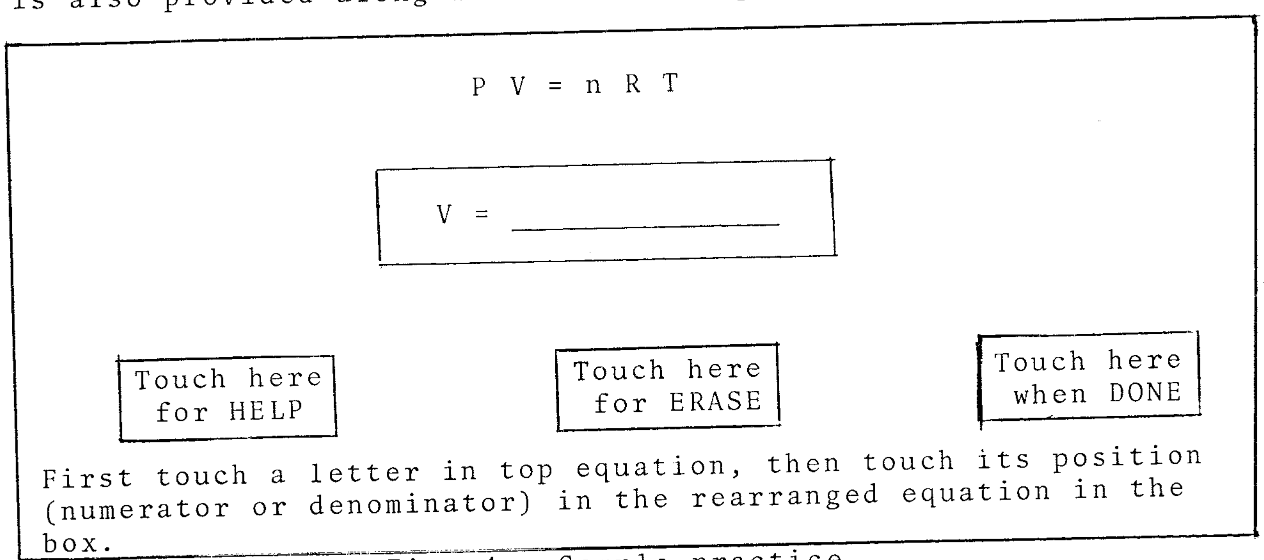


Fig. 4. Sample practice gas law problem.

Other PLATO lessons used in a general chemistry course cover basic theoretical principles and provide individualized help on topics such as the metric system, scientific notation, nomenclature, atomic structure, ionic and covalent bonding, chemical formulas, balancing equations, stoichiometry, chemical equilibrium, percent composition, and reactivity of halogens.

In the first semester organic chemistry course, PLATO lessons are available for each major topic in the course. The programs are used as assigned homework and students receive credit for completing the lessons.

Student acceptance of this approach to teaching has been very good. In a survey of 340 students in a general chemistry class, over 94% felt that PLATO should continue to be used. In general, PLATO receives higher student ratings than lectures, the textbook, or personal tutors.

REFERENCES

1. Stanley Smith and Bruce Sherwood, "Educational Uses of the PLATO Computer System., SCIENCE, 192, 344(1976)

2. Ruth Chabay and Stanley Smith, "The Use of Computer-Based Chemistry Lessons: An Individualized Component of Large Lecture Courses", J. Chem. Ed., IN PRESS (1977)

3. Stanley Smith and Ruth Chabay, "Computer Games in Chemistry", J. Chem. Ed., IN PRESS (1977)

Use of Computer Banks of Questions for Generalizing General Chem. Exams

J. W. Viers
Virginia Polytechnic Institute and State University
Blacksburg, Virginia 24061

Presented to a session on Computer Assisted Programs at the Fifty-Third, Two-Year College Chemistry Conference, Delgado Community College, New Orleans, Louisiana, March 18, 1977.

The task of preparing multiple choice exams in which similar, and frequently exact, questions are repeated from year to year is a familiar one to most chemistry instructors. The clerical tasks or retyping the questions and of proof reading to detect errors which must be done each time a question is used can be eliminated by use of a data bank of questions which are stored on a peripheral device and retrieved by use of a computer.

VPI & SU has about 2500-3000 general chemistry students each quarter who are taught in 15 sections by a total of about 20 instructors throughout the course of a year. We have combined examination questions from each of these instructors ahd nave generated a data bank of approximately 1200 unique questions for our general chemistry course, covering all of the traditional areas of general chemistry. An effort has been made to be sure that the format of the questions conform to the format encountered in most introductory textbooks, i.e. upper case-lower case letters are used, chemical formulas using superscripts and subscripts in the normal textbook notation, etc. We have also made an effort to have the questions completely self-contained so that no additional pieces of information such as tables, etc., are needed by the student taking an exam.

Some of the advantages we have found, in addition to relieving the clerical work once a data bank is established, are:

1. Ambiguous wording in questions, which are frequently found by the student as the instructor goes over the exam, can be noted and changes made in the working so that the ambiquity is not repeated the next time the question is used.

2. Each question can be graded as to level of difficulty based on student response. It is then very convenient to make up multiple exams of approximately the same level of difficulty for use in PSI programs requiring such tests.

3. Scrambled versions of the exam can be easily generated for use in crowded classrooms where it is difficult to separate the students or to proctor effectively.

4. For courses with multiple sections, it is possible to standardize to some extent the difficulty of exams among the sections, since all instructors would typically use the same data base for preparing exams.

The disadvantages of using these types of exams are:

1. There is a large amount of effort required to generate the initial data base. Anyone envisioning using such a system would do well to start with a selection of questions which have already been entered onto a computer and stored on cards or magnetic tape, as a starting point.

2. It is necessary to continually update the data base since one is never satisfied with using the same questions over a period of years. However, the updating is usually gradual and does not require a major effort.

In conclusion, we have found use of the computer for generating multiple choice exams to be valuable and time-saving. Our bank of 1200 questions have been used successfully for two years and is easily transferable to other schools which have access to a computer with a peripheral storage device such as tape drives or disk drives. We would be very interested in trading data banks with other people who have used this approach and would be happy to make our data bank available to anyone who would be interested in initiating such a program.

Computer Assisted Testing in Allied Health Chemistry Taught with Mastery Units

Ethelreda Laughlin
J. Guy Laughlin
Cuyahoga Community College, Western Campus
Parma, Ohio 44130

Presented to a session on Computer Assisted Programs at the Fifty-Third, Two-Year College Chemistry Conference, Delgado Community College, New Orleans, Louisiana, March 18, 1977.

During the winter quarter of 1977, for the first time at Cuyahoga Community College, a chemistry course was taught using mastery learning units. The course was a short Organic Chemistry-Biochemistry that is offered primarily for nursing students working toward the baccalaureate degree.

The format followed was mainly that of the Personalized System of Instruction (PSI) of Georgetown University with necessary modifications for a two-year college. The course material is divided into small units that the student learns at his own pace. He is tested on a unit after completion of the material and must achieve a grade of B or better to go on to the next unit. There is no penalty for taking the test a second or a third time.

Each unit begins with an introduction, usually a case history. For example, the unit on vitamins and enzymes begins with this story:

> Two fraternity houses had a common food service. With the cooperation of the students, one group was served the usual fare, the other was given a diet deficient in Vitamin B_1 for a period of one month. Only the directors of the study and the dietician knew which was the test group.
>
> The house given the test diet had been made up of a harmonious group. On the test diet, the men became argumentative, generally disagreeable, and very irritable. With reinstatement of an adequate vitamin B_1 diet, good dispositions returned and harmony was restored at the fraternity house.

The introduction is followed by a list of five to ten objectives for the unit. These are stated as behavioral objectives. One, for example, in the unit on proteins states: Given a test for a protein, describe how the test is performed and what a positive test indicates.

The material in the unit is presented so that each of the objectives is met. There is a self-study test for the student and answers are given at the end of each unit.

Two classes used the mastery units during the winter quarter. There were twenty-five in a day class and seventeen in the evening section. Since the students worked at their own pace, they were ready for testing at different times. The students met at regularly scheduled times just as if a traditional lecture were to be held. Morale was high and the course was popular.

Enrollment is usually heaviest during the fall quarter. How can one teacher manage seventy-two students in a PSI program? when testing goes on continuously?

The great drawback to the PSI system is a logistical one: tests must be prepared, administered, graded and recorded for each student on demand. No two tests can be identical (to prevent cheating), yet all tests for a given module must be reliable and uniform in difficulty. The obvious solution is to automate the testing process. The following description is a tentative design for an automated testing system (hereafter referred to as ATS) to fulfill the testing requirements of a modularized course in introductory allied health chemistry.

Since students will be requesting exams on demand, the file of questions must be ready for access at any time. Use of mark sense forms is not desirable, as the students' "sloppiness" can invalidate a correct answer. Most importantly, chemical formulas and structures must be properly presented as part of the exam to be generated. The students must have the facility to ponder each question selectively, change answers, and reread questions. When finished, the system must immediately furnish the score, text references for incorrect answers, and indicate completion/repetition of the module. The instructor must be able to add his/her own questions to the file, delete or modify existing questions, configure exams either by explicit question number or implicit weight (difficulty), and receive a statistical analysis of each module as it is completed.

The hardware configuration necessary to implement such a system would have to be an on-line, interactive one. Remote terminals with Cathode Ray Tubes (TV screens - referred to hereafter as CRT's) would connect to a main computer. The terminals would display the test questions and receive the answers; the main computer would maintain the question file and provide specific test items as demanded by the terminals.

At Cuyahoga Community College, Western Campus, we have decided to use the Intecolor 8001 interactive 8-color graphics terminal, interfaced to a Digital Equipment Corp. PDP-11 Processor. The PDP-11 is an extremely reliable and efficient computer easily interfaced with other peripheral devices such as the Intecolor 8001. The 8001 has an 8-color graphics capability based on an internal microcomputer - making it an "intelligent" terminal.

The format of the questions to be presented will be multiple-choice (true-false is a possible subset of this form). Since the overall goal of ATS is to prepare students for their state board examinations, it was decided to present them with tests in a similar format. Such questions require only a single-letter answer, easily typed by the student at the terminal, easily recognized by the computer without ambiguity.

Each question (as now envisaged) will consist of:

- up to 4 lines of question text
- up to 4 possible answers
- the correct answer
- a numerical weight for difficulty
- a text reference
- an internal pointer to the accompanying diagram (if any).

The Software (Programs) structure of ATS will include:

- a "Menu" program to guide the non-computer oriented user to the correct ATS function with proper security (no student inquiries into the question file permitted!)
- a question file Maintenance Routine (to add, change, delete questions)
- a student file Maintenance Routine (to keep track of the students in each course or section)
- a teacher file Maintenance Routine (to configure exams)
- a test generator (the only function visible to the student)
- a test scorer (for statistical analysis of the exams).

The actual programming work will commence in July with a pilot course slated for late September. We hope to report on the results by next January.

Computer Assisted Instruction and Computer Test Construction in Chem. at Middle Georgia College

Ronald A. DeLorenzo
Middle Georgia College
Cochran, Georgia 31014

Presented to a session on Computer Assisted Programs at the Fifty-Third, Two-Year College Chemistry Conference, Delgado Community College, New Orleans, Louisiana, March 18, 1977.

Since 1972 the Chemistry Department at Middle Georgia College has been using an interactive computer to supplement its traditional curricula. (Interactive means that you can converse with the computer. This is usually done with a typewriter.) To better understand our attempts in this area, some background information should be mentioned: Middle Georgia College is one of thirty-two institutions which make up the University System of Georgia. The University System has 130,000 full time students, 1500 of which attend Middle Georgia College. A central site known as the Office of Computing Activities (OCA) operates a CDC CYBER 70, Model 74 computer, two IBM 370/158 computers (each with approximately 2-6 million bytes of core storage), and other hardware. These facilities are accessible in batch or interactive modes by thirty-three institutions which comprise the University System Computer Network (USCN). (Batch usually refers to the process where one gives the computer a problem and returns for the solution at a later time.) Most of the USCN schools have their own computer facilities which have both stand alone capabilities (the ability to work independently of a larger computer) and the capability to interact with the central computer hardware. Some of the schools in the USCN only have teletype terminals (typewriters) serviced by the Network computers. At Middle Georgia College we have three interactive computer terminals used to assist with instruction and a small computer (IBM System/3) serving the administrative needs. We are planning to build a larger computer center which will serve both academic and administrative needs.

Approximately half of the instructional computer usage at the central site is centered around drill, tutorial, and simulation programs. Problem solving (including research) and programming courses constitute the other half.

Each institution in the University System has a Network Computer Coordinator. When I was asked to be the Computer Coordinator at Middle Georgia College in 1973, the offer was accepted without a teaching load reduction or a salary increase. It was not a popular job. I was the fifth person to assume the duties in the four year history of the position. In the fall of 1976, after three years as Computer Coordinator (a new endurance record), I requested a reduction in my teaching assignment. This was subsequently granted. The situation is now ideal. I have time to do what I feel to be the most important job of a Computer Coordinator, that of increasing the school-wide usage of the computer as an educational tool by making faculty members aware of the material available to them and to their students.

We have over four hundred Computer Assisted Instruction (CAI) programs in our public libraries (a public library's contents are available to the entire Network and maintained by the OCA).

These four hundred computer tutorial programs represent over twenty content fields including chemistry, sociology, political science, mathematics, biology, business, medicine, computer programming, foreign languages, and physics. We are presently evaluating each of these programs and demonstrating them to appropriate faculty members. This project was initiated ten weeks ago and is doing very well. We are emphasizing to the faculty that no knowledge of computers is required to make use of the lessons. We have student aides available forty hours a week to help students and faculty operate the hardware and assist with any problems that may arise.

Our experience indicates that the most effective way to increase faculty usage is to have an individual meeting with each faculty member. It is usually a waste of time to rely on mimeograph handouts and announcements at faculty meetings to accomplish this task. It is important to stress the small amount of effort that is required of the faculty to enable their students to benefit from this educational tool.

The OCA has installed MULTITUTOR (a CAI authoring language) which gives more ambitious faculty members the capability to author their own tutorial programs. MULTITUTOR utilizes many features of the PLATO IV language, TUTOR, while requiring only conventional terminals to author and execute CAI lessons. MULTITUTOR appears to be a logical first stage for institutions interested in eventually adopting PLATO because lessons written in MULTITUTOR are compatible with the PLATO system.

In the fall of 1976 the OCA announced the availability of a computer assisted test construction system (TCS) that would be available to the thirty-three institutions in the USCN. An initial package of 50,000 items (examination questions) was presented to us free of charge by the University System of California Project SOCRATES. The present status of the California project is unknown. According to some reports it may have been abandoned when funding stopped.

Some problems have developed and our TCS system is still not being fully utilized. However, I can tell you what is available and of the exciting potential uses. I am also here to offer you the TCS software and data files (the 50,000 items) if you are interested in setting up a similar system on your own campus.

TCS provides a means for faculty to construct examinations from large data files of text items (over 50,000 and growing). Typical of the eighteen subject areas represented are chemistry, accounting, astronomy, biology, business, data processing, economics, history, marketing, mathematics, physics, and psychology.

You may dislike the idea of a computer generating your examinations. You may feel that you can write better examination questions for your <u>own</u> students than a computer can. But TCS examination questions are not written by a computer. The questions are written by your peers. The computer merely serves as a storage device for examination questions written and used by chemistry instructors around the country. The TCS can be thought of as a way for faculty members from around the United States to share ideas.

In addition to generating examinations and allowing ideas to be shared, TCS can be used to prepare worksheets, homework, pretests, makeup examinations, diagnostic tests, challenge examinations, drills, and student self-paced study material. As a particular example of self-study use, we are expecting thousands of questions for nursing students to use in their preparation for the state nursing examination.

There are four indexing fields associated with each test item. These are:

1. content category - what subject, e.g., chemistry, and what area of that subject, e.g., thermodynamics

2. cognitive level - recall, application, interpretation, problem solving

3. item type - true-false, multiple-choice, short answer, essay.

The TCS service also provides a computer program for test scoring and analysis via optical scanners and statistical packages.

The statistical package prepares an eight page report which includes about twenty types of analysis (mean, standard deviation, reliability, standard error of measurement, summary graphs, range of scores, percentage of responses to each choice, difficulty index, discrimination index, T-scores, raw scores, percentiles, etc.). The statistical package defines all terms used in the analysis and explains how each analysis should be interpreted. For example, the report might state: "Your standard error or measurement is 2.0549. This means that for any particular test score the odds are 2 to 1 that the student's true score (his average score on several similar tests) will not deviate from the one obtained by more than 2.0549 points. The more reliable and error-free the test, the smaller the standard error of measurement."

Recapitulating, we have a system that (1) generates examinations, (2) grades examinations, and (3) prepares a statistical analysis of the examination questions, answers, and scores.

Dr. John Edwards of the Division of Education and Technical Support of the USCN has offered to cooperate with interested conferences attendees by sharing our material (files and software) and providing technical advice. His address is: Office of Computing Activities, Graduate Studies Research Building, University of Georgia, Athens, GA 30602. The approximate cost to you would be two or three dollars to cover postage and computer time. We have estimated that four 2400 foot, 9-track tapes (standard industry compatable) will be required to store all of the material. Your institution would have to supply these blank tapes and have a computer that can read CDC format.

The current national computer cost per student per course is $25.00. (It is less than this in the USCN.) It is commonly accepted that computer costs are constantly decreasing in much the same way as the hundred dollar pocket calculator of a few years ago is selling for four dollars today. With continuously lowering computer costs, it is inevitable that computers will take an ever increasing role in education.

If you are interested in tapping this technology for your own chemistry department, your minimum need is a coordinator with release time. (As obvious as this may sound, Middle Georgia College is the only USCN institution that gives its Computer Coordinator a course load reduction.) The position of Computer Coordinator should be filled by somebody from within the existing academic ranks (i.e., not a computer major). The person chosen for the job should be one who has demonstrated an active interest in CAI in his own area and who can enthusiastically extrapolate his experiences to assist faculty in other academic areas.

Computer Modules in Chemistry

Sam Wiley
California State University Dominguez Hills
Carson, California 90747

Presented to a General Session at the Fifty-Eighth, Two-Year College Chemistry Conference, Santa Ana, California, March 10, 1978

At this point, we can now look back over more than a decade of developmental work in computer-assisted instruction. During this time there have been several large programs such as PLATO, TICCIT, and CONDUIT, all aimed at encouraging more wide-spread use of computers in education. However, in spite of these and many other efforts, the total impact of instructional computing has been slight.

Among the major blocks to more widespread use of the computer materials which have been developed appear to be the problems associated with transfering programs from one site and/or computer system to another. An instructor who wishes to introduce computer-based instructional materials into a course is still forced, in most cases, into either developing the materials himself or undertaking extensive revision of existing programs. Also, there is the additional problem of integrating computer material into existing courses. This paper is a report on a cooperative project aimed at overcoming some of these barriers to more widespread use of computers in science instruction.

The project is a collaborative effort involving a number of faculty from both small colleges and large universities. Here we will focus on the chemistry materials, but these are but a part of a larger effort including work in both mathematics and physics.

At the beginning, it was clear that many impressive computer-based educational aides had already been developed in the past but as was mentioned earlier, the impact of these efforts has been less than might have been hoped. This rather disappointing situation may be attributed, in part at least, to the following:

1. Many colleges have had inadequate facilities for the support of widespread computer use. A particularly serious problem is the lack of graphic capabilities, for this is one of the areas in which computers show the greatest educational promise. With the continuing cost reduction in computer hardware and the recent promising developments in microcomputers, we may soon hope to see significant improvements in this situation.

2. Although many computer-based materials are available, very few are available in a form which can be transferred from campus to campus with little effort in adaptation. Among the more serious roadblocks to cooperative utilization are the use of machine specific programming language features and/or a lack of proper documentation. Many instructors lack the time or expertise required to perform the necessary conversions. Even the various "dialects" which exist for languages such as BASIC can provide strong barriers to transfer.

3. There is also a lack of computer-oriented textbooks into which these materials can be integrated. Publishers have in the past shown some reluctance to publish such texts because of what they view to be a limited audience. There also have been some recent encouraging developments in this area. One possibility for the future is that we may see some computer software being marketed by publishers in a manner similar to audio visual materials.

COMPUTER MODULES

A modular format was chosen for the material to be developed, allowing the units to be used individually or together, at the choice of the instructor. The modules are written so that no computer sophistication is required of either the student or the instructor. Emphasis has been placed on the use of "canned" rather than student-written programs, and documentation is provided for both the student and the instructor. In addition, the programs were written for use with minimal computer facilities. No graphic capabilities are required and all of the programs can be implemented on 10K words or CPU or less.

Each module is limited to a single major concept. The amount of material covered is intended to be the equivalent of one lecture to one week's worth or work. If the material requires a greater amount of time, modules are broken into separate units of this length.

The units are designed to provide students with an active role emphasizing the "discovery" of concepts and relations. As they progress through the units, they are required to answer questions and solve problems by interacting with the computer. The modules are suitable for any of the following uses:

1. as a first-exposure self-study unit.
2. as a supplement to traditional lectures.
3. as a work book or problems book for students having difficulty with problem solving.
4. as review units of earlier material.
5. as a study guide for a unit in a self-paced PSI course.

This offers a variety of ways in which one or more units can be integrated into an existing course.

The modules are aimed at the level of the introductory college freshman courses. At present, the total coverage of the chemistry modules is roughly equivalent to the major topics covered in the first year of chemistry. However, they are designed so that they can be used independently. Thus an instructor may choose to introduce as few or as many as he likes in a given course. Some of the units have prerequisites, but these can be satisfied in a variety of ways, including the study of standard texts or lectures, so that the use of preceding modules is not required.

A uniform general structure and educational philosophy was imposed on all the modules, although the nature and amount of computer usage may vary from one to another. Each consists of a student manual and a teacher's guide. The student manual contains discussion of the material and instructions for the students on the use of the computer programs in the module. The discussion material is not just a rewrite of a textbook chapter. It contains exercises, some involving use of the computer and some involving hand calculations, which must be completed before proceeding to next portion of the discussion. This is in keeping with the general philosophy of requiring the active participation of the student in progressing through the module. Each manual also contains a clearly stated set of learning objectives which, along with the several versions of the unit tests provided in the teacher's guide, allow for the easy integration of these units into a self-paced PSI course. In addition to the unit tests, the teacher's guide also contains suggestions for implementation of the units in a standard course, along with other pedagogical considerations.

STUDENT MANUAL

The student manual has seven major sections:

1. Objectives
2. Prerequisites

3. Pre-test and answers
4. Introduction
5. Discussion
6. Problems
7. Appendix (flowcharts and listings)

The Objectives are a clear statement of the skills the student is expected to achieve on completion of the unit, while the Prerequisites section outlines the background assumed. The pre-test is designed to allow the student to determine whether or not he meets the stated pre-requisites. The Introduction provides both a summary and overview of the module.

The Discussion if the meat of the material. It contains the text and exercises related to the topics under consideration. Some of these exercises involve the use of "canned" computer programs and some do not require a computer. Where computer use would be ineffective and long explanations might be involved, reference is made to other texts. As mentioned earlier, the programs used in this section are "canned", but a complete description of what is being done is given.

The Problems contain additional work with concepts of the module. Again, some may not involve the use of the computer (they may be like the usual numeric problems in a text), and some may involve further work with the canned programs. In addition, any student assignments involving programming are relegated to this section so they may be used at the in--structor's discretion.

The Teacher's Guide contains a statement of educational objectives and suggestions for implementation of the module. (Where it may fit in the usual sequence of courses, time required and computer requirements.) This section also deals with variations based on the level of the student and his experience. Solutions to all problems are provided. In addition, several versions of exams which test the student's master of the material are provided, along with answers.

A software section containing complete flowcharts and listings, in both BASIC and FORTRAN, for all programs is included. This does not, by the way, constitute an endorsement of these languages as the best. It is simply an acknowledgement of the fact that almost everyone has access to at least one of them.

As was mentioned earlier, within this general outline the manner in which the computer is employed varies from module to module. Some involve computer simulations of chemical processes: Some contain "games" which illustrate pedagogical points: Others utilize the computer to generate self-tests for the students: Still others are used to compare the results of exact calculations with approximations. There are also programs which carryout numerical demonstrations or encourage the "discovery" of basic principals. There is even a program to diagnose student errors. Some (the modular appendices) do not involve the use of the computer at all.

None of these are conventional CAI programs. They are all designed to minimize both terminal time and memory storage requirements. A typical program is 100-200 statements long in BASIC and requires 2-3 K of storage. To illustrate the computer use more fully, we now will briefly describe each of the modules:

Abstracts of Completed Units[1]

Module on Stoichiometry

Unit 1. "The Mole Concept," by R. Williams - The unit deals with problems involving the mole concept, elemental composition, and determination of empirical formulas. MOLE generates unique exams of five questions for each student to be taken away and solved. The student returns to the terminal for checking of his answers. Appendices "Exponential Numbers and Logarithms" and "Use of Conversion Factors" provide prerequisites to this unit.

Unit 2. "Solving Stoichiometry Problems," by R. Williams - This provides problem-solving practice on simple stoichiometry problems, limiting reagent, and percent yield problems. Like MOLE, STO1 and STO2 make extensive use of the RND function of BASIC to ensure that individually generated exams are different.

Module on Gases, Liquids, and Solids

(Unit 1 on Behavior of Gases is in preparation.)

Unit 2. "Phase Equilibria," by M. Bader - This unit discusses the phase diagram of water, primarily, and provides the needed prerequisite to the unit on colligative properties. Very interesting layman's examples (dew, fog, ice-skating) are used to illustrate phase equilibria. A quantitative section on the Clausius-Clapeyron equation may be included at the discretion of the instructor.

Module on Solutions

Unit 1. "Introduction to Solutions. Weight Percent, Volume Percent and PPM," by M. Bader - As a first introduction to concentration units, weight percent, volume percent, and PPM are easily mastered. The testing of these concepts is postponed until the student has completed other concentration units.

Unit 2. "Molarity, Molality and Concentration Conversions," by M. Bader - CTEST is a 2-pass quiz program. The first pass generates a quiz which a student takes off-line. In the second pass the student enters his answers and the program grades them. This is based on the use of a random number generator which is seeded by the clock. The seed is printed out as the quiz code number. This seed is used in the second pass to regenerate the answers to the same quiz.

Unit 3. "Dilution Problems," by R.T. O'Neill - This uses a tutorial program DILUTE which diagnoses student errors in setting up dilution problems.

Unit 4. "Solution Stoichiometry," by R.T. O'Neill - Program ENDPT uses a game format to discover the volume of a strong base of known molarity needed to exactly neutralize an aliquot of acid of known concentration. This program prepares the student for his initial exposure to laboratory titration using an indicator-determined endpoint. This unit is in two parts, the second part which may be postponed for later treatment involves problems in terms of equivalents and normality. This unit does not assume a background in acid-base or redox reactions, merely that two reagents react in a chemical equation.

Unit 5. "Colligative Properties of Solutions," by M. Bader - COLLIG generates quizzes with problems on Raoult's Law, lowering of vapor pressure, elevation of boiling point, depression of freezing point, and osmotic pressure. The unit on Phase Equilibria or its equivalent is a necessary prerequisite.

Module on Chemical Equilibrium

Unit 1. "Introduction to Chemical Equilibrium," by J. Manock - This uses two programs which allow the student to "discover" chemical equilibrium and the equilibrium constant. Program EQSIM leads to the discovery of chemical equilibrium by a simulation of a system, A = B + C, which starts with pure A and comes to equilibrium. A sequence of pictures shows the random positions of gaseous molecules A, B, and C at the times chosen by the student. It shows that equilibrium is dynamic, not static. It portrays the relationship between numbers of molecules of each kind; the student can count them. Then the equilibrium is approached from the B + C side. Program KEQ is on the discovery of the functional form of the constant of equilibrium. The program gives simulated equilibrium concentration data for various initial conditions, and allows the student to input his choice of combination of concentration terms until he finds one which is a function invariant with respect to initial conditions. The first example is the simple A = B + C, the second one is A = 2B. The emphasis of the module is for the student to be led to a quantitative understanding of an equilibrium expression through the exciting mode of discovery.

Unit 2. "Le Chatelier's Principle," by A.K. Jameson - LECHAT is a simulation of a chemical system in equilibrium by teletype graphics. Stress may be applied on the system by the student in the form of addition of reactants or products, or changing pressure. The program simulates how the system reacts, showing before and after pictures.

Unit 3. "Chemical Equilibrium Calculations," by C.J. Jameson The program EQUIL allows the student to find equilibrium concentrations by a trial and error approach, using a comparison of the value of the reaction quotient with the equilibrium constant at each stage. The student has to choose the direction in which the reaction has to go in order to get to the equilibrium state. The student manual shows algebraic methods of solving problems. The program EQCALC uses the same approach on the student's own choice of reaction and initial conditions on systems too difficult to do algebraically because they involve high-order polynomial equations. Program EQUIZ is a 2-pass quiz-generating program which uses a random selection of systems and data, and on second pass, given the quiz code number, will print only the answers to any quiz.

Unit 4. "Equilibria in Acid-Base Systems," by F. Settle - This unit uses two programs to explore acid-base equilibria. In ACID the student will (1) discover how pH and degree of dissociation changes with analytical concentration of an acid or base and (2) find limits of applicability of an approximation commonly used. The student does hand calculations using a simplifying approximation and compares with the exact calculations done by the program. In BUFFER he discovers how a buffer system reacts to the addition of small amounts of strong acid or base. The student inputs such changes, the program does the calculation of pH. This is otherwise very time-consuming to demonstrate by the lecture method. Appendices "pH" and "Exponential Numbers and Logarithms" provide prerequisites to this unit.

Unit 5. "Heterogeneous Ionic Equilibria," by J. Manock - HETERO is a numerical demonstration of the constancy of the solubility product and its lack of dependence on the amount of solit present. Precipitation problems arranged in increasing complexity are illustrated in the student manual.

Modular Appendices

Unit 1. "Exponential Numbers and Logarithms," by C.J. Jameson - This unit shows how a number may be written in exponential notation and how mathematical operations involving numbers written in exponential notation are carried out. Logarithms and antilogarithms are defined and their use illustrated with many examples. This unit serves as a prerequisite to many later units.

Unit 2. "Use of Conversion Factors," by R. Williams - This unit shows the importance of units and introduces the method of dimensional analysis in solving problems. The program UNITS tests him on problems using conversion factors.

Unit 3. "pH, Strong Acids and Bases," by F. Settle - This unit deals with the ionization of pure water, the introduction of pH and the Bronsted-Lowry concept of acids and bases. The calculation of pH from known H_3O^+ and OH^- concentrations is also shown with many illustrative problems.

Currently available modules can be purchased by contacting the project director:

Professor Harold Weinstock
Dept. of Physics
Illinois Institute of Technology
Chicago, Illinois 60616

Project partially supported by grants from the National Science Foundation and the Exxon Foundation.

---

1 Reprinted from Jour Chem Ed., Vol. 54, 238, April, 1977.

Nutritional Analysis Aided by Computer

Stanley R. Winter
Golden West College
Huntington Beach, California 92646

Presented to a General Session at the Fifty-Eighth, Two-Year College Chemistry Conference, Santa Ana College, Santa Ana, California, March 10, 1978.

Introduction

A computer program has been developed which uses food composition tables to calculate total and average amounts of nutrients present in foods consumed during a one to seven day survey period. Percentages of the Recommended Dietary Allowances (RDA) are determined for calories plus eight of the nutrients. Using the program a student can determine whether she or he is eating a well-rounded diet which is likely to provide all required nutrients in adequate amounts or if instead his or her diet is skewed in a particular direction providing inadequate amounts of certain nutrients. The program thus offers a student insights into the nutritional consequences of his or her own eating habits and provides a rational basis for improving one's eating habits. The program can also be used to design nutritionally sound diets for special circumstances -- for example, an 800 calorie diet of foods the person likes, a "busy menu" consisting of foods that are quick to prepare but nutritious for hectic times when it is difficult to eat well, or camping diets that are nutritious but which store well and are easy to fix while camping. The diet analyses and diet designs carried out with the program personalize courses in which they are used by helping to relate topics such as vita mins, minerals, carbohydrates, fats, protein, and fiber to the students' own lives. The nutrition program was designed for use in the chemistry of nutrition course which as been developed by the author. The program is currently being used on campus in anatomy and physiology courses, in our one semester "nursing" chemistry course, and in standard nutrition courses taught by the Home Economics Department at our sister school, Orange Coast College. The program is also the basis of a one-half unit open-entry/open-exit adult education course in nutrition analysis.

Computer and Program Specifics

Computer: IBM 370/155
Operating System: OS/US1
Language: APL/SV (Interpreter)
File Processor: TSIO

	Bytes
Files:	
Nutrition Analysis Text and Food Composition Data	977,000
Student Data Storage	1,048,000
Comments	74,000
Workspaces:	
Nutrition Analysis Program	61,400
Recipe Program	61,400
Newfoods Program	61,400
Instructor Utility Programs	61,400

The program is interactive allowing students to input their own data, modify the data if necessary, and obtain a printout. When demand is high, a high speed printer is used to facilitate the output of the ten to twenty pages of data obtained from a seven day diet survey.

The majority of the food composition data used is from Handbook No. 456 of the Department of Agriculture. This data can be obtained in card or tape form from:

Action Data Processing, Inc.
817 Silver Springs Avenue
Silver Springs, Maryland 20910
Telephone: (301) 587-0558

Additional food composition data has been obtained from other sources including Handbook No. 8 of the Department of Agriculture, "Food Values of Portions Commonly Used" by Bowes and Church (J.P. Lippincott Company, New York, N.Y.), food labels, and direct from food manufacturers (McDonald's, Kelloggs, etc.).

Important Features

Data Input - Students enter the type and amount of each food consumed by giving (a) the food number from Handbook No. 456 (or one assigned by the computer when nutrient data is entered for a food) and (b) the number of servings consumed. Data is entered by meal type -- breakfast, lunch, dinner, and snacks. Between 30 minutes and 2 hours is generally required for entering seven days worth of food consumption data.

Data Storage - The data is stored by student I.D. number and is retained for up to three weeks. Data storage allows students to enter their data in portions rather than all at one sitting, and it protects against loss of data should the computer go down during input. Most importantly, however, it provides a chance to correct errors and obtain a new printout if, as often occurs, errors in food consumption data entry are discovered after the first printout of the nutrition data is obtained.

Editing Function - Correctness of food consumption is verified by the student at the end of the data entry for each meal. An editing function allows errors to be corrected including delection or addition of food items. The data for any meal previously entered can be called up and edited at any point. The ability to recall and edit data is crucial since errors in food numbers or number of servings, or missing or extra food are frequently discovered days later when the nutrition data is being analyzed.

Class Data - Students are queried during the program as to the class they are in. An auxiliary program allows instructors to obtain composite data for their class including class averages for all men, all women, and total individuals for calories and all nutrients. In addition, the number of men, women, and total individuals in the class who were below a specified percentage of their RDA (usually 100%) is determined for calories and each of the eight nutrients for which an RDA is available. The students (as well as the instructors) find these summaries of the data for the class to be quite interesting.

Auxiliary Programs for Student Use - Several small auxiliary programs have proven to be very useful. A program entitled Recipe asks a student to enter the name, serving size, number of servings, and ingredients in a recipe; the nutrients in a serving of the food are then calculated. A food number is also assigned to the food item (his or her own tuna salad or blender drink for example) so that the food can then be used in the main nutrition program. A program called Newfoods allows food composition data from a food label or another source to be entered; a food number is then assigned allowing the food to be used in the main nutrition and Recipe programs. Foods entered through the Recipe and Newfoods programs are placed on a temporary food list and do not become a part of the permanent food list until transferred by the instructor, generally at the close of each semester.

Instructor Auxiliary Programs - Several small programs are helpful to the instructor. The data summary program has already been described. An edit routine allows changes to be made in food composition data. Another program allow the names, food numbers, and standard servings of around 800 of the most commonly eaten foods to be printed out for reproduction and distribution to the students. This abbreviated food list allows most food numbers and numbers of servings to be found by students without sorting through the 4,000 or so entries in Handbook No. 456. Another small program lists data entered through the Newfoods and Recipe programs. This list is posted so these foods can be used (after checking the nutrients for accuracy hopefully) by other students in their analyses.

Analysis of Printout - Unfortunately, most students tend to look at only the "bottom line" of their printout (their average daily intake) to see which nutrients are above or below the 100% RDA level. A worksheet has been prepared which takes the students through a more thorough analysis of the data. The student is asked to find several foods that are high (more than 10% of the student's RDA per serving) in all nutrients for which the student was below 100% of the RDA on his or her daily average. Graphs are prepared of the daily intakes (in terms of percentage of the RDA) of nutrients in order to gain a better picture of variations in nutrient intake during the week. The nutrition value of the various meals (breakfast, lunch, dinner, and snacks) are compared on a nutrients versus calories basis. Fat and cholesterol intakes are compared with the Heart Association's recommendations. Students that are concerned with their weight are asked to track down which two days, which meal, and which foods in those meals are primarily responsible for high calorie intakes. Fiber and salt (sodium) intakes are compared to amounts recommended by various nutritionists. Calcium intake is discussed in relation to protein and phosphorus intakes.

Student Response - The main nutrition program asks students for comments and suggestions for improvements at the end of the printout. These comments plus responses to questions concerning the computer program on course evaluations, as well as personal conversations with students indicate a very favorable reaction of the students to the program. Despite frustrations with the computer and the considerable time required to carry out the analysis (6 to 16 hours), almost all students indicate it was worth the effort. In evaluations, over 95% usually indicate the program was quite worthwhile or very worthwhile (the two highest ratings on a 5 point scale). It is not uncommon to have students indicate the analysis was the best part of the course. (The author has chosen to interpret such comments as pluses for the program rather than the less enjoyable alternative interpretation regarding the quality of the rest of his course. Other data fortunately supports this conclusion.)

DEVELOPMENTAL LEARNING

Chemistry & Cognitive Skills

Patricia K. McCoy
Jefferson Community College
Louisville, Kentucky 40200

Presented to a General Session of the Fifty-Sixth, Two-Year College Chemistry Conference, Vincennes University, Vincennes, Indiana, October 8, 1977.

Two years ago one of my colleagues, Ellen Korn, in the Natural Science Division received a F.I.P.S.E. Grant. The purpose of this grant was to establish a Natural Science Learning Laboratory. The program developed was called a Multilevel Remediation Program. Figure one shows the model for the program. Notice at the base is a list of cognitive programs. The theory is that students deficient in certain cognitive skills cannot successfully complete Algebra, Chemistry, and Biology. The purpose of the cognitive programs is to teach these skills to the student. This is accomplished by audio-tutorial programs and computer testing. This paper will compare final grade averages of students who did not need programs with those of students who either took the programs or needed to take them. Through the analysis of this data, we were able to show a definite need for cognitive remediation.

Ms. Korn designed a Cognitive Diagnostic Examination which is given to students entering Algebra, Chemistry, and Biology. The answers are placed in a computer which gives a printout showing each student's cognitive profile. Look at Figure two; this is a typical printout sheet. You will notice the cognitive areas thought necessary for science and mathematics courses and a list of the programs which go with each area. The asterisks on the sheet indicate the programs the student needs to complete. The student, hopefully, progresses

COLLEGE-LEVEL BIO.	COLLEGE-LEVEL CHEM.	COLLEGE-LEVEL MATH
BASIC INFORMATION-BIO.	BASIC INFORMATION-CHEM.	BASIC INFORMATION

COGNITIVE BASE

Visual Language	Generalities and Specifics
Abstract Language	Recognition of Implication
Verbally Defined Language	Identification of Inference
Search Process for Words	Recognition of Presupposition
Search Process for Patterns	Elements of Discovery
Coupling Words and Patterns	Simple Visual Relationships
Complex Relationship of Words and Patterns	Complex Visual Relationships
Recognition of Argument, Justification and Proof	

Figure 1

CHE 110-4 10:20 MW

Visual Language;	10	/10
Verbally Defined Language;	27	/34
Abstract Language;	12	/21
Visual Relationships;	8	/8
Part-Whole Relationships;	12	/18
Pattern Recognition;	18	/22
Logical Interaction;	7	/14
Reasoning;	36	/52 Items 8-59
Total Score;	43	/59

VL
VDL
SPW
AL *****
SVR
CVR
RAJP
GS
RI
CWP ****
CRWP****
ED ****

Figure 2

from the simple skills to the complex skills. Students found deficient in three or more specific skills are advised to enroll in the Learning Laboratory.

Once a student enrolls in the laboratory, he or she is expected to complete all the cognitive programs needed. Many of them do not do this. Each program consists of two components. The first component is an audio-tutorial program with a study guide. Once the student completes this component, the next step is to go to the computer to be tested. When the computer component is successfully completed the student continues with the next program. This sequence is continued until all the programs are completed.

Most of my chemistry students work on the cognitive programs and the chemistry programs simultaneously. According to Figure one, the chemistry programs are not usually started until the cognitive programs are completed. Since the students are enrolled in chemistry at the same time, they need help in the subject matter as well as the cognitive areas. The Chemistry Audio-tutorial programs are designed to coincide with my lecture material. Students having difficulty in lecture can come to the Natural Science Learning Laboratory for additional help. Since the Learning Laboratory meets twice a week, the chemistry student did the cognitive programs one day and the chemistry programs the next day. They are also free to go to the laboratory at other times. Unfortunately, what happens many times is even with the supplementary chemistry programs the student who is deficient in the cognitive areas cannot assimilate the course material.

The results of the experiment so far are varied. One problem we have is that our test has not been validated. The data which will be reported consists of students in my Developmental Chemistry Course and my Chemistry 110 class. The total number of students participating in the Cognitive Testing for Fall 1976 and Spring 1977 was 84.

Figure three is a graph comparing programs taken with point standing. The point standings were figured as a zero for students failing or those who withdrew failing; one for students completing the course with a D; two for students completing the course with a C; three for students completing the course with a B; and four for students completing the course with an A. Fifty three of the students needed three or less programs. These students had an average grade standing of 1.5. Of these fifty-three students, eight had a final average of four. None of these students required any programs. Notice the comparison between students taking programs and those who took no programs. The average of students who did not take the required programs was 0.55. This data supports the validity of the test. It also supports the theory that students who are successful in chemistry do not require cognitive remediation, and most students who need remediation and do not take it are not successful in chemistry. Since we do not have many students who completed all the required programs, it has been difficult to validate the content of the individual programs.

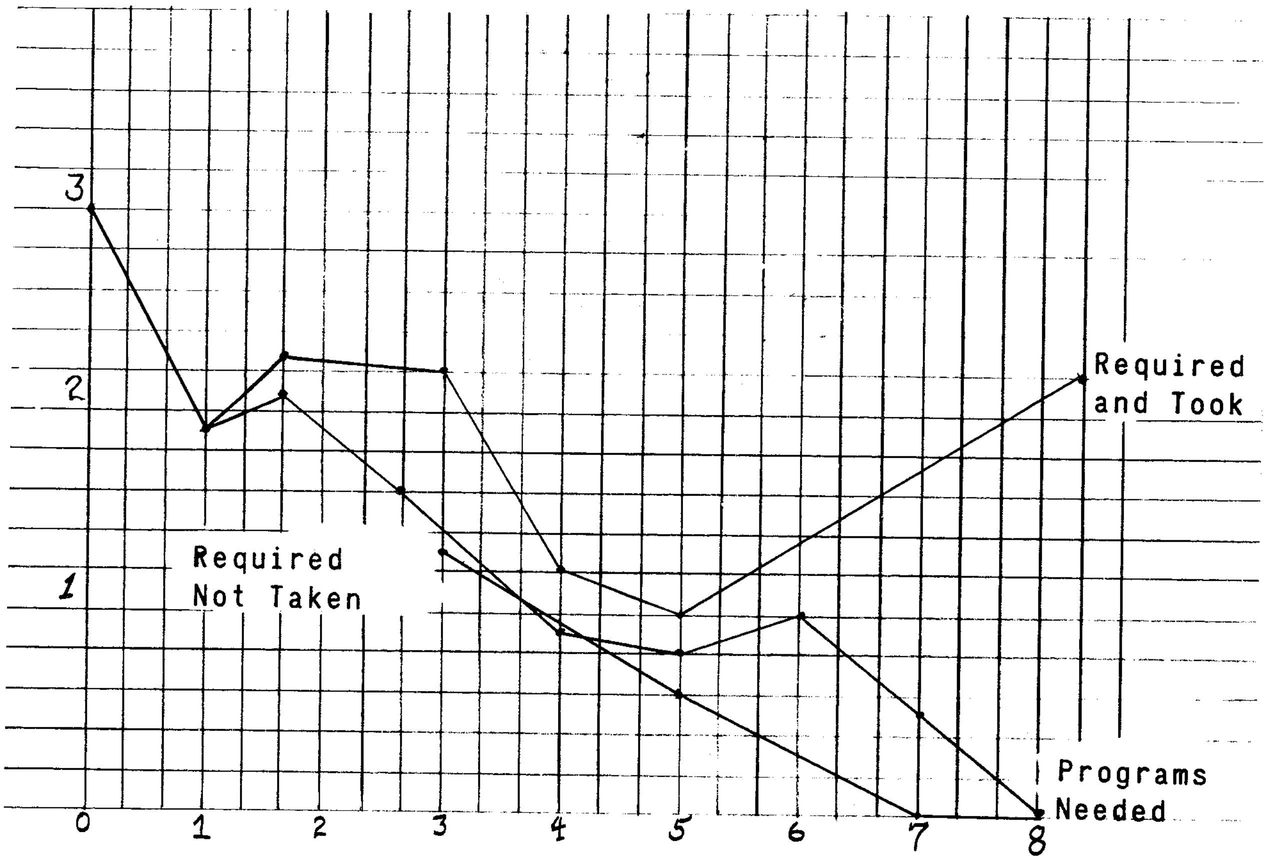


Figure 3

PROGRAM TITLE	AV-NR	AV-TR	AV-NTR
Visual Language	1.3(76)	1 (3)	0.8 (5)
Verbally Defined Language	1.4(80)	2 (1)	1 (3)
Abstract Language	1.4(75)	0.5 (4)	1 (5)
Search Process for Words	1.4(69)	0.9 (8)	0.9 (7)
Elements of Discovery	1.4(68)	2 (3)	0.8 (13)
Recognition of Generalities and Specifics	1.4(63)	0.8 (5)	1 (16)
Recognition of Implication	1.4(71)	2 (1)	0.8 (12)
Recognition of Presuppositions	1.3(61)	1.3 (4)	0.7 (19)
Search Processes for Patterns	1.4(70)	2 (4)	0.9 (10)
Simple Visual Relationships	1.4(39)	0.6 (9)	0.8 (36)
Complex Visual Relationships	1.4(75)	0 (2)	0.7 (7)
Coupling Words and Patterns	1.5(62)	0.6 (9)	0.5 (13)
Complex Relationships of Words and Patterns	1.4(61)	1.3 (11)	0.8 (12)
Recognition of Argument, Justification and Proof	1.7(44)	0.7 (15)	0.8 (25)
Identification of Inference	1.4(73)	0 (3)	0.9 (8)

Figure 4

Figure four gives some information about the individual programs. Each program is given by name. Listed beside each program are the averages of the students who did not require the program, the students who took the program and those who did not take the program. The number of students in each category is also listed. Notice the averages of the students who did not require programs are much higher than those who took no programs.

The cognitive areas which seemed more indicative of success in chemistry were Visual Relationships, Part-Whole Relationships, Pattern Recognition and Logical Interaction. The programs in these areas begin with "Elements of Discovery" in Figure four and continue through the last program on the list, "Identification of Inference". Other than the program on "Recognition of Generalities and Specifics", the averages for students who did not take these programs were below one. Students who took the programs; "Elements of Discovery", "Recognition of Implication", "Recognition of Presupposition", "Search Process for Patterns", and "Complex Relationships of Words and Patterns" had higher averages than those who did not take these programs. This would indicate that once the content of these programs is mastered, the student has a better chance of passing Chemistry.

The data formulated on the remaining programs is difficult to evaluate. The students who completed the programs had a lower average than those who did not take them. There could be many reasons for this. A few of these will be presented for your consideration. One reason could be the way students used the laboratory. Many of the students who were having difficulty with the course material came to the Learning Laboratory and worked on the chemistry programs and did not complete the Cognitive Programs. The additional exposure to the course material was invaluable to many students who usually would have failed. The cognitive skills are developed through the teaching process as an adjunct to the chemistry material itself. The chemistry tapes are also designed in this manner. Some of the students took only the cognitive programs and did not do the chemistry. This was a handicap in most cases.

Another consideration would be the content of the programs. The content of these programs will be reevaluated. They may need to be revised.

The conclusion from the data presented in this paper is that there is definite need for cognitive remediation if one is to be successful in chemistry. However, the question remains; if a student does not have these skills, can they be acquired through training? This is a difficult question to answer. Most of our data indicates that this can be accomplished. There still is not enough proof to answer this question. The test needs to be validated and some of the programs need revision. Hopefully, the answer to this important question will be found soon.

Prior Preparation of Chemistry Students

Frank Walmsley
University of Toledo
Toledo, Ohio 43606

Presented to a General Session of the Fifty-Third, Two-Year College Chemistry Conference, Delgado Community College, New Orleans, Louisiana, March 19, 1977.

What sort of background do students have when they begin taking college chemistry? Of particular interest to many college chemistry teachers is the background of students who want to major in science, engineering or pharmacy, but are not able to succeed in the first general chemistry course. The background and attitudes of 270 students who were taking a course designed to prepare them for the first general chemistry course were surveyed.[1] These students either had not taken high school chemistry or had received a nonpassing grade (<45) on the Toledo Chemistry Placament Examination.[2]

Table 1 shows the composition of the class. The health classification includes pre-med, pre-dent and medical technology. There were very few students taking the course for general education credit. The prime goal was preparation for another chemistry course.

Table 1

Class Composition

Arts & Sciences		54%
Chemistry	6%	
Health	75%	
Science	11%	
Other	7%	
Engineering		24%
Pharmacy		14%
Education		4%
Other		4%

Most of the students who had taken high school chemistry had taken it either one or two years previously. That is, they were just entering college from high school and had taken high school chemistry as a junior or senior. As shown in Table 2, there was a considerable number who had taken high school chemistry more than three years previously; these students were somewhat older and had not been in school at all for several years.

Table 2

When High School Chemistry Taken

Previous year	13%
Two years previous	29%
Three years previous	14%
More than three years previous	8%
Not taken	36%

Since many students are underprepared because of difficulty with mathematical calculations it was interesting to see how much math had been taken in high school (Table 3) and when the last math course, either college or high school, was taken (Table 4). It appears that the students are more up-to-date on their math than on their chemistry since the percentage not having taken a math course for more than three years is small.

Table 3

Amount of High School Math Taken

2 years	24%
2.5 years	7%
3 years	28%
3.5 years	8%
4 years	33%

Table 4

When Last Math Course Taken

Previous year	51%
Two Years previous	32%
Three years previous	8%
More than three years previous	9%

It appears that a basic knowledge of elementary mathematics is present but the students have had little experience applying it. To state it in a somewhat different manner one could say that the students lack practice in working word problems.

In addition to actual knowledge, an important aspect to success or failure is attitude.[3] As shown in Tables 5 and 6, the general attitude of the class was good both before (the first day of class) and after (the last day of class).

Table 5

Feelings About Chemistry

	Before (%)	After (%)
I like chemistry very much.	19	19
I think chemistry is OK.	38	56
I don't like it too much.	12	13
I don't like it at all.	4	7
I'm uncertain about it.	27	6

Table 6.

Feelings About Math

	Before (%)
I like math very much.	26
I think math is OK.	53
I don't like it too much.	14
I don't like it at all.	3
I'm uncertain about it.	3

Another measure of attitude is self-assurance. It appears that the students were realistic in their estimation of abilities (Tables 7 and 8). One would guess that the large numbers who were not willing or able to estimate, on the first day of class, their abilities were those who had not taken high school chemistry.

Table 7

Ability In Chemistry

	Before (%)	After (%)
I find it easy.	7	9
It's not too easy, but I can do it.	31	51
I find it a little difficult.	25	26
I find it very difficult.	9	11
I don't know.	28	4

Table 8

Ability In Math

	Before
I find it easy.	15%
It's not too easy but I can do it.	54%
I find it a little difficult.	23%
I find it very difficult.	6%
I don't know.	2%

Poor study habits have been mentioned as a characteristic of the underprepared student and may indeed be true of most freshmen. Table 9 shows that most students had good intentions with regard to styding chemistry, but when asked at the end of the course "How much time did you spend outside class studying chemistry?" the result was much less than that anticipated at the beginning of the course.

Table 9

Study Time

Time Spent Outside Class In Hours Per Week	Before (%)	After (%)
Less than 1	1	8
1 to 2	18	34
3 to 5	37	41
5 to 7	32	14
More than 7	12	4

Does the Toledo Chemistry Placement Examination identify the underprepared student? The students just described went on to the first general chemistry course and were statistically indistinguishable from the rest of the class.[1] Grades of students who passed the placement test and a few who didn't but tried the first general chemistry coursey anyway are shown in Figure 1. The placement test scores are grouped and the grades in the first general chemistry course of students in each group were averaged (A=4, B=3, C=2, D=1, F=0, W=0). The figure shows that there is a regular decrease in average course grade with decreasing placement test score. For students below 45 the average grade is less than D.

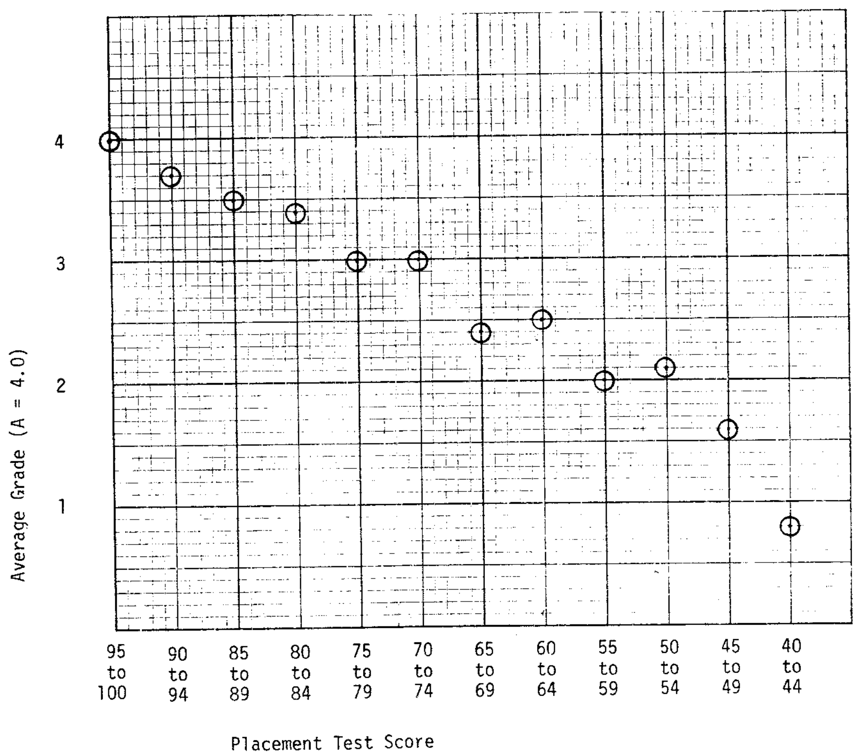


Figure 1. General Chemistry Course Grade vs Placement Test Score

REFERENCES

1. F. Walmsley, J. Chem. Educ., 54, No. 5 (1977).
2. Available from Examination Committee - American Chemical Society, University of South Florida, Tampa, Florida 33620.
3. L.J. Kotnik, J. Chem. Educ., 51, 165 (1974).

Remediation: A Fact of Life in the Community College

Phillip E. Pierpont
Vincennes University
Vincennes, Indiana 47591

Presented to a General Session of the Fifty-Sixth, Two-Year College Chemistry Conference, Vincennes University, Vincennes, Ind., Oct. 8, 1977.

When the cover story, "Why Johnny Can't Write," appeared in Newsweek in 1975, many people, parents and educators alike, seemed surprised by the article's thesis that current and future college graduates probably would be "unable to write ordinary, expository English with any real degree of the structure and lucidity."[1] Although SAT verbal scores (and math scores also, but to a lesser degree) had already declined each year for twelve years at the time the article appeared, the general citizenry had shut, and has continued to shut, its eyes to the fact that its progeny--the "best educated generation in American history", as the cliche has it -- simply cannot communicate its ideas on paper. We have not become a "verbal," as opposed to a "writing," culture overnight. The non-writing generation of the late 1960's and early 1970's was largely the product of the same kind of educational system that had produced its parents. If we were able, somewhow, to subject all of those surprised parents to the same kind of testing their children faced, they probably would do no better.

However, this probably truth does not mitigate the fact that modern college graduates do write poorly on the whole; nor does it obviate the fact that this non-ability to write was not as many disappointed parents might wish to believe, somehow a communish plot wrought upon an unsuspecting, whole college generation by left-leaning, liberal, college-English professors. The fact is that we are a non-writing society because, it is my conclusion, we are a highly anti-intellectual society. Our beloved and basic muth of the glorious, handsome, largely illiterate athlete-hero, somehow pulled through it all and kept eligible for the "big game" by the misanthropic shrimp-boat-sized, bespectacled intellectual, only newly humanized, has been alive and well in America far longer than Hollywood's 1930's musicals, far longer than the NCAA, perhaps far longer than the opening of the western frontier. Our present problem arises partially from the long life of this myth. Parents in the 1950's wanted the best for their children, yet these children did not come unaided by their parents to the attitude that it is "cool," perversely right, and masculine, not to achieve academically-- especially in the English class taught by that sweet little- old lady in tennis shoes-and somehow "uncool," wrong, and ef- feminate to excell--especially in English. It is even possible that our present problem is the product of a conscious under- development become culturally and subconsciously habitual and nearly unremediable. Unfortunately, the victim of this complex-- far more complicated than I have implied here -- of factors is the non-writing, non-reading student who sits across the desk, or lectern, or even cafeteria table from each of us as we at- tempt to fulfill our vocations in the two and four-year colleges of this country. I would surmise that teachers in the junior and community colleges were not surprised in 1975 by that News- week article because the nonliterate student had been a fact of our lives for so long.

Whatever the causes of this tragic phenomenon of a supposed- ly well educated, but functionally illiterate generation, the phenomenon and the attempts to remedy it have caused a whole separate set of problems that must be resolved, or at least acknowledged before any new teaching "strategy" can be applied. These problems include the damage done to the student's self- esteem before he gets to us, his hostility toward learning in general and the language arts in particular, the new psycholo- gical impact and societal stigma of placement in a remedial course, the pragmatic problem of non-transferability of most remedial courses, and the too heavy leaning upon standardized tests to do our thinking for us.

I would like to touch upon these points individually, but briefly, and then outline for you the approach we have taken to this problem here at Vincennes University. First, as most of us who operate in the "open door institution" context know, the students who come to us through our ever-widening front doors are certainly not sold upon themselves or their own abilities. Whether their teachers in their elementary and secondary schools realize it or not, they made many of these young people into "losers." Whether the individual teacher could not teach, or was not prepared culturally or education- ally to teach, or simply chose not to try to teach this kind of student, the basic fact is that he did not teach this stu- dent. The tragedy is that he did not let the damage rest at the "not-teaching," but for whatever reason and by some man- ner, he managed to transfer most of the blame for the "no- teaching" to the student, now a "non-learner." The student comes to us convinced that he cannot learn. He has been down so long that nothing really looks like up. We find this stu- dent in our classrooms because his parents were unwilling to admit that he might no longer be college material, or because there are no jobs out in the world, or because it is more "cool" to go to school, any school, than to stay home, or, fortunately, because, despits it all, he sometimes has not really given up on himself. I have become convinced that we cannot serve this student unless we do acknowledge the student's selfesteem as a factor which should influence our approach to him.

Second, almost every student who enters our classrooms with damaged self-esteem probably also carries with him a hostility toward learning, the intensity of which is contradictory to the fact that he is in the classroom at all. Students whose only exposure to creative language was in a literature context, especially one dominated by long-dead poets whose language sounded "strnage," and students whose only exposure to composition or thetoric was in a sequence of grammar lessons or an occasional essay description of a sunrise, or an essay on the "tutor-tyro complex in the fiction of Ernest Hemingway," probably hate English, their own language, more than any other one subject matter in their pasts or in their futures. Black students especially see standard English, "White" English, as their enemy and often feel compelled to reject it in order not to reject it in order not to reject their own regional, urban dialectal types of English.[2] Convinced that students will recognize what is good for them, some confidently urge a return to "the basics" to overcome these hostile feelings. While I agree only somewhat with a recent article about "The Politics of 'Back to Basics'" approaches,[3] and while I do not advocate a retreat from the effort to give every student a writing mastery of standard English, I do conclude that anyone who advocates a mere return to those so-called "basics," or to a remedial program premised solely on them as a solution to all our problems is a fool and that teaching as a profession would be better off without him.

Third, placement in a course labeled "remedial" will definitely do a student new psychological harm if his self-esteem is already damaged. The word "remedial" itself is a clue here. Literally, it derives from "remedy," and implicitly it diagnoses the student to be remediated as somehow imperfect, less than he should or could be, or somehow "sick" -- even if only academically -- and in need of a cure. In its commonest meaning we understand "remedial" to involve the "correction" of something wrong or in bad repair. Consequently, as I have seen it in many initial advising sessions into which the parents have intruded themselves, parents themselves, despite their desires for their children, do not want their children in these courses; they refuse to be labelled as the parents of a person in need of remedial courses. Parents, of course, won't admit, perhaps even to themselves, this reality. Instead they argue about paying for courses that won't transfer, that aren't part of the requirement for their son or daughter's major. Who, then, can blame the student for not wanting to be stigmatized, irrevocably branded even on his college transcript as non-normal. I do not think a cessation of use of the word remedial is the solution, and I certainly don't advocate not telling the student that he needs "remedial" help. I do think the telling could be humanized and compassionate. I think the reality of the need can be expressed in terms of the student's own best long-term interests (even though at 18 he probably is not thinking in the long-term), because without such courses, even though non-transferable, he may not be able to transfer anywhere except to back home and to a job he may not want.

Fourth, in placing students in such courses, we probably lean too heavily upon the standardized tests. I do not deny the value, nor the implications of the SAT score, as a predictor of future success in college, but I conclude that we can too easily determine a student's future if we, as individual teachers, let all of our judgments on the individual student's behalf be framed by our acceptance of the value of the nationwide, comparative ranking. We violate our roles as humanistic, educated people if we chart future live on the basis of a supposedly objective, non-subjective test score. We do use SAT scores in English placement here, but I feel that we regard these scores as an indication of what is likely to be the future academic success of the student <u>only if</u> we do nothing else but sit back, wring our hands, and whisper "sad, sad."

I do think we have made an attempt to utilize these data as they were intended to be used: as indicators and screening devices, and not as social determiners. In the self-study produced for our Spring 1976 North Central Evaluation, the study's authors pointed out that only 18.7% of our students had SAT scores above 450; 36.2% fell into the 350-450 range; and the remaining 42.1% were below 350.[5] In our program as it now exists, we have used SAT scores for initial English and reading placements. All students with verbal scores below 330 must enroll in our remedial, non-transferable reading course, "Reading Techniques." All students with scores above 600 are given advanced placement in Composition I. While most accept this advanced placement, some do not. At one point in our development toward our present approach we had a remedial composition course into which roughly half of our incoming, first-time students were placed largely on the basis of their SAT scores. As I understand it, the same cut-off -- higher than the presently used 330 score -- was used for placement in both reading and basic composition. To our credit, we did test all students so placed with other standardized instruments, or, in composition, with a diagnostic essay. Students whose additional scores and/or demonstrated abilities ran counter to the SAT placement were excused from their remedial contexts by the end of the first week of classes.

Because I think we are becoming more successful every semester in the Reading Techniques course, I would like to comment briefly upon that program before turning to the composition program. Once a student is placed in Reading Techniques, he is tested with the Nelson-Denny Reading Test. The test is a timed test, and it is essentially a screening device, not a descriptive instrument. Consequently, it doesn't really tell us much about our students except that they cannot read. The test itself is geared--in readability--toward students with 9-12 grade reading levels. Students lacking those reading equivalents do poorly, because they cannot even read the test, and while we can place them into a reading level equivalent, the test does not really pinpoint the students' problems. Greater precision than this is important when we deal with students who expect to fail. Therefore, we have developed a test of our own. The test is non-timed, is diagnostic and descriptive, and is intended ultimately to pinpoint the problems of students who read below the 6th grade level. (It is possible to be measured at the 6.2 level in Vocabulary on the Nelson-Denny if one gets even one of a hundred items, each with five choices (distractors), correct. The comprehension unit measures at 6.0, if one gets seven of thirty-six items correct. It seems possible that sheer guessing on vocabulary will result in more than one right answer.) We have attempted to validate the test items by administering it to our entire group at the beginning of the present semester. The test has also been evaluated and judged basically sound by Dr. Roger Farr of Indiana University, who has national stature on testing and who authored the widely-used Iowa Silent Reading Test. My purpose in pointing out this test development is not to heap laurels on the intellects of its authors, or to label them "innovators," but rather to suggest that innately our reading faculty responded to the factors I discussed briefly above and is concerned with the needs of its students. As a group, the reading faculty has developed a flexible syllabus which permits a kind of personalized-individualization of its program to deal with each student at his own level.

In addition to its more "method-oriented" activities, this group has also managed funds to keep its reading labs available several nights per week for use as an "open lab." Within the program itself, we are also developing reading units, and vocabulary and jargon lists directly applicable to the University's various curricula, especially the vocational curricula. This effort is undertaken to try to establish"common ground" with the student, and therrby overcome his hostility and sense of the non-applicability of the program to his total course of study. All of these activities--and many more not subjected to similar oversimplification have been undertaken as part of a conscious effort not to reduce the student to a standardized test score, but to approach him as an individual, breathing human being.

Our modularized, self-paced approach to Composition I has a more pragmatic history than our approach to reading. First, until five years ago we had a separately identified remedial course in composition. As a consequence, I have been told, of Admissions area complaints that V.U. was hard to market because of that three-to-six hour (one-to-two semesters) requirement of that program, we were mandated to develop a self-paced, and/or modularized, and/or anything else that would do, hopefully in one semester, all the same things we were doing in both the remedial and composition programs.

More nilly than willy, we developed a new program. Through several years of revision, we presented the program in "packet" form. Each student took six separate pre-tests in six areas of grammar and usage. If he failed a test, he purchased the packet covering that area. Once he managed to pass all these areas, then he was permitted to write. He then took a pre-test in an area like Exposition. The pre-test consisted of an essay on an assigned topic. If the essay passed, the student moved on. If he failed, he bought the Exposition packet, worked exercises, sample paragraphs, and then wrote a post-test. One of the problems with this approach was that it did not encourage the student to become interested in writing until he passed all of the grammar tests. These grammar tests were not validated statistically, nor were they evaluated in concert with a sample of the student's writing. Consequently, the student's course of study became "individualized" only when the teacher finally got to him. The process was very efficient for him only if his last name began with "A". Since the course was self-paced, students could exit the course as quickly or slowly as their abilities permitted. In each fall semester that this approach was used, about 400-5-- students--perhaps 50-100 fewer than would have been in the old Basic Composition program--did require at least two semesters to complete the course. To exit, however, the student had to complete all his work at a "C" level (some at a C-). There was no possibility of a D or F in the course. This part of the course construct is still in force.

Two years ago we sought a publisher, completely revised all the units, and published them in three texts. While the packets had been combined into larger units, the student still needed to buy only those texts his teacher assigned. However, the student still had to pass all grammar areas before he could begin to write. We added one rhetorical unit to the five already in use. Where we had had a pre-test and possible post-test in each rhetoric area before, we did away with the rhetoric pre-test concept and permitted the student to write directly for a grade. We drastically shortened the exercises in the rhetoric chapters and converted some exercises into small graded units which were "programmed" as a preparation for the one or two long assignments in each writing genre. Where we had had a possibility of five essay pre-tests and five post-tests requiring 3400-4000 words, we now had thirteen paragraph and short essay assignments totaling about 2800 words in all. Apparently we underestimated the psychological impact of <u>thirteen</u> assignments, even though five were only paragraph length. In the first semester of the texts' use, 592 students, a 20% increase, required an additional semester to finish the course. By spring semester, we revised the number of assignments by canceling the paragraph-length papers (which had been required exercises before we published in book form). My point is that we had individualized and modularized, but we had failed to take the student himself into adequate account. Low in both self-esteem and ability, he collapsed under the weight of what only <u>seemed</u> a heavy load. Beyond just limiting the number of assignments, we also have established a contract system--with explicit due dates for each unit--which encourages the student to work in stages toward limited goals. Once he accomplished the work required for a "C" grade, the student can exit the course, or he can continue to work for a higher grade.

Unfortunately, we still have the problem of dealing more realistically with our testing in the basic skills, but we have been working for some time to reduce those six, fifty-item tests to one, fifty-item test. We computer graded and analyzed all of last year's testing to develop a core of items for a validated test. As we got into the analysis of our print outs, we realized that the histograms implied that some of the tests were not valid. Others seemed more so. Initially we performed a statistical validation process which eliminated 90% of our test items. From our experience, we knew that such a stringent process was not "valid". Our tests had been accurate, by our observation, and therefore needed a different statistical consideration. However, we ultimately chose not to eliminate the items which the upper 28% got wrong and the bottom 28% bot right, and not to eliminate the items which the top group got right and the bottom group wrong. Arbitrarily we eliminated all items which at least 72% of the entire sample got right on the premise that these items probably tested commonplace problems which most could handle. From the remaining items which seemed to test situations that many students were not absolutely sure of, we fashioned the one composite test.

In a limited and unscientific way we developed a "culturally fair" diagnostic test, geared to Indiana students with low SAT scores, which seems to have worked. As a result, our new pre-tests more clearly distinguished among the students bunched at the 72% level. The stronger students held above the 72%, but the linguistically weaker students dropped far below. Since we are employing these pre-tests for diagnostic purposes, no grading bias was significant to us or to the students. We recognized who required modular work and who did not. We assign no grades to the completion of the Basic Skill Modules. The reliability quotient of the items in the test bank--our immediate goal in a computer generated repeatable test system--averaged in the six areas as 0.77 to 0.79. Also, we have linked this composite test to a written essay for joint evaluation as the professor determines the additional aids the student needs to resolve any deficiencies. We also decided that by withholding the student from writing until he mastered (at 70%) all the grammar units, was both artificial and unwise: artificial because it separated grammar and usage from a direct application context; unwise because it failed to capitalize on the first-time student's basic enthusiasm at the beginning of the semester.

We made one other major change in the program. Prior to this year, we placed hardware and appropriate software in each classroom in which Comp I was taught for use during the class hour. The arrangement was costly and inefficient. It also made the teachers feel like clerks, a complaint since the inception of the program. Since we had long ago decided that the low teacher morale had engendered resistance to this new, modularized system in which professors no longer lectured or held discussion, we sought for several years to get the money to equip a centralized Comp I writing lab.[6] Once funded, we changed paint colors, bought much new equipment for the lab, gave the teacher a chance to lecture briefly at set dates to these self-paced classes, largely freed the teacher from this clerk-like role in the classroom, and purchased a broad range of new support materials. The immediate results were improved faculty morale (partially in response to the new high level of administrative support in funding) and a more enthusiastically executed program. In the long term we expect that, since we had traditionally taken the problems of the student into account, the new faculty enthusiasm will produce a better program for the students. In the short term, use of the lab has increased beyond all expectations. Last week along, more than 1200 students on both voluntary and class-hour related bases made use of the facilities in the lab.

Although we use machines extensively, we have learned that, contrary to the reigning educationist gospel, individualized instruction, per se, is not a solution, and that machines, unless used properly, do anything but personalize instruction. We have discovered, not surprisingly, that to some degree, just removing the remedial tag from Comp I has reduced some student resistance to the idea of applying more than one semester, when needed to the completion of the course. We have not, however, misled students who need the remedial work necessary to adequate completion of the course.

FOOTNOTES

1. Merril Sheils, "Why Johnny Can't Write," Newsweek, 8 December 1975, p. 58.

2. For an interesting statement of this view, see Ossie Davis', "The English Language is My Enemy," reprinted in TLE Six, Louis Locke and others, ed. (New York: Holt, Reinhart and Winston, 1972), pp. 205-06.

3. Paula Johnson, "The Politics of 'Back to Basics,'" Profession 77 (New York: Modern Language Association of America, 1977), pp. 18-21.

4. For an up-to-date discussion of the SAT score decline, see the study produced by the advisory panel organized by CEEB and ETS.

5. Self-Study, 1976 (Vincennes: Vincennes University, 1976), p. 18.

6. For a nuts and bolts (perhaps too simplified) article on building the individualized program, see William Belmore and Martha Sellers, "Individualized Instruction," Community College Frontiers, 5 (Winter 1977), 13-17.

NATURAL PRODUCTS IN CHEMICAL EDUCATION

Chemistry in Wood Preservation

Donald A. Kulp
Southern Wood Piedmont Company
East Point, Georgia

Presented as a part of a Natural Products in Chemical Education Symposium at the Fifty-Seventh, Two-Year College Chemistry Conference, Clayton Junior College, Morrow, Georgia, December 10, 1977.

Wood preservation is the art of protecting timber in any of its forms against deterioration by any agency which would attempt to destroy it by utilizing it for food. This protection is accomplished by the application of a chemical or chemicals. Typical destructive agencies are fungi, insects, and marine borers. Service life of wood is accomplished by controlling one of four factors, the control of any one of which will arrest deterioration. The first factor is cellulose, which the destructive agencies use for food. The second factor favoring deterioration is a favorable temperature. The third factor is moisture, and the fourth factor is air. The only one of the four that man can control economically is the food supply so that by the application of wood preservers the cellulose is made inedible. The very nature of our business depends on chemicals, on chemists who develop the materials for preventing deterioration and chemical methods used to evaluate the work that has been done.

There are three major types of chemical wood preservatives in use. The granddaddy of all preservatives is creosote. Creosote is a by product of the destructive distillation of coal and 162 different chemicals are found in creosote.

The second major type is pentachlorophenol. The first form used was trichlorophenol, later tetrachlorophenol was used, and eventually pentachlorophenol was developed by complete chlorination of the phenol molecule. The functions and applications are similar to creosote but the process imparts a rustic brown color to the wood instead of the black creosote color.

The third major type of materials includes the water borne salts of chromium, copper, and arsenic which used in combination in wood in the right proportions become permanently affixed to the cellulose in the wood. This process imparts a light olive green color with a beige undertone color to the wood. Certain utilities will prefer one process over the others to obtain the color of pole desired for ecological considerations.

Costs are about the same for the three types of materials for imparting service life to items such as railroad cross ties, building poles, lumber, car decking, and cross arms.

There are several methods for application of wood preservatives. The least effective is brushing and spraying such as would be done by a homeowner brushing wood preserver on some porch decking. The next method is dipping or cold soaking such as when a farmer soaks fence posts in a stock tank of preservative for up to 72 hours. The next most effective method is a hot and cold bath. The poles are put into an open tank and the wood preserver is heated up and then the hot preserver is pumped off and cold preserver is added or the poles are put into cold preserver involving a partial vacuum effect.

The most effective method is the pressure treating process. The industry is set up to use this method. The heart of the pressure treatment plant is a tubular pressure cooker type cylinder 6-10' in diameter (most are 8' in diameter) and 105'-123' long with track laid in the cylinder to accept the tram cars loaded with material that are rolled in the cylinder before the doors are bolted on. To treat pine air pressure is built up to 40 p.s.i. and preservative is added to fill the cylinder to overflow. Perhaps 10 pounds of preservative may be added per cubic foot and creosote weighs 9 pounds per gallon so more than a gallon of creosote may be added per cubic foot. Following the pressure treatment a vacuum of 25" or 26" is applied for an hour to remove excessive preservative from the wood cells.

Douglas fir from the west coast is more difficult to treat so that instead of applying pressure first a vacuum is used first to aid entrance of preservative.

In general woods that are more durable resist treatment and woods that deteriorate rapidly accept treatment more readily. White oak is very durable but is harder to treat than red oak which is less durable.

Wood treatment specifications may include the amount of wood preserver retained in the wood and the depth of penetration. In the case of southern yellow pine the required penetration is 2 1/2". Poles that do not have specified retention and/or penetration must be retreated.

Wood samples 0.2" in diameter are taken from every twentieth treated pole and checked in the laboratory visually for penetration and chemically for retained preservative. For creosote a toluene extraction method is used. The lime ignition method is used for measurement of pentachlorophenol. In the case of the water soluble preservatives the cores are dissolved with a mixture of nitric and perchloric acids and the liquid is analyzed for copper, chromium and arsenic. The American Wood Preservers' Association which is made up of suppliers, treaters, users, educators, chemists, consultants, commercial inspectors, and distributors of treated wood is the industry's specification writing organization. Its book of standards is the Bible of the industry. Assay methods are used as a measure of quality except for railroad crossties where gauge reading and penetration are used.

The service life of cross ties is about 40 years for mechanical reasons so that is the basis for the amount of chemical treatment applied. Poles have a 35 year service life.

Relating Chemical Fundamentals to the Environment

Winslow H. Hartford
Belmont Abbey College
Belmont, N.C. 28012

Presented as a part of a Natural Products in Chemical Education Symposium at the Fifty-Seventh, Two-Year College Chemistry Conference, Clayton Junior College, Morrow, Georgia, December 10, 1977

For the past six years a highly successful course "Man and His Environment I and II" EV 301-302 (4-4) has been taught at Belmont Abbey College. The course includes all the natural sciences and is taught with a humanistic approach to non-science majors who are mainly juniors and seniors.

The preparation for this course has been underway perhaps 60-65 years without my realizing it because what we are asking the people who take this course is to be aware of the world in which they live. Twenty-five years with a small company where teamwork is the key to efforts and 12 years with a large company are a part of this background. Awareness doesn't mean much unless it is tied in with a sense of values. The difference between man and the rest of the animal kingdom is that man is a scientist and animals are not and thus, man can reason out the difference between good and evil. The ability to observe, measure, and then decide has been involved from the earliest times.

The seven early metals were related to the planets and astrological signs. The sign of the element copper is allied to the sign for Venus, ♀, because ancient Egyptian looking glasses made of polished copper were used by women as shown on paintings in the tombs.

We owe a lot to Arabs as chemists because with the fall of Rome western culture declined and the Arabs took good care of science from 400 A.D. until it was brought back to the western world by returning crusaders. "Al" in Arabic is related to out world "the" as shown in "alkali" and the symbol "K" for potassium comes from the Latin "kalium" from the "kali". The word "alcohol" originated from "al" and "kohol" meaning literally "the medicine".

History teaches us that to simplify we must go back to basics. We cannot solve environmental problems by symptomatic treatment. Many times the cure is as bad as the disease.

Up until very recently our world has been a mechanistic world working under the principles of Isaac Newton and principles of the industrial revolution, not the principles of the electronic revolution, in which the initial work was done in the 1890's involving Becquerel, Roentgen, Einstein, Boltzmann, deBroglie, and Shcroedinger.

From here we go into the great principles; the first and second laws of thermodynamics: "You can't create matter or energy from nothing" and you can't create wealth from nothing either. The second law says that "you can't even break even".

Energy is degraded in translation. The pecking order of energy is considered: fusion > fission > x-ray > ultraviolet > visible > infrared > microwave. The translation of energy is related to the thermodynamic temperature. The wavelength of radiation is correlated with the absolute temperature, $h\nu = kt$. When somebody talks about translating energy with microwaves, forget it, the thermodynamic temperature os microwaves is below room temperature. In fusion, we are talking about temperatures of 10^8 or 10^9. Gravitation energy of the mass of the universe is the greatest source of energy. In 10 billion years only 10% of gravitational energy has been used up.

We consider cycles as in agriculture involving plants, animals, the sun, fuels, nutrients, and mechanical energy. The LeChatelier Principle is involved - nature fight back. It is important in the "greenhouse" effect. Usually the factor limiting growth of plants in fertile soil is the CO_2 concentration in the atmosphere. As plants grow, water vapor is produced and as the earth's temperature rises clouds will form, which reflect back solar radiation that would otherwise warm the earth.

Electrochemistry is a good example of the second law. For example, in the case of a fuel cell, which is reacting finally divided carbon with hydrogen peroxide yielding CO_2 and water, the E° is 1.64 volt and the ΔG is proportional to the voltage. In a laboratory cell with an internal resistance of 0.04 volt and electrodes of 100 cm^2 the current polarization or over voltage plus internal resistance heat loss increases as the current increases. This is why fuel cells after a very ambitious start did not get off the ground. The percent of the available free energy obtainable drops rapidly as the current drawn from the fuel cell rises.

One of the problems in the study of the environment is that the system is so massive that changes show up so slowly.

We talk about energy sources, ecology, field biology, mineral resources, food, and population problems. We emphasize the problems rather than the symptoms. We talk about thermodynamic soundness and being aware of what is going on in the environment.

The laboratory work is field trips. Fossil fuel power plants, nuclear power plants, nature study areas, mining operations, and chemical extraction facilities are visited.

In the second semester the students are introduced to the idea of growth and the Gompertz growth curve. Growth curves point to an eventual world population equilibrium at about 10 billion persons. Exponential growth can only be sustained in the early stages of the growth curve. Growth problems and business decisions are related to economics, political science, and sociology. The four solutions to all environmental problems are brought out:

(1) By voluntary action of a free and informed society.

(2) By economic pressures and incentives of the economy.

(3) By political fiat

(4) By purposeless drifting and violent readjustment through war, famine, disease, and death

The economics of environmental actions must be thought out through measurements and cost studies. Greed and apathy are the serious obstacles in resolving problems.

The syllabus and course outlines follow:

SYLLABUS

EV 301-302 MAN & HIS ENVIRONMENT I & II (4-4)

<u>Semester I</u>

Unit 1: History and philosophy of science: Scientific method and scientific law, particularly the basic laws of materials and energy.

Unit 2: Energy: sources, interconversion, environmental effects, long-range conservation and planning.

Unit 3: Ecology: ecosystems and energy; material and energy cycles; biomes, life-zones, and biological succession; food chains, food webs, and biological mangifications, stability, diversity, and change.

Unit 4: Mineral Resources: genesis, availability, energy-environment considerations. Hydrology and oceanography.

Unit 5: Human Ecology: demography and population trends; food and nutrition; environmental disease.

(Units 4 and 5 may be interchanged)

<u>Semester II</u>

Unit 1: Air: Meteorology, air resources, air pollution, air resource planning.

Unit 2: Water: hydrology review, water resources, water pollution, water resource planning.

Unit 3: Land: Land use, rural and urban; solid waste; land resource planning.

Unit 4: People: Economics, sociology, and politics of the environment. Social planning.

Unit 5: Values: Toward a solution. The ethics of it all.

<u>Textbook</u>: G. Tyler Miller, Jr. "Living in the Environment", Wadsworth, 1975.

<u>Course Mechanics</u>. Regular lectures, using guest speakers as available.

First Semester: 5 team reports, one on each of the subject areas. 5 field trips; Coal and nuclear power generation, field ecology, mineral mining and chemical processing, water supply.

Second Semester: 3 team reports, in the areas of air pollution and air resource planning; water pollution and water resource planning, and land use planning.

Second Semester (con'd)

3 field trips; environmental laboratory, sewage disposal paper mill. One computer study; air pollution. About 6 weeks before semester ends, teams choose a field problem, consult with civic planning organizations, visit the site, write a report.

Emphasis in examinations is on essay questions as opposed to objective fact-finding. In the 2nd semester, map problems depicting environmental problems are an important part of all examinations.

Students are provided with collateral book references which are updated each year. There are three bibliographies available; the one in Miller; the current "Environmental Abstract Index", and a privately prepared bibliography (indexed) listing about 1000 references in the Abbey Library covering 1971-1975. Students are asked to use these information sources and avoid general encyclopedias. Some collateral references are:

Hodges, Laurent. "Environmental Pollution", 2nd ed. Holt, Rinehart and Winston, Inc. New York, NY 1977.

Hammond, Allen et al, "Energy and the Future", American Association for the Advancement of Science, Washington, DC, 1973.

Recommended Reading List:

Bronowski, Jacob. "The ascent of Man", Little Brown & Co., Boston, MA, 1976.

Miller, G. Tyler, Jr. "Energetics, Kinetics and Life: An Ecological Approach", Wadsworth Publishing Co., Belmont, CA, 1971.

Commoner, Barry, "The Poverty of Power", Bantam Books, Inc. New York, NY, 1977.

Schumacher, E.F., "Small is Beautiful: Economics as if People Mattered" Harper & Row Pubs. Inc., New York, N.Y. 1973.

Miller, G. Tyler, Jr. "Living in the Environment, Concepts, Problems Alternatives", Wadsworth Publishing Co., Belmont, CA, 1975.

Ophuls, William. "Ecology and the Politics of Scarcity: Prologue to a Political Theory of Steady State:, W.H. Freeman, San Francisco, CA., 1977.

Cox, Harvey. "On Not Leaving it to the Snake", MacMillan, New York, NY 1978. (Out of print)

Meadows, Donnella H; Meadows, DennisL.; Randers, Jorgan; Behrens III, Wm. W., "The Limits to Growth; A Report of the Club of Rome's Project on the Predicament of Mankind", 2nd ed., Potomac Associates, Washington, DC, 1974.

Saturday Review. Dec. 10, 1977 "God and Science: New Allies in the Search for Values", an SR Special Report pp 13-43.

Plant Materials in Teaching Chemistry
Acid-Base Indicators from Purple Pen Hulls and Dark Blue Grape Hulls

W. G. Sink
Bloomsburg State College
Bloomsburg, PA

Presented as a part of a Natural Products in Chemical Education Symposium at the Fifty-Seventh, Two-Year College Chemistry Conference, Clayton Junior College, Morrow, Ga., December 10, 1977.

The red coloring matter of the hulls from purple peas attracted our attention as a possibility for demonstrating paper chromatographic separation. The development of a complete color range is quite rapid requiring only about 3 days from green to dark blue giving an almost black appearance.

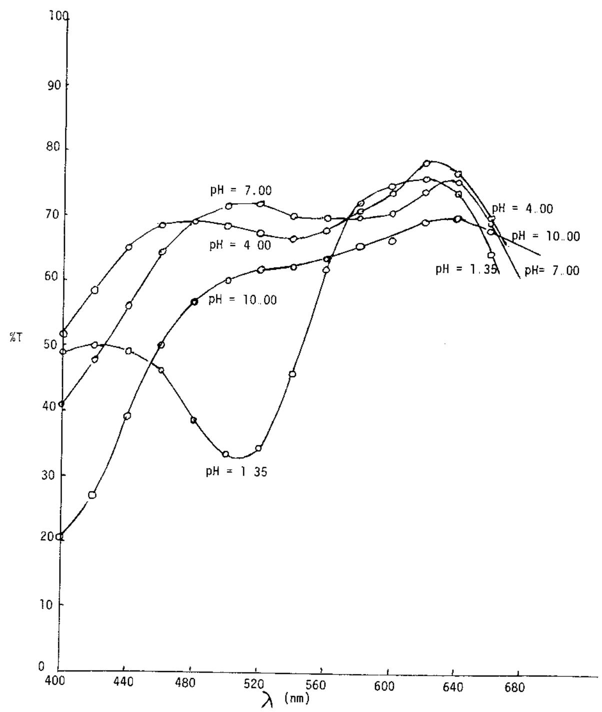
A batch of green purple hulls was extracted with alcohol giving a beautiful red solution. "Green" hulls throughout this paper refers to hulls before becoming dry. Attempts were made to separate this chromatographically with alcohol-acetone solvent and also by adding water to the mixture. Apparently this gave some resolution into the red colored material and chlorophyll. In attempting to develop the color bands with $NH_{3(g)}$ and $HCl_{(g)}$ a distinct color change was noted that was sharp and reversible.

The chromatographic investigations were abandoned in favor of further investigations of the colored product as a possible acid-base indicator. The colors are: pink in acid in basic solution with the visual change at approximately pH = 4.20. Figure 1 shows a series of curves for 5T = f (λ) at various pH values.

Figure 1.

Spectral Curves for Pea Hull Indicator

%T = f (λ) at various pH values



Differences in the nature of the color from green and dry hulls are seen in Figures 2 and 3. I think the main difference is due to the presence or absence of chlorophyll. However, either serves as a good indicator.

Figure 2

Ethyl Alcohol Extract, Green Pea Hulls

%T = f (λ) in basic, neutral, and acid solutions

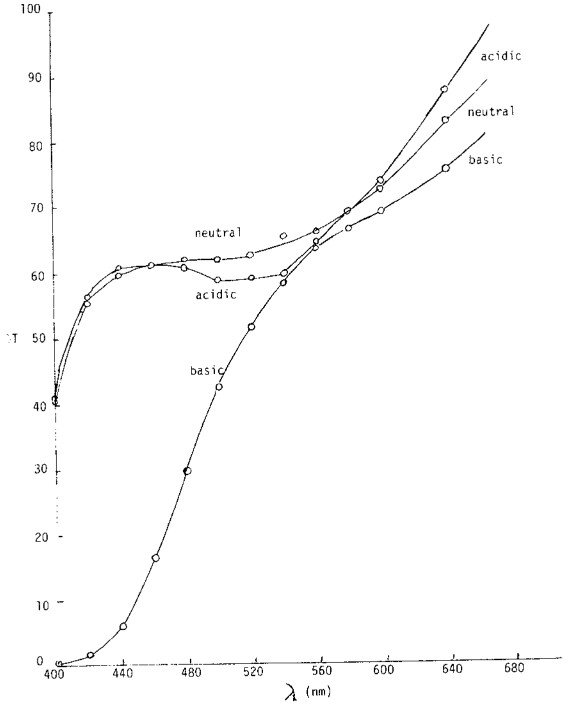
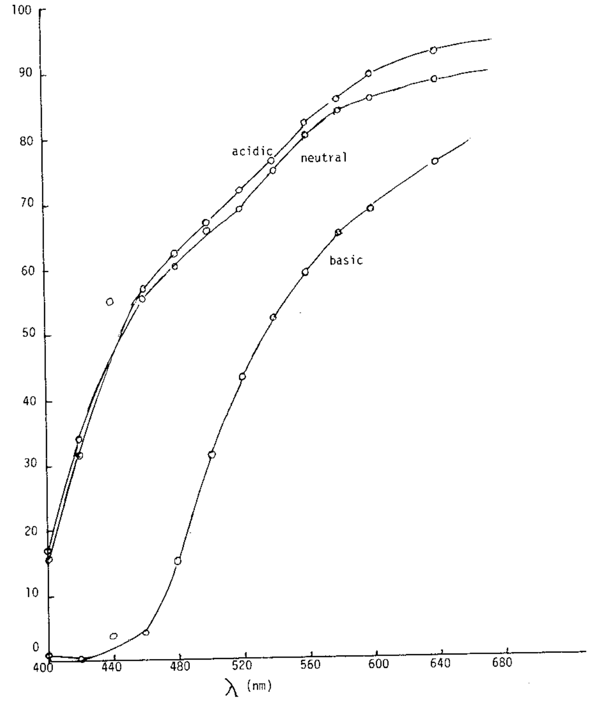


Figure 3

Water Extract Dry Hulls in 20% Alcohol

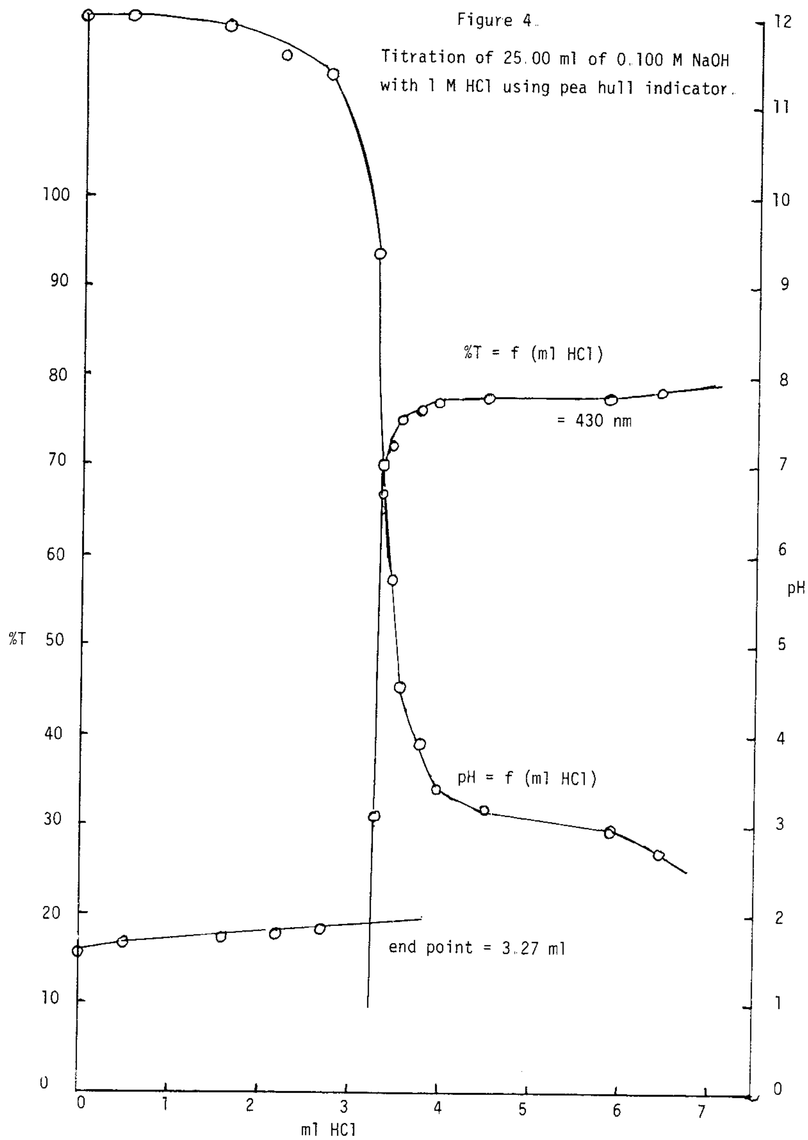
Proteins precipitated by alcohol

Basic, neutral, and acid solutions



A solution in 20% to 25% ethanol seems to be stable for long periods of time. My samples show no deterioration after 4 months. Also a sample was evaporated to dryness obtaining a highly viscious, almost plastic mass which is quite stable and which readily redissolves in water.

As further tests of the usefulness of this indicator several photometric titrations were made. A typical result is shown in Figure 4.

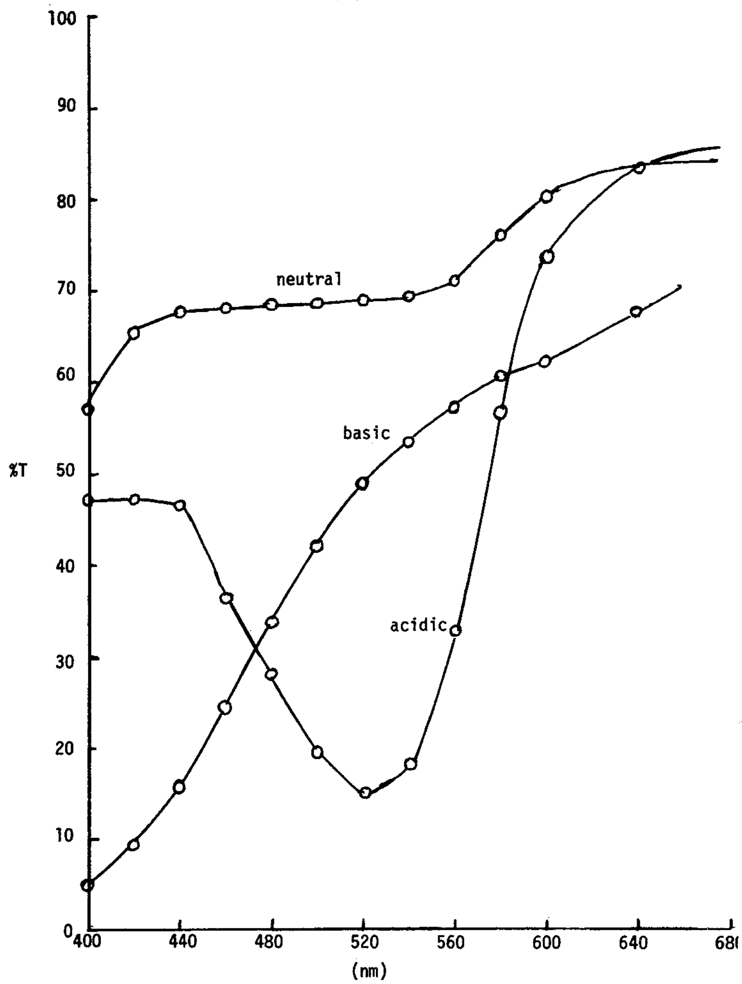


In the meantime the coloring matter from dark blue grapes was similarly investigated. Again very sharp end points were obtained in either direction. To get relatively "pure coloring matter the hulls from grapes were extracted with hot water. This gave beautiful colors--red in acid and green in base.

Figure 5 shows the "purer" red nature of grape hull coloring matter and explains the sharp color transitions from acid to basic. Actually the maximum difference in 5T occurs at 400 nm. However, here we see a decided difference between acidic and neutral colors as contrasted with pea hull extract.

Figure 5.

Grape Hull Extract
(one drop per milliliter water)



Similarly pH-photometric titrations were made using grape hull indicator. Again both end points are very sharp.

It is hoped that these experiments might suggest some projects involving natural plant products. If you have infrared equipment you might like to take up the study of the chemical changes as the pea hull coloring matter develops during the maturity period.

Practically, either of these colored products have excellent potential as acid-base titration indicators. They offer definite advantages over phenolphthalein in titrations of alkalinity because of the sharp change from base to acid. This is particularly useful for teaching purposes since standard acids are more stable and less corrosive on burettes. Also they can serve as good indicators for photometric titrations.

In addition they have potential as harmless food coloring materials and the alcohol precipitated protein from pea hull extract has potential as a nutritive food adjunct.

Water Sampling and Analysis with Environmental Implication

W. G. Sink
Bloomsburg State College
Bloomsburg, PA 17815

Presented as a part of a Natural Products in Chemical Education Symposium at the Fifty-Seventh, Two-Year College Chemistry Conference, Clayton Junior College, Morrow, Ga., December 10, 1977.

"Natural" water samples afford many opportunities for typical chemical analyses that enhance student interest because of practical environmental implications. Many of these can be carried out satisfactorily with either inexpensive equipment or with sophisticated instrumentation, depending on the purposes and facilities available. Also they provide good exercises in stoichiometry.

A list of some typical analyses that can be made are given below along with a few remarks.

1. Solid Contents

   Measuring the samples can provide some early practice in the use of volumetric apparatus, balances and filtering techniques. By supplying flow rates for stream samples, calculations of total sedimentation loads for specified time periods (e.g. tons/year) provide good exercises in scientific notation. Dissolved solids contents can be related to ionic conductivity if conductivity meters are available.

2. pH

   pH measurements may be carried out with the use of indicators or with pH meters. Not only is this important in the "health" of natural water sources but the student may enjoy preparing his own phenol red indicator and measuring swimming pool samples.

3. Color

4. Turbidity

   Turbidity measurements are of practical importance as a measure of water treatment plant efficiency. If colored samples are obtainable they can be used to provide an introduction to and practice **with simple** spectrophotometers.

5. Hardness

Titrations with EDTA can serve to introduce the preparation of a standard solution, the standardization of a titrant and the concept of complexation. Titrations of hard water with "standard" soap solutions are interesting in that the formation of the insoluble soap provides an insight into "bath tub rings". In either method the effect of removing hardness ions with cation exchange resins is very interesting.

6. Dissolved Oxygen (DO) and Biochemical Oxygen Demand (BOD)

Measurement of DO by the Winkler (or Modified Winkler's) provides a wealth of practical chemical analytical experiences. The stoichiometry in converting dissolved oxygen to manganic hydroxide to free iodine to thiosulfate is excellent. Students can use simple titration apparatus with pre-standardized thiosulfate or they can prepare and standardize their own solution.
DO can also be measured instrumentally using polarographic technique or oxygen specific electrodes with pH meters. These measurements provide interesting information when applied to a variety of samples involving different types of sources under various conditions of depth, flow rate, temperature, pH, seasons, etc. My deep well sample shows practically zero DO.

Besides providing routine type analytical measurements these provide some excellent possibilities for undergraduate special and research type projects. Although suitable incubators may not be available for BOD determinations, similar determinations may be made quite simply. Measure the DO of a "good" water sample in a closed container and then add a sample of organic humus or leaf mulch. Withdraw sample at time intervals and measure the DO. This will be found to be depleted quite rapidly. For a high degree of depletion a "breather" with an oxy-absorbent should be provided. (Fig. 1)

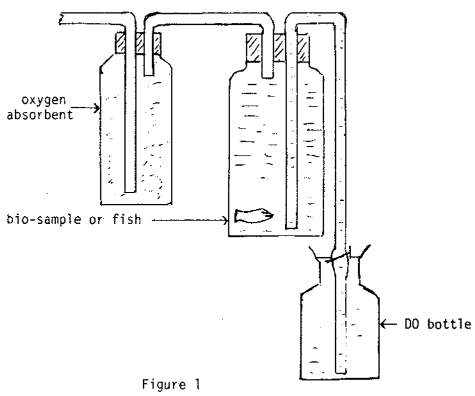


Figure 1

Similarly the DO depletion can be followed after introducing fish or other oxygen consuming organisms. Students can study the DO levels necessary for different species.

7. Chemical Oxygen Demand (COD)

The COD determination is an interesting redox method. The acid-dichromate can be standardized with a reagent grade sugar. From this can be calculated the factor given in the standard APHA method. An interesting application follows: A water supply in a small resort town developed an odor and undesirable taste. Guests were leaving the motels and the city fathers were desperate. Additions of chlorine at the rate of 3 to 5 pm were disappearing almost immediately. A COD measurement showed that an inversion had occurred in the storage lake.

Additional interesting projects can be assigned as follows:

1. Determination of DO saturation values as functions of oxygen pressure, temperature, pH and salinity.
2. The removal of oxygen by boiling.
3. The DO depletion by sweeping with inert gases as used in polarography.

8. Heavy Metal Cations

Toxic metals such as Hg, Cd, As, etc. in water supplies in highly industrialized areas are very important. These can be measured most effectively if atomic absorption (A.A.) equipment is available. Ordinary flame emission can be used for some metal cations.

9. Alkalinity

The APHA standard method using standard acid with double indicator end points (phenolphthalein and methyl orange) provides an excellent exercise in stoichiometry. From the two end points the free hydroxide, the bicarbonate or carbonate and total alkalinity can be determined.

10. Chlorine

The o-tolidine method can be done visually or instrumentally. This can be used to introduce the concept of synthetic standards. Students find it interesting to apply this to domestic water supplies and swimming pools. It also provides a good method to study the relative analysis error concept.

11. Phosphate

The blue phosphomolydate complex provides an excellent spectrophotometric method of high sensitivity. Phosphate levels are good pollution indicators. A student designed his own sampler, Fig. 2, and followed the level up a stream. On coming to a fork in the stream the PO_4^{-3} level told him which branch to take. This led him to a sewage disposal installation.

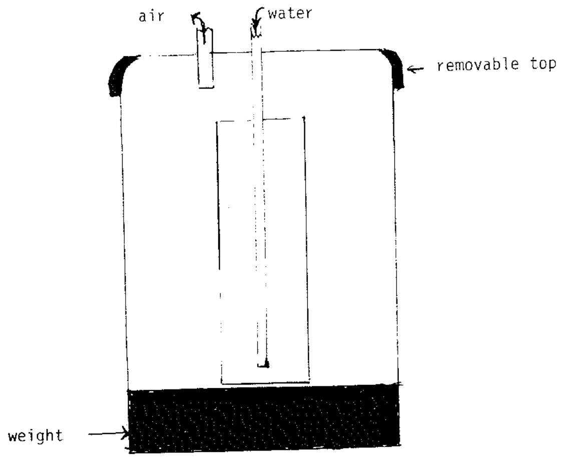


Figure 2.

General construction of water sampling bottle. Outside container should have a capacity of at least three times that of the inside container. The inside container is stoppered or capped before removing.

12. Nitrates

These are also indicators of pollution levels. Nitrates may be used to follow seasonal changes due to agricultural chemicals. Along with phosphates it provides information related to trophic levels related to eutrophication.

13. Chlorides

Chlorides may serve as a clue to land fill seepage.

14. Pesticide Residues

References for Specific Methods

1. "Handbook for Analytical Quality Control in Water and Wastewater Laboratories" (1972) and "Methods for Chemical Analysis of Water and Wastes" (1974) by National Environmental Research Center, distributed by U.S. Environmental Protection Agency, Office of Technology Transfer Washington, D.C. 20460.

2. "Standard Methods for the Examination of Water and Wastewater," American Public Health Association, Inc.

3. Various Collections of Standard Analytical Methods and Analytical Instrumentation Books.

4. ASTM Standard Methods.

Modeling the Biosphere — Chemistry, Physics, and Biology for Environmental Planning

William M. Cooke
University of North Carolina
Charlotte, N.C. 28223

Presented as a part of a Natural Products in Chemical Education Symposium at the Fifty-Seventy, Two-Year College Chemistry Conference, Clayton Junior College, Morrow, Ga., December 9, 1977.

Several scientific disciplines are integrated into a mathematical treatment of the dispersion of pollutants in the North Sea. The project discussed was a joint effort of 400 scientists sponsored by the European Common Market, NATO, and Belgium. This study required five years and produced a mathematical tool for characterizing the chemistry of the North Sea region.

A mathematical model is a computer program. Meteorology, hydrology, and ecology data are fed in and the model can be used in environmental planning.

Eight heavy metals, several pesticides, nutrient, nitrogen, phosphorous, silicon are measured and followed in the North Sea model. The geographic boundary is established and it is subdivided into niches. Complex calculations are required by the movement of the water. Heavy metals are added from the land. Sulfur compounds from the land are oxidized to sulfates and then reduced in the sea to H_2S and released to the air. The heavy metals such as iron, copper and manganese tend to precipitate as sulfides near the sea coasts, especially near estuary inlets. When oxygen content is down to 5 ppm fish can barely live. At Antwerp the oxygen content is zero and the river is sterile. Pollutant tend to move up the coast and the mussels have to be grown in sanitary ponds inland now.

Mass balances can be calculated for a niche resolving inputs and losses of materials.

Sailing ships are ideal for obtaining samples as they do not emit organic pollutants. Automatic sampling units are now available for obtaining samples regularly in addition to the land stations. Data is fed into a computer in Brussels.

Mathematical models can also be used in predictions of action of radioactive materials in air.

Natural Products — In and Outside the Classroom

Sherman Burson
University of North Carolina
Charlotte, N.C. 28223

Presented as a part of a Natural Products in Chemical Education Symposium at the Fifty-Seventh, Two-Year College Chemistry Conference, Clayton Junior College, Morrow, Georgia, December 9, 1977.

Biochemistry is a good course for using natural products as a vehicle for maintaining interest. Biochemistry really is natural products. It is amazing to me how easy it is to get involved in mechanisms, theories, concepts and let biochemistry get to be really a theoretical and dry kind of chemistry. I spent five years in pharmaceutical research on lipids, polysaccharides, proteins, and vitamins and my graduate work was on the synthesis of vitamins so that I had a real advantage in natural products from my background.

It is my feeling that within reasonable limits the topical list is less important than the background of experience of the instructor of the course and how the instructor relates with the students. It means more to the student to have the instructor talking about something that he has done personally or something in which he has a vital interest.

This material came from the textbook *Advanced Organic Chemistry* by Fieser and Fieser, Reinhold (1961). This book starts with some natural products and products made from them.

cane	$\longrightarrow$	sugar	prehistoric
fats, oils	$\longrightarrow$	soap	
roots	$\longrightarrow$	indigo, alizarin	ancient Egyptians
mollusk	$\longrightarrow$	Tyrian purple	Phoenicians
pine rosin	distillation $\longrightarrow$	oil of turpentine	
(adapted to increase the alcoholic content of wine c.a. 900 A.D.)			
wood	pyrolysis $\longrightarrow$	charcoal and pyroligneous acid	
grape	$\longrightarrow$	tartaric acid	
lemon	$\longrightarrow$	citric acid	
apples	$\longrightarrow$	malic acid	
milk	$\longrightarrow$	lactic acid	
fats, oils	$\longrightarrow$	glycerol	
urine	$\longrightarrow$	urea	Rouelle 1773
animal tissue	$\longrightarrow$	cholesterol	Cherruel 1815
opium	$\longrightarrow$	morphine	Serturer 1805

In 1931 Butenandt isolated androsterone. From 15,000 liters of urine 15 mg androsterone were obtained.

The analytical methods used to characterize the compound had been developed in 1831 by Liebig, and in 1911 Pregl developed micro analysis.

The structure of cholesterol was established in 1932. In 1934 Butenandt confirmed the structure of androsterone. The synthesis of androsterone from cholesterol is an interesting process.

Androsterone is a derivative of male sex hormone and testosterone is a primary hormone and much more powerful and it is interesting to compare their structures with the differences in activity and to compare these structures with those of female hormones.

A capon unit is used to measure activity of hormones and is the amount of substance that injected into each of three capons on two successive days produces on the third or fourth day an average increase of 20% in comb area as measured by a shadowgraph.

The vitamins provide illustrations of vital natural substances. Vitamin B_{12} and biotin have especially interesting structures and properties. A dictionary of chemical names can be a source of interesting examples.

Formic acid, for example, was isolated in 1749 by the distillation of red ants and the name comes from the Latin "formica" for ant.

Another source of information is Azimov's Biographical Encyclopedia of Science and Technology, New York, Avon Books, 1976. The people are listed in chronological order and there is a name index in the front and a subject index in the back. It is very interesting to read from one person to the next.

Council Members of the Royal Institute of Chemistry in Great Britain have compiled abilities and qualities necessary for successful chemists as given in Chemistry in Britain.

Ability	Qualities
integrity	personal and scientific integrity demonstrating honesty, trustworthiness, reliability and moral courage
logical thought	
communication	includes ability to listen and read
technical competence	capability to maintain up to date practical and theoretical knowledge and understanding in chemistry generally and in ones area plus other disciplines
scientific initiative	powers of observation, and perception needed for original, creative, and inventive thought
analysis	
motivation	
collaborative ability	
natural products	
industriousness	
practical expertise	
safety consciousness	

LEADERSHIP QUALITIES

integrity	motivator	foresight	analysis
judgment	decisiveness	knowledge	stability
communication	organization	dedication	loyalty
industriousness	personality	human sensitivity	

It is interesting that integrity is first on both lists. In terms of leaders our goal is not robots who are going to become technicians in the laboratory, but human beings who are going to become practicing contributing individuals.

I think we have a need to get back to basics. There is a need to consider the needs of our students as potential chemists, as human beings, how we interact with them, how we exploit our own advantages of experience and background and in terms of natural products. I think that natural products represents to me a really useful kind of teaching tool. I think each one of us represents a natural product in a real sense to be exploited to the fullest in teaching work with each one of the individuals with whom we deal in the classroom.

APPROACHES TO TEACHING CHEMISTRY

The Undergraduate Research Experience

George Sanzone
Virginia Polytechnic Institute & State University
Blacksburg, Virginia 24061

Presented to a General Session at the Fifty-Third, Two-Year College Chemistry Conference, Delgado Community College, New Orleans, LA, March 18, 1977.

Abstract

An Experimental Program in undergraduate Chemical Education is described in which 47 students from 16 academic disciplines have participated. The program stresses the Liberal Arts nature of chemistry in the teaching of non-chemistry majors. It is based on the premise that chemistry is elevated to the rank of a liberal art not by its being studied, but by its being done by the students. This has required a new definition of Undergraduate Research.

During the past seven years a great number of students, primarily nonchemistry majors, have entered my laboratory to engage in undergraduate research. The object of this talk is to share some of my experiences with these students and to try to understand just what is the irresistable lure to work in an overcrowded room in an old and obsolete chemistry building.

To begin our discussion, we should perhaps agree on some definitions. First, we might ask: What is Research? A rather formal answer might be: Research is a purposeful attempt to extend the frontiers of knowledge. My students give a much more relaxed answer: "Research is getting nothing done every day until you're done." The formal, more-stodgy, definition will do for our purposes. Next we ask: What is Undergraduate Research? If research is the advance of the frontiers of knowledge, then undergraduate research is NOT research done by undergraduates.

The problem is that the frontier of our undergraduates is not the same as the frontier of our science. In fact, no two of my students have had the same frontier. Also, if we do our job right, the frontiers of our students change as our students develop. Consequently, we have adopted the following definition: any undergraduate working at his individual frontier is engaged in undergraduate research. With this definition, the research experience is available to all students, no matter what their academic level or the major area of study.

Now you might ask, why should we engage ourselves in this activity called undergraduate research? There are two viewpoints which must be considered.

First consider the Instructor's point of view. Many of us are greedy; undergraduates might be considered as tools with which to get our personal research moving. But there is little likelyhood of this kind of progress with the first or second year non-major students we are discussing. Perhaps the motivating factor is a desire to teach. This ambition is realizable. The kind of students who enter this type of program are self-committed; they want to be there. Frankly, if we cannot teach this kind of student, we are in the wrong business. Another reason for engaging in the direction of undergraduates might be a personal desire to lose sleep. For the fact is, you must be willing to commit at least two hours per week per student you direct. We conclude that the basic reason for a faculty member to operate an undergraduate program will be a masochistic desire to teach students in a one-on-one teaching situation.

Now let us consider the Student's viewpoint. What can we offer the lower-level undergraduate non-chemistry major. I believe that what we offer is a unique Liberal Art experience. The program I am about to describe is predicated on the idea that Chemistry is a liberal-arts subject. But what is it that elevates a subject to this level? Consider some of the other liberal arts. Everyone cannot write a poem or a book, yet everyone can obtain the literary experience by reading. In the fields of music or art, some, but by no means all of us, can play musical instruments, draw or sculpt. But everyone of us can experience music, painting and sculpture by listening to or seeing it. The essential feature is participation, feeling, experiencing. If Chemistry is a liberal art, it is not the studying of Chemistry, it is the doing of Chemistry which elevates it to this level. This is why we have tried to share the research experience with any qualified student who wants it, no matter what the student's major field of study or academic level.

How does our philosophy or approach to the definition of undergraduate research work in practice? In the past seven years, 52 students from 16 disciplines, freshmen to seniors, have participated in this program. See Table I. In general the group has always been a mixture of chemistry and non-chemistry majors. The chemists stay in the group longer and provide continuity in the projects. The non-chemists usually stay for one or two years. Almost every student who joined the group thought they could contribute little to the program; almost every student was wrong!

TABLE I

Student's Major Discipline	No. of Students
Agriculture	1
Agricultural Education	1
Biochemistry	3
Biology	3
Chemical Engineering	3
Chemistry	18
Computer Science	2
Electrical Engineering	7
Electrical Engineering Technology	1
English	1
General Engineering	1
Horticulture	1
Mathematics	1
Mechanical Engineering	3
Physics	3
Physchology	1

Some idea of the range of projects worked on by the students can be obtained from the titles of the student-presented papers listed in the Appendix.

The bulk of the rest of this talk will involve slides of student projects. All of the illustrations shown will be:

slides of student-built systems, or
slides from student papers, or
slides of student notebooks.

The following are examples of work done by first and second year students.

Case Studies

(a) 4" diameter shock tube
(b) 1" diameter shock tube
(c) sampling orifices
(d) quadrupole mass spectrometer ion source
(e) electron multiplier
(f) quadrupole oscillator
(g) gas inlet systems
(h) G.C. - Mass Spec problem
(i) Mass-Spectrometer Shock-Tube Sampling Problem
(j) A student-built Time-of-Flight spectrometer
(k) CS Synthesis
(l) CO and CO_2 Lasers

SUMMARY

With proper guidance, with proper motivation, with the proper environment, undergraduate students can do anything! But most of all, undergraduates can learn and they can enjoy learning.

Two major pitfalls were encountered. As the group grew, the problem was to make certain that each student was growing. A student seminar sequence was established. We meet one evening (or Saturday morning) each week to hear seminars on various aspects of the work of the group. The students give the talks and criticize each other's presentations. The second problem was to keep the students from putting too much time on their projects at the expense of their other courses. Frequently, we have had to slow our students down and to encourage them to work on their formal courses.

The program in undergraduate research has been, we believe, truly successful. In closing, I would like to express another note of philosophy. In our work, we are not trying to convert non-chemists to chemists; we do not proselytize. While in lab, the math major remains a math major, but the chemistry he does is tailored to show him how math is applied in chemistry; similarly with the other disciplines. The student's choice of major is treated with respect. Although there may be little difference in the professional training of a freshman or sophomore chemistry or English major, there is a tremendous difference in attitude, in the way each student thinks of himself. This question of attitude is more critical for non-technical majors. If we as scientists would like the respect of non-scientists, then we must return this respect in kind.

The Chemistry Lab as a Search for Pattern

Ralph Gable
Davidson College
Davidson, N.C. 28036

Presented to a General Session at the Fifty-Seventh, Two-Year College Chemistry Conference, Clayton Junior College, Morrow,Georgia, December 9, 1977.

We generally want to teach the tools of the trade to the students. These are both actual physical equipment tools and apparatus and metal tools and techniques, and manipulative abilities that are necessary to chemists. We like to have experiments that give experience in the use of experimental methods, to have the students evaluate data, and as illustrations of how things behave - the chemical principles. Seeing how things behave is very important.

At Davidson College we have an introductory course for nonscience oriented students called "The Science of Chemistry" which starts with a little philosophy of science and the structure of the scientific revolution and moves on into current ideas, theories, and our understanding of matter from the chemical point of view and then into a consideration of natural products, the environment and the significance of this to the individual in later life.

The laboratory is an important part of the course. The students are generally well motivated. I have moved to have the course not graded for the laboratory in the case of my students so that the students and I can be strictly on the same side of the desk and the student response has been very good and having the idea of the laboratory as a search can be followed up on better without problems of assigning grades for looking in the wrong place on the part of the student. On the other hand, if we are attempting to teach the use of techniques like titration, grades are certainly important, but for this course exploring was more important than the finding the professor's answers.

I start the laboratory the first day of class at the student union and it consists of a card game called "Eleusis". It is described in several places by Martin Gardner in his second book of mathematical puzzles and games published in 1961 and in 1959 he described it in a Scientific American mathematics and games column and it has been published several times by the author of the game, a Mr. Abbott. It happens that just two months ago in October of this year, Martin Gardner again came back to the Eleusis game and describes the "New Eleusis Game" which has some new rules. The game is a strong analogy to the history of the development of scientific thought. We try to understand our experiences. This means defined relationships between various experiences. I refer to these as pacts. In the Eleusis game, briefly, the individuals form into small groups. The dealer, who can be called "Big Daddy" or "Mother Nature" makes up a rule on which the cards are to be played and then the other players play their cards and are told either a "yes, the play was successful" or "not successful". The idea is to be successful as possible. Of course you can be successful if you understand what the rule is or you should have a lot better chance at it. Really this is the way we work in science. We may not realize it, because a lot of other people have played the game ahead of us, but we depend on the rules as they have been perceived by other scientists. We start out thinking of chemistry as a pattern of relationships in an analogy to finding patterns among the cards. The game itself gives an analogy to the scientific method in its strengths and its weaknesses. The students have the opportunity to experience having successful hypotheses thrown out. They experience the development and rejection of ideas during the course of a two or three hour laboratory period.

We have the students thinking of chemistry relationships and looking for patterns in topics like equation balancing and stoichiometry. They can appreciate how today's fact may become tomorrow's nonsense as they have experienced having successful theories blasted in the course of the card game.

In the second laboratory moving from the man made patterns without the fear of acids the students are given Campbell's "blue bottle" experiment. The student shakes the bottle and it turns blue and then clears up. If it is shaken again, it turns blue and clears up. The idea is to explain this. The hypotheses are based on what is seen. One is that a blue material is distributed and then rises up. About one hour is spent working in the laboratory and the professor and the assistant ask questions, not answer them, to help the formulation of ideas. Then a symposium is held in class to relate the ideas and get a concensus as to the reaction. This reaction is described by J.A. Campbell in J. Chem. Ed. 578-583, 1963.

It is an oxidation of glucose and the oxygen carrier is methylene blue. This reaction is related to the hemoglobin carrying oxygen through our blood and oxidizing glucose in the body.

In the next experiment they work with a sealed bottle that they do not open. At the end of the experiment the bottle is opened to show that it had a partial vacuum.

In the next experiment they are checked into their desk, taught to use the analytical balance, and shown film strips of laboratory equipment to give them background.

The next period they make a tin oxide and from the composition the formula is calculated. The variations are considered and non-stoichiometric compounds are discussed.

Moving into another realm of an applied type antacid tablets are compared - Tums[R], Rolaids[R], and the smaller Phillips tablets. They are titrated semi-analytically for comparison. Relevance of measurements is discussed. Water hardness or alkalinity could be done.

Field trips are made to the local water plant and the local sewage plant to observe applied chemistry.

A couple of the periods are used for discussion. A required part of the course is a paper written by the student of equal weight to the hour test. The laboratory groups of about 16 members present these papers each on a significant topic in science or technology at the discussion sessions. One lab period is used for check out.

It is not a comprehensive lab and it is not designed for the person who has to take more chemistry but throughout is the idea of chemical laws and our understanding of science as really an expression of relationships between things. Use of the Eleusis game shows in a more relaistic way how scientists accept, use, and discard ideas.

Operation of a Chemical Engineering Technology Lab

John R. Hallman
Paul D. Neumann
Nashville State Technical Institute
Nashville, Tennessee 37203

Presented to a General Session at the Fifty-Seventh, Two-Year College Chemistry Conference, Clayton Junior College, Morrow, Georgia, December 9, 1977.

The building of a pilot plant is an accepted part of the process of taking a chemical reaction from the glassware stage to the full scale plant.

It is also accepted industrial practice to employ engineers, chemists, and technicians, including chemical engineering technicians to operate, test, check-out, and maintain chemical units both pilot plant and full scale size.

Nashville State Tech offers a unique two year chemical engineering technician training program that is Engineer's Council for Professional Development (ECPD) approved and which in= cludes a substantial amount of industrial type experience. Since 1970 the construction of a laboratory facility duplicating as closely as possible an industrial pilot operation has been underway. Full utilization is made of the ingenuity of each student. The designing of much equipment is done by the students. The students do their own fitting, piping, electrical work, and checkouts. The plant is designed in the form of an operating loop and the storage tank for finished material is also the raw material supply. The liquid is pumped, heated, cooled, split apart, evaporated, blended and restored. Methods are devised by the students for obtaining samples and checking them. The material must be taken out and put back at the same flow rate, composition, and temperature.

The evaporator has a capacity of about 35 gallons per hour. Eventually it is planned to have a mixture of isopropyl alcohol, glycerine and water with enough sodium chromate to run a magnetic system and the isopropyl alcohol will be taken out at the evaporator and blended back in at the center in the same composition as it was taken out. This will create some interesting analytical problems.

The construction of the apparatus commenced in 1970 and pumps, heat exchangers, recorders and other components have been added to by successive classes as funds have permitted. All parts are required to be installed level and square. Terminology and measurement skills are stressed.

An $8.000 computerized sampling and mixing unit was designed and built by the students.

A 12,000 gallon tank and the evaporator are permanently installed, but the rest of the equipment components are equipped with wheels and can be taken apart and reassembled for practice. The efforts to operate the equipment have generated many practical problems that the students have learned from.

In the operation of the equipment a second year student is teamed with a first year student so that the skills of operating controls can be passed on.

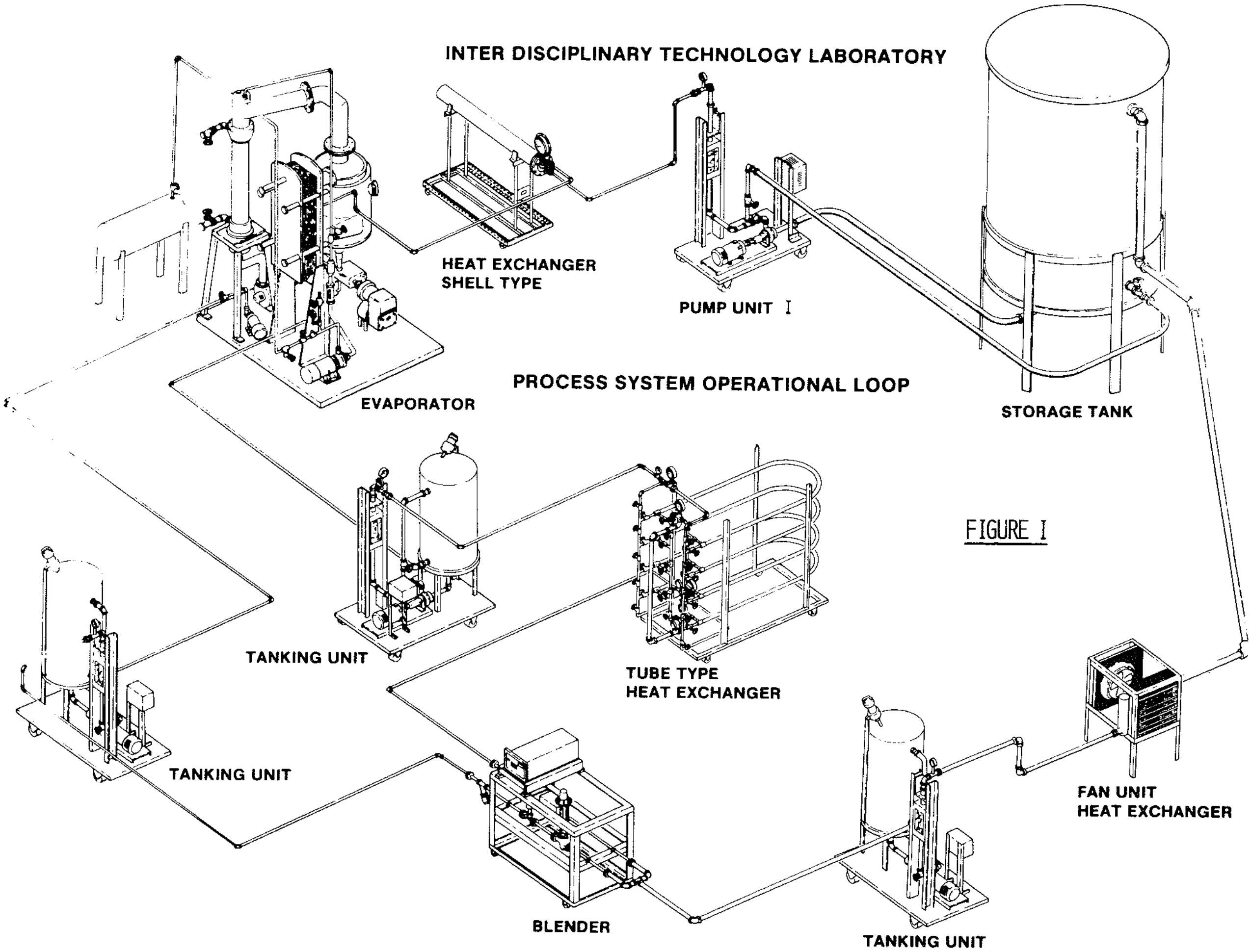


FIGURE I

Pitfalls in the Development of a Nontraditional Chemistry Course

Gloria Cooper
Central Piedmont Community College
Charlotte, N.C. 28204

Presented to a General Session at the Fifty-Seventh, Two-Year College Chemistry Conference, Clayton Juniot College, Morrow, Georgia, December 9, 1977.

The philosophy of the development of a nontraditional chemistry course for the non-scientific person is to seek to accommodate the student whose educational background rules out the more conventional college level chemistry. It endeavors to attract these students by introducing topics that are relevant to the student's everyday living modes and to whet his/her appetite for further study in the area.

The course uses a non-traditional open laboratory that allows flexibility of schedule. The laboratory experiences are designed to take the student into the community for an on-the-spot look at the community in action and the use of chemical techniques and their relevance. The experiments are designed around these community labs (i.e. the crime laboratory of the local police department). The laboratory subjects for the experiments are primarily provided by the student (i.e. cosmetics, antacid tablets, paint samples, digarettes of different brands, or samples from the home bar). The group interaction periods consider topics of interest following a brief presentation on the topic.

The pitfalls are numerous. They exist in the realms of obtaining proper guidance and counseling for the student, orientation of faculty attitudes to this type of course, selection of a reference book with enough technical background, and yet relevant to the student. Constant re-evaluation of the course content is necessary. One should include the proper amount of material and cover fewer topics well rather than making the mistake of trying to cover too much material. Therefore, the course outline should be concise and relevant. The outlint needs to be reevaluated and student input is desirable. When an outline doesn't work, change it.

Relevancy In Chemistry Teaching

William B. Robertson
East High School
Charlotte, N.C. 28223

Presented to a General Session at the Fifty-Seventh, Two-Year College Chemistry Conference, Clayton Junior College, Morrow, Georgia, December 9, 1977.

In recent years, introductory chemistry textbooks have made extensive usage of such qualifying subtitles as "A Contemporary Approach," "Action Chemistry", "A Conceptual Approach", "An Environmental Approach", "An Interdisciplinary Approach", "A Learning Systems Approach", "A Life Science Approach", and "A Modern Introduction", to name a few, to call attention to the application of chemical principles to areas of current emphasis.

Teacher guides accompanying most of the currant chemistry textbooks for the introductory chemistry course, at both the high school and college levels, abound with recommendations for effect chemistry teaching. It is generally agreed that there is no one best method of teaching chemistry. Inasmuch as we deal with a heterogeneous group of students in each section having different backgrounds, experiences, interests and personal goals, it behooves the dedicated chemistry teacher to employ all available techniques in order to motivate a goodly number of students. Most teachers agree that motivation is generally easier in the introductory course.

However, interest once aroused must be maintained and hopefully improved in an effort to slow the rate of attrition that characterizes many first-year courses. A technique recommended by the author, which has been found to be effective in both high school and college chemistry teaching covering more than twenty years, is the constant emphasis on relevancy in both the lecture and the laboratory programs.

Many students taking introductory chemistry as an elective or as a required course ask, "What good is this to me?" This "show me" attitude plus those who are anti-science oriented can be effectively met with a strong infusion of relevant examples of chemical principles. The transition from the conventional laboratory and problem-solving activities to those of relevant application is largely due to my youngest son, Jim, now a polymer chemist, when enrolled in my Chemistry II course. While perusing my personal chemistry library, he noted that many laboratory experiments had been used over and over again. He asked for permission to analyze sea water and to synthesize some "worthwhile" compounds instead of the same "old thing". The ensuing approved experiments really turned him on and gave him the "feel" of chemistry.

There are numerous relevant laboratory experiments available in current first-year laboratory manuals to choose from in developing a relevant approach to conceptual experimentation. A number of suggestions are herewith presented for your consideration. For example, from the television commercial, "Do Rolaids[R] really absorb 47 times their own weight in stomach acidity?" can be effectively answered in a very relevant laboratory experiment that seems to really turn students on. The experiment can be expanded to compare other antacid products. The percentage chromium in a chrome razor blade, the zinc content of Lavoris, the synthesis of an alum from scrap aluminum cans, the fluoride content of water, and the analysis of commercial bleach have been well received by my students and added a new enthusiasm to the laboratory program.

Problem solving activities can be similarly treated. Instead of the usual formulas employed in mole problems, the formulas of relevant substances, some produced in local chemical industries, plus an inclusion of practical information about the substance is very well received. Lithium metal for example, is mined at nearby Bessemer City, NC. Surveys revealed that few students knew anything about lithium metal and its compounds. Mole problems dealing with relevant lithium compounds was very well received. Tetraethyl lead was the basis for another set of problems that not only provided homework dealing with the mole concept, but provided much relevant information for the student in the introduction. A sample set is provided for your consideration.

<u>Atoms, Molecules, and Moles</u>

1. Given: Lithium (from the German word "lithos" meaning stony) was discovered by Johann Arwedson (Sw)

in 1817 and named by J.J. Berzelius. Lithium, a white metal with a silvery luster, is the lightest solid element known having a specific gravity of 0.531. It is a member of the alkali metal family (Group I-A) and the least active chemically. The metal melts at 180.5°C and boils at 1336°C. The electron configuration is $1s^2$, $2s^1$ with an atomic radius of 1.33 angstroms and a univalent cation radius of 0.60 angstroms.

FIND:
- a. mass of 1 mole (g-atom) of Li metal .... ______ g
- b. number of atoms in 1 mole of Li metal ..... ______
- c. mass of a single atom of Li .... ______ g
- d. melting point of Li .... ______ °F
  ______ °K
- e. density of Li metal .... ______ g/cm^3
- f. volume occupied by 16.75 grams of Li metal. ______ cm^3
- g. number of moles of Li metal in 16.75 g .... ______
- h. number of atoms of Li in 5.25 g .... ______
- i. atomic radius .... ______ in
  ______ microns

SOLUTION: (Show all work below including units.)

Atoms, Molecules, and Moles

2. Given: Lithium occurs in trace amounts in most rocks with the average content of the earth's crust being estimated at 0.006%. It is frequently a minor constituent of natural brines and spring waters. Lithium metal is mined from open pits near Bessemer City, NC. The primary source is spodumene (lithium aluminum silicate) $LiAl(SiO_3)_2$ or $LiAlSi_2O_6$. Extensive deposits of spodumene is also found in Quebec. The commercial production of lithium in the United States has become important only since 1930. Lithium never occurs in the free state. Forty-two percent of the total grease used in the United States contains lithium soap. The wing skins of aircraft operating at Mach 2 are constructed from lithium-aluminum alloy.

FIND:
- a. mass of 1 mole of lithium aluminum silicate ______ g
- b. percent lithium in spodumene .... ______ %
- c. percent aluminum in spodumene .... ______ %
- d. percent silicon in spodumene .... ______ %
- e. number of moles of $LiAl(SiO_3)_2$ in 137.25 g of the compound .... ______
- f. number of grams of Li that could be obtained from 350.75 grams of lithium aluminum silicate.................................... ______ g
- g. number of grams of Li that could be obtained from 18.25 pounds of $LiAl(SiO_3)_2$....... ______ g

SOLUTION: (Show all work including units.)

3. <u>Given</u>: Lithium reacts easily with many elements. The metal reacts at room temperature with nitrogen to form the reddish-brown nitride, Li_3N. The halogens (F, Cl, Fr, and I) react readily with lithium, light being emitted. The reaction of lithium with hydrogen produces lithium hydride, LiH. The metal burns when heated in oxygen to form the oxide Li_2O. The interaction of ammonia gas with Li_3N forms lithium amide, $LiNH_2$. The amide starts to decompose at 320°C, melts at 375°C and is transformed above 400°C to the imide, LiNH. Lithium alloys with Al, Cu, Pb, and Mg.

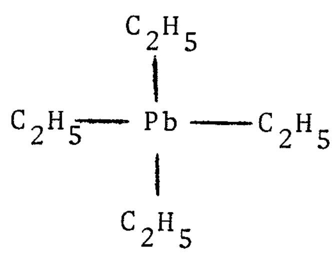
FIND:
a. mole weight of lithium amide .... ______ g
b. weight of a pound mole of lithium amide ...... ______ lb
c. number of atoms in 1 molecule of lithium amide ______
d. number of molecules in 1 mole of lithium amide ______
e. mass of a single molecule of lithium amide ... ______
f. number of grams of Li obtained from 18.85 g of $LiNH_2$ .... ______
g. number of grams of Li in 0.750 mole of $LiNH_2$. ______
h. number of atoms of Li in 0.750 mole of $LiNH_2$. ______
i. percentage Li in $LiNH_2$ .... ______
j. number of moles of $LiNH_2$ in 47.75 g of $LiNH_2$.. ______

SOLUTION: (Show all work including units.)

3. <u>Given</u>: The phenomenon known as "knocking" in an internal combustion engine depends markedly on the nature of the constituent hydrocarbons in gasoline. The "knocking" tendency of a fuel is expressed in terms of an "octane number". The octane rating of a gasoline product may be greatly improved by the addition of small amounts of tetraethyllead (TEL), sometimes referred to as tetraethylplumbate or lead tetraethyl. This antiknock agent controls the concentration of free radicals and in the prevention of premature explosions in the combustion chamber. Tetraethyllead is a colorless, oily liquid with a faint fruity odor, whose vapors form explosive mixtures with air. It burns with an orange-colored flame with a green margin. Tetraethyllead has a specific gravity of 1.653 and boils at 200°C with decomposition. The vapors are very toxic and fatal lead poisoning by ingestion, vapor inhalation, or skin absorption may occur. Open-cup flash point is 185°F.

The formula for tetraethyllead is given as: $Pb(C_2H_5)_4$ or $(C_2H_5)_4Pb$

The structural formula is:



FIND: a. Mole weight of tetraethyllead .... ______ g

b. Percentage composition .... ______ %C
______ %H
______ %Pb
______

c. Number of atoms in 1 molecule of cpd ..... ______

d. Number of molecules in 1 mole of cpd ...... ______

e. Mass of 1 molecule of cpd.................. ______ g

f. Number of moles in 98.75 grams of cpd...... ______

g. Number of grams in 0.625 moles of cpd...... ______

h. Number of atoms of lead in 0.625 mole of cpd ______

i. Number of atoms of lead in 98.75 g of cpd . ______

j. Density of tetraethyllead.................. ______ g/cm^3

k. Volume occupied by 0.625 mole of cpd...... ______ cm^3

l. Mass of 62.50 ml of cpd .... ______ g

m. Glash point of tetraethyllead.............. ______ °C
______ °K

n. Grams of Pb that can be obtained from 1.65 moles of tetraethyllead................... ______ g

o. Grams of Pb that can be obtained from 1.75 pounds of tetraethyllead................. ______ g

p. Number of moles of tetraethyllead in 1.25×10^{22} molecules of cpd .... ______

q. Number of millimoles of tetreaethyllead in 37.75 grams of cpd .... ______

SOLUTION: (Show all calculations including units. Attach additional sheets as may be required.)

Students are also interested in experiments that involve relevancy to daily activities. I have made a tabulation which, though not complete, lists lab manuals that contain such relevant lab exercises. Some have been particularly successful. An example is the making of alum from an aluminum beer can. An experiment on the synthesis of aspirin brings up the unit "grain". Witherite, impure barium carbonate can be converted to hydrated barium chloride, the empirical formula can be obtained, and the remainder can be analyzed for chloride.

Relevant Laboratory Exercises in Chemistry

LABORATORY CHEMISTRY, University of Maryland Staff, Vol. I. 2nd Ed. 1975 Burgess Puablishing Co.

Synthesis of Alum Crystals from Scrap Aluminum Metal, Exp. 6, p 40.
Analysis of Commercial Laundry Bleach, Exp. 9, p 59.
Analysis of Antacid Tablets, Exp. 11, p 69.
Determining the Mass of a Limiting Reagent, Exp. 7, p 46.

LABORATORY CHEMISTRY, university of Maryland Staff, Vol. II, 2nd Ed. 1975 Burgess Publishing Co.

Determining the Purity of Student-Prepared Benzoic Acid. Exp. 3, p 22.

FUNDAMENTALS OF CHEMISTRY IN THE LABORATORY, Irgolic, K.J. et. al. 2nd Ed. 1977. Harper & Row

Alum from Waste Aluminum Cans, Exp. 3
Antifreeze Mixtures, Exp. 7
Alka-Seltzer and a Little Gas, Exp. 8
Copper (II) and Algae, Exp. 12
Water Hardness, Exp. 13
Molecular Weight of Some Pharmaceutical Chemicals, Exp. 14
Caffeine in a Chloroform-Water System, Exp. 16
Some Commercial Antacids, Exp. 17
Caffeine and Non-Prescription Drugs, Exp. 37
Chemical Oxygen Demand, Exp. 39

WHAT CHEMISTS DO - A LABORATORY MANUAL, Nordmann, J. 1974. Harper & Row

Sodium Bicarbonate in Baking Powder, Exp. 7A
Urea in Urine, Exp. 7B
Lead in Glazes, Exp. 8A
Fluoride in Water, Exp. 8B
Iron in Water, Exp. 8C
pH of Commercial Natural Products, Exp. 9D
Total Acid in Citrus Juices, Exp. 10C
Vitamin C in Citrus Juices, Exp. 11A
Reducing Agents in Cold-Waving Solutions, Exp. 11B

A PRACTICAL LABORATORY MANUAL FOR COLLEGE CHEMISTRY, Shen, L.C. 1973 Barnes & Noble

Analysis of Table Salt, Exp. 12
Analysis of Chalk, Exp. 21
Crystallization & Analysis of Oxalic Acid, Exp. 22
Analysis of Aspirin, Exp. 23
Assay of Hydrogen Peroxide, Exp. 25
Analysis of a (Chrome) Razor Blade, Exp. 26
Analysis of a Household Bleach, Exp. 27
Purity of $FeSO_4(NH_4)_2 \cdot 6H_2O$
Assay of Vitamin C Tablets, Exp. 29
Analysis of a Silver Coin, Exp. 30
Precipitation Analysis of Nickel, Exp. 31
Precipitation & Analysis of $Cu(NH_3)_4SO_4 \cdot H_2O$

EXPERIMENTS WITH MATTER, S.S. Swain, 1975. North Carolina State University, Department of Chemistry, Raleigh, NC

- Halide Content of Sea Water, Exp. 11
- Do Rolaids® Really Absorb 47 Times Their Own Weight in Excess Stomach Acid, Exp. 16
- Phosphates in Detergents, Exp. 18
- Establishing the Stoichiometry of a Precipitation Reaction & Using It to Determine the Zinc in Lavoris, Exp. 21
- The Oxidizing Power of Bleach, Exp. 26

LABORATORY MANUAL FOR CHEMISTRY, MAN, AND SOCIETY, 2nd Ed. Jones, M.M. and Dawson, J.W. 1976., W.B. Saunders Co.

- Preparation of an Aluminum Compound from Aluminum Cans, Exp. 24
- Separation of Cations by Paper Chromatography, Exp. 8
- Titration of Magnesium Salts in Hard Water, Exp. 45
- Analysis of a Stomach Antacid Tablet, Exp. 15
- The Preparation of Aspirin, Exp. 27
- Swimming Pool Chemistry: The Effect of Sunlight on Available Chlorine (Hypochlorite), Exp. 49

FREEMAN LABORATORY SEPARATES, 1974. W.H. Freeman & Co.

- Isolation & Study of Caffeine, #1116
- Synthesis & Titration of an Unknown Acid, #1110
- Determination of Phosphate in Detergents, #1192
- The Use of Paper Chromatography in the Separation of Iron (III), Nickel (II), and Copper (II) Ions, #1245
- Determination of Sodium Carbonate in an Unknown - Volumetric Analysis, #1088
- The Formation of Salts, #1010
- The Enthalpy of Fusion of Naphthalene, #1098
- Vapor Density Method of Molecular Weight Determination, #1161
- Determination of Mole Weight By Freezing Point Depression #1097 & 1162
- The Formula of a Compound from Experimental Data, #1216
- The Selective Crystallization of Salts, #1035
- Heat of Solution, #1099
- pH, Hydrolysis, and Buffers, #1138
- The Oxidizing Power of a Household Cleaner, #1250
- Some Inorganic Preparations, #1238

EXPERIMENTS IN THE CHEMISTRY OF FOODS, Weaver, E.C., 1974. Manufacturing Chemists Association, Washington, DC

- Caffeine in Tea, Exp. 8
- Iodine in Iodized Salt, Exp. 9
- Recovery of Iodine from Seaweed, Exp. 12

LABORATORY PROBLEMS IN GENERAL CHEMISTRY, 3rd Ed. Nechampkin, H. 1962, Crowell Publishing Co.

Extraction of Eugenol from Cloves, Exp. 44
Analysis of a Tin-Bearing Alloy (Solder), Exp. 45
Determining CO_2 in Baking Powder, Exp. 28
Analysis of a Bleaching Powder, Exp. 28

ENCOUNTERS IN EXPERIMENTAL CHEMISTRY, jolly, W.L., 1973. Harcourt Brace Jovanovich, Inc.

Synthesis of Aspirin (Includes solubility tests and melting point determination as an index of purity), Ex-. 8
The Determination of Vitamin C in Foods, Exp. 17
The Analysis of Water for Total Cation Concentration, Alkalinity, Total Dissolved Salts, Exp. 18

QUALITIES & QUANTITIES IN THE LABORATORY, McCurdy, R.M., and Greene, H.H. 1975. Harcourt Brace Jovanovich Co.

Titrations and Solution Stoichiometry, Exp. 16
Preparation of Hydrated Barium Chloride from Witherite, Exp. 23. (This student syntehsized hydrate can then be used in the traditional laboratory exercise in the determination of an empirical and the gravimetric analysis of a water-soluble chloride.)

LABORATORY EXPERIMENTS FOR BROWN AND LEMAY CHEMISTRY, Nelson, J.H. and Kemp, K.C. 1977. Prentice-Hall, Inc.

Separation of the Components of a Mixture, Exp. 3
Chemical Reactions of Copper and Percent Yield, Exp. 6
Chemicals in Everyday Life: What are They & How Do We Know, Exp. 7
Paper Chromatography: The Separation of Cations and Dyes, Exp. 10
Determination of Orthophosphate in Water, Exp. 28
Analysis of Water for Dissolved Oxygen, Exp. 29
Preparation of Silly Putty: A Polymeric Silicone, Exp. 35
Quantitative Analysis of Oral Antiseptics, Exp. 36

Chaos Can Be Fun, If It's Organized

Rod O'Connor
Texas A&M University
College Station, TX 77843

Presented to a General Session of the Fifty-Eighth, Two-Year College Chemistry Conference, Santa Ana College, Santa Ana, CA, March 11, 1978.

The problems facing the general chemistry teacher today are in the same areas as those that have always faced teachers - how to select an appropriate body of knowledge to comprise the course content and how to impart that knowledge to students effectively. However, the teacher today faces some complications in both these areas that most teachers did not have a few years ago.

In terms of course content, the available catalog of topics for general chemistry has been significantly expanded in the last few years. A great deal of what used to be reserved for advanced courses in analytical or physical chemistry and, to a smaller extent, organic chemistry has become an accepted part of the general chemistry course. As a result much of descriptive chemistry, including discussion of common industrial processes, has been phased out. There is now a rather widespread feeling that a return to more descriptive chemistry may be desirable. The teacher is, therefore, caught in the dilemma of trying to select from an ever expanding body of knowledge those topics which are most appropriate to the general chemistry course without, in most cases, the option of increasing the number of credit hours for the course.

There is probably no "ideal" content for general chemistry, but the wise teacher will make a major effort to determine the prerequisite character of the course for student needs in subsequent courses in chemistry and related fields. The key to appropriate course content design, then, is the development of a feedback mechanism involving faculty teaching subsequent courses and former students at various stages of their academic (and, perhaps, post-academic) careers. Brief questionnaires are useful for this purpose, with a checklist of content topics that the evaluator may use to indicate the relative "prerequisite" importance. It should be noted that this "priority listing" is quite different from an evaluation of teaching effectiveness, although it may be physically included with an effectiveness analysis, as will be discussed later.

In the other major area, that of imparting knowledge effectively, today's teacher also faces some special problems. However, modern instructional technology offers some excellent problem-solving tools and appropriate feedback information can also be used in improving this area.

With a general national feeling that every student should be encouraged to pursue a college career, at least for a couple of years, the chemistry teacher today usually has a class that is quite heterogeneous in mathematical and scientific background, in interests and career goals, and in learning rates and mechanisms. To attempt to teach such a class by a method that worked well for a homogeneous group interested in chemistry has very little chance of success. Failure rates are likely to be high, unless standards are significantly lowered, and both students and teachers are likely to be frustrated and dissatisfied.

Background deficiencies identified early can often be remedied effectively by use of remedial and review programs involving computer-assisted-instruction or any of a number of other programmed or audiovisual techniques.

Reasonably uniform progress through a set of clearly specified learning objectives can be achieved with students of diverse learning rates and mechanisms by providing a variety of learning resources as alternatives or supplements to the conventional classroom activities of lecture and discussion. Such resources may include programmed-instruction materials, slide/tape units, films, videotapes, and other AV materials. A particularly promising resource for those with budget limitations is the microfiche program, first available commercially for college chemistry in 1978.

If, as in most courses today, student interests and career goals are diverse, these need not pose a problem. Rather, they can be employed as a positive motivation by providing varieties of problem sets illustrating applications of chemistry in other fields. While assisting in the learning of chemical concepts and problem solving skills, such applicational examples help develop a positive student attitude that in turn fosters more effective learning.

For courses involving self-paced instruction or multiple sections, the capability of producing large numbers of essentially equivalent exams is important for properly measuring student progress in the achievement of learning objectives. A technique useful for this purpose involves preparation of question variations on 5" x 8" cards for rapid assembly of alternate exam sets. Proper card coding and use records can ensure the uniqueness of each equivalent form.

Learning cannot be considered truly effective unless significant retention is involved. While short range retention can be measured reasonably well by comprehensive examinations (such as the typical "final exam"), the measurement of teachers in subsequent courses can prove useful in assessing retention of specific "prerequisite" material. Feedback questionnaires from students on how their progress is reflecting retention of general chemistry material can also be useful. This aspect of evaluating teaching effectiveness can be included with a request for content topic prerequisite value, as described earlier.

If a teacher truly wishes to assess the impact of an instructional system on student learning, post-course evaluation alone is not enough. This measures only what a student knows on completion of a course. Unless the student's knowledge was also measured at the beginning of the course, there is no real evidence of the role of the learning system in the student's accumulation of knowledge. Pre-testing, then, is a valuable component of any evaluation process. For schools giving advanced placement or other types of credit by examination, the pre-testing can be coupled with this activity. This not only provides useful initial comparison data, but it also affords a mechanism for students at an appropriate level of knowledge to "test out of" a course, avoiding the redundancy of "travelling a familiar road".

The innovative teaching of chemistry requires a continuing evaluation and program revision. If properly done, such teaching can be as creative and rewarding as any other research endeavor.

References

1. "Personalized Teaching for a Class of Thousands: The Learning Systems Approach", R. O'Connor & L. Peck., J. Coll. Sci. Teaching, VII(2), 85-87 (1977)

2. "Chaos Can Be Fun, If It's Organized", R. O'Connor., J. Chem. Educ., 54, 631(1977)

3. TOPICS-AIDS, R. O'Connor, American Chemical Society (Dept. 102), 1155 Sixteenth Street, N.W., Washington, D.C. 20036 ($4.75)

4. Solving Problems in Chemistry (2nd ed.), R. O'Connor, C. Mickey, & A. Hassell, Harper & Row, 10 East 53rd Street, New York, N.Y. 10022 ($6.95)

5. Microfiche Programs in Chemistry - write for latest information from Prentice Hall Media, 150 White Plains Road, Tarrytown, NY 10591

COMMITTEE ON CHEMISTRY IN THE TWO-YEAR COLLEGE

Division of Chemical Education
American Chemical Society

1979 ROSTER OF COMMITTEE MEMBERS

Chairman — John P. Mitchell, Tarrant County Junior College Hurst Texas 76053 (817) 281-7860)
Past Chairpersons — William W Griffin Hinds Junior College Raymond Mississippi 39154 (601-857-5261)
Curtis Dhonau Vincennes University Junior College, Vincennes, Indiana 47591 (812-882-3350 and 812-321-3952)
Douglas J Bauer Mohawk Valley Community College, Utica, New York 13501 (315-792-5378 and 315-896-6310)
Cecil Hammonds Penn Valley Community College Kansas City, Missouri 64111 (816-756-2800 and 913-648-7069)
Ethelreda Laughlin Cuyahoga Community College Western Campus, Parma, Ohio 44130 (216-845-4000)
William T Mooney Jr , El Camino College, via Torrance, California 90506 (213-532-3670)
Chairman-Elect — Paul Santiago Harford Community College, Bel Air, Maryland 21014 (301-838-1000)
Treasurer/College Sponsor — Dr J Smith Decker 444 East First, Mesa, Arizona 85203 (602-969-5466)
Secretary/Editor — Jay and Ellen Bardole, Vincennes University Junior College, Vincennes, Indiana 47591 (812-882-3350)
General Membership Chairman — Mike Knoll Vincennes University Junior College, Vincennes, Indiana 47591 (812-882-3350)

Region I — Western States

Alaska Arizona, California Colorado, Hawaii, Idaho Montana, Nevada New Mexico Oregon, Utah, Washington, Wyoming

Western Regional Vice-Chairman (1979): William H Wyatt, El Paso Community College, Colorado Springs Colorado 80903 (303-471-7546)
ARMSTRONG, Mabel K (1981): Lane Community College, Eugene Oregon 97405 (503-747-4501)
BIEVER Keith J (1981): Bellevue Community College, Bellevue, Washington 98007 (206-641-0111)
BOND Douglas (1979): Riverside City College, Riverside, California 92506 (714-684-3240)
CUNNINGHAM Alan (1981): Monterey Peninsula College, Monterey, California 93940 (408-649-1150)
GILBERT Margaret (1979): Trinidad State Junior College Trinidad, Colorado 81082 (303-846-5011)
HUBBS Robert (1979): DeAnza College Cupertino California 95014 (408-257-5550)
LUNDSTROM, Richard A (1980): American River College Sacramento, California 95841 (916-484-8137)
SCOTT Peter (1980): Linn-Benton Community College Albany, Oregon 97321 (503-923-2361)
STERNER Wanda (1980): Cerritos College, Norwalk, California 90650 (213-860-2451)
TAYLOR Robert (1979): Community College of Denver, North Campus, Denver, Colorado 80216 (303-287-3311)
TRUJULLO Anthony (1980): San Joaquin Delta College, Stockton California 95204 (209-446-2631)
VANDERBILT A.H (1981): Sierra College, Rocklin, California 95677 (916-624-3333)
WESTOVER Ross (1980): Canada College Redwood City California 94061 (415-364-1212)

Region II — Southern States

Alabama Arkansas, Florida, Georgia Louisiana Mississippi, North Carolina, Oklahoma, Puerto Rico, South Carolina, Tennessee, Texas

Southern Regional Vice-Chairman (1979): Charles Howard, University of Texas at San Antonio, College of Sciences and Mathematics Division of Earth and Physical Sciences, San Antonio, Texas 78285 (512-734-5381)
ALLISON Harrison (1980): Marion Institute Marion Alabama 36756 (205-683-2871) Mail to P.O. Box 548, Marion, Alabama 36756
BAKER Marion (1981): Valencia Community College, Orlando, Florida 32802 (305-399-5000)
BARBER Ms Anne (1980): Manatee Junior College 5840 26th Street W., Bradenton, Florida 33505 (813-755-1511)
BARTLEY Edith (1980): Tarrant County Junior College, South Campus, Forth Worth, Texas 76119 (817-534-4861)
CHEEK, William R (1979): Central Piedmont Community College, P.O Box 4009, Charlotte, North Carolina 28204 (704-373-6968)
HUSA, William J (1981): Middle Georgia College Cochran, Georgia 31014 (912-934-6221)
INSCHO F Paul (1979): Hiwassee College Madisonville, Tennessee 37354 (615-442;2128)
KING Floyd (1981): North Lake College, 2000 Walnut Hill Irving Texas 75062 (214-255-5230)
KUCHERA, John (1979): Northern Oklahoma College, Tonkawa, Oklahoma 74653 (405-628-2581)
LEACH, Bill (1979): North Harris County College, 2700 W Thorne Dr . Houston, Texas 770 (713-443-6640)
MINTER Ann P. (1980): Roane State Community College, Harriman, Tennessee 37748 (615-354-3000) (615-483-7124)
SIMS Joyner (1979): Chipola Junior College, Marianna, Florida 32446 (904-482-4935)

Region III — Midwestern States

Illinois Indiana, Iowa, Kansas Kentucky, Michigan, Minnesota Missouri, Nebraska, North Dakota Ohio, South Dakota, Wisconsin

Midwest Regional Vice-Chairman (1979): Cullen Johnson Cuyahoga Community College, Metropolitan Campus, Cleveland, Ohio 44130 (216-845-4000)
BURNS Ralph G (1980): East Central Community College, Union Missouri 63084 (314-583-5193
CLOUSER, Joseph L (1981): William Rainey Harper College, Palatine, Illinois 60067 (312-397-3000)
ELKINS Dean L (1980): Henderson Community College, University of Kentucky, Henderson, Kentucky 42420 (502-827-2867)
GREENBERG Elliott (1980): Prairie State College, Chicago Heights, Illinois 60411 (312-756-3110, Ext 272)
HITTEL David (1980): Bay de Noc Community College, Escanaba, Michigan 49829 (906-786-5802)
KOCH Frank (1979): Bismark Junior College Bismark North Dakota 58501 (701-223-4500)
MALIK, Virginia (1981): Cuyahoga Community College Western Campus, Parma, Ohio 44130 (216-845-4000)
REDMORE Fred (1981): Highland Community College, Freeport, Illinois 61032 (815-325-6121, Ext 331)
ROBIN, Burton (1979): Kennedy-King College, 6800 S Wentworth Avenue, Chicago, Illinois 60621 (312-962-3200)
SCHULTZ, Dorothy (1979): Jackson Community College Jackson, Michigan 49201 (517-787-0800)
SOSINSKY, Jack (1980): Loop Junior College, Chicago, Illinois 60601 (312-269-8056)
SUSSKIND Tamar (1979): Oakland Community College, Auburn Heights, Michigan 48057 (313-852-1000)
WEISSMAN Katherine E (1980): Charles Stewart Mott Community College, 1401 East Court Street, Flint, Michigan 48503 (517-845-3670)
WINKELMAN John (1978): Illinois Valley Community College Rural Route One, Oglesby Illinois 61348 (815-224-6011)
YODER James (1979): Heston College, Heston Kansas 67062 (316-329-4421)

Region IV — Eastern States

Connecticut, Delaware, District of Columbia, Maine, Maryland Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, Virginia Vermont West Virginia

Eastern Regional Vice-Chairman (1979): Vera Zdravkovich, Prince George's Community College, Largo, Maryland 20870 (301-322-0432)
ADAMS, David L (1980): North Shore Community College Beverly Massachusetts 01915 (617-927-4850)
AYERS Howard A (1980): Franklin Institute of Boston, Boston, Massachusetts 02116 (617-423-4630)
BERKE, Thomas (1981): Brookdale Community College Lincroft, New Jersey 07738 (201-842-1900)
Sister Bohdonna (1980): Manor Junior College Jenkintown Pennsylvania 19046 (215-885-2361)
BROWN, James L (1979): Corning Community College Corning, New York 14830 (607-962-9242)
CHERIUM, Stanley M (1979): Delaware County Community College, Media Pennsylvania 19063 (215-353-5400)
CLEVENGER, John V (1979): Lord Fairfax Community College, Middletown Virginia 22645 (703-869-1120)
CUCCI, Myron W (1981): Monroe Community College Rochester New York 14623 (716-442-9950)
FINE Leonard W (1980): Housatonic Community College Bridgeport Connecticut 06608 (203-336-8201)
GAGILONE Onofrio (1981): New York City Community College 300 Jay St Brooklyn, New York 11201 (212-643-7224)
HAJIAN, Harry G (1981): Rhode Island Junior College 199 Promenada St., Providence, Rhode Island 02880 (401-311-5500)
JEANES Opey D (1979): John Tyler Community College, Chester Virginia 23831 (804-748-6481)
PETERMAN, Keith (1981): York College of Pennsylvania York Pennsylvania 17405 (717-846-7788)
SOLLIMO, Vincent (1979): Burlington County College Pemberton New Jersey 08068 (609-894-9311) Mail to Box 2788, Browns Mills, New Jersey 08068
STEIN, Herman (1980): Bronx Community College, City University of New York, Bronx New York 10453 (213-367-7300)
VLASSIS C.G (1979): Keystone Junior College La Plume Pennsylvania 18440 (717-945-5141)
ZORANSKI, Ed (1980): Atlantic Community College Mays Land, New Jersey