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AUTHOR Bolton, Ruth
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ABSTRACT

This report traces the development of a "Practical Chemistry" or "Vocational Chemistry" course for high school students who do not plan to attend four year colleges. Work was begun in 1964 at Northview High School, Covina, California and has resulted in the writing of experiments and Teacher's Guide materials as well as textbook materials for a program entitled, "Action Chemistry." An evaluation of the course at Northview High School indicates that the grades of students enrolled in the course improve during the year they are enrolled. A description of the program and a listing of the text and experiment contents is included. (TS)

BUILDING A CHEMISTRY COURSE

FOR THE NON-COLLEGE-BOUND HIGH SCHOOL STUDENT

Ruth Bolton

Northview High School, Covina, California

Presented to the National Science Teachers Association at the Convention in Los Angeles, California, October 30 and 31, 1969, and to the California Chemistry Teachers Association in the meeting at the University of California at Irvine, California, December 4, 1971.

Two cries are abroad in the educational world today, one is for "relevance" and one for equal opportunity for all young people to share alike in everything education has to offer. No one can question the relevance of science in our modern technological society. The many courses in general science offered in secondary schools, even where science is not a requirement for graduation, recognize the need to give high school students an introduction at least to science. But these courses do not go far enough. Courses developing the basic concepts and practical skills of the individual disciplines, biology, chemistry, and physics are needed, not only for colloege bound students, but also for those planning at most on some type of occupational training after high school. Such courses should be scientifically sound, even though their design must take into account limited background, low reading ability, and poor mathematical skills in the students. This calls for a new and fresh approach, and enrichment by constant relating of the science to everyday life and economic opportunity.

HISTORY

At Northview High School, the need became clear early in the 1960's. Students frequently dropped in at the chemistry laboratory saying they wished they could take chemistry but were sure they could not pass the course. They wanted to learn something about the subject and were also conscious of the chemistry requirements in such occupations as beautician, police and fire service, agriculture, non-professional forestry, and para-medic technical work.

In the 1964-1965 school year, Northview tried a pilot class in "Practical Chemistry". The class was small. The course content was adjusted to the vocational plans of the students.

During the same school year, 1964-1965, the "Goal-Centered Curriculum Project" for Northview High School was begun. A survey had shown that sixty percent of the student population was not planning on college. This sixty percent included students from a low income area many of whom were Mexican-Americans. Few of the usual course offerings seemed to them relevant to their experience. New courses and the new approach were needed.

The summer of 1965 saw the planning and organization of the specifics of the "Goal-Centered Curriculum" for the following school year. A new vocational track was set up. Courses more realistic for non-academic students were written for six curriculum areas, English, Social Studies, Chemistry, Nurses Aid, Business Education, and Industrial Education.

The pilot class in "Practical Chemistry" had been experimental. Many ideas regarding the presentation of essential concepts and laboratory exercises had been tried. Based on this experience, and as part of the "Goal-Centered Curriculum Project", a new expanded course outline and teacher's guide with lessons planned for each day of thirty-six weeks was written. Also written, were a student workbook and laboratory manual, and a set of objective tests. The 1962 edition of Modern Chemistry, Dull, Metcalfe, and Williams, Holt, Rinehart and Winston, Inc., was used as a text and reference.

However, only selected sections of this text were assigned for student reading. Simplified statements of the more difficult concepts were written and duplicated.

The course was activity centered. Concepts as well as laboratory skills were developed through simple experiments. Illustrations were presented by means of free films and materials from industry.

On March 23 and 24, 1966, the "Goal-Centered Curriculum" Conference was held at Northview High School. Participation was California State wide. The *"Vocational Chemistry" was one of the five programs presented in the opening session. Three successive workshops considered vocational science for non-college-bound students.

(*New title for "Practical Chemistry")

In the presentation of the "Vocational Chemistry", which is really more accurately designated as "Pre-Vocational Chemistry",the purpose of the program was defined. In the modern world "it seems important that basic concepts of chemistry should be made intelligible to as many as possible of our young people, and that young people interested in occupations having clearly defined bases in chemistry should be given an opportunity to acquire the knowledge and skills of chemistry within their abilities and suited to their vocational needs". In the workshop discussions an extension of these purposes was stated. "Courses in science, suitably structured, offer the non-college-preparatory student an opportunity comparable to that offered the college preparatory student. Pre-technical training is substituted for pre-professional training; an appropriate introduction to science in our modern culture is provided for each group."

The workshop groups explored many problems relating to non-college preparatory science. The following are few of the ideas brought out.

Methods for creating interest

1. Tie concepts to historical science
2. Look to industry and actual jobs to find threads of common basic principles
3. Make sure to have something specific to show what has been taught in the course
   (The current phrase is "instructional accountability")
4. Find something new in approach. Do not compound an injury inflicted in the past.
5. Involve the individual student in every possible way. This may be the key to success not only of any one course, but of an entire science program.

These basic ideas for creating and sustaining interest have served as a guide both in the experimental period and in developing the chemistry program from 1966 to the present.

Methods The discovery method, so successful in modern college preparatory chemistry, has been equally successful in this program. Students enjoy the laboratory work, and, through it can be lead to basic chemistry. Also, interest is kept high by involving each student in every possible way, by providing some activity for every class period, and by keeping the work moving.

In planning experiments, it has been found that an experiment is most successful which develops a single clear-cut concept. These students are easily confused by too much detail. A number of short experiments is better than a single long one with many steps. Quantitative experiments require a review of the mathematics involved, usually. As in college preparatory laboratory, students need an opportunity to try out ideas of their own, but only, as for all beginning students, in teacher approved experiments.

At Northview, with few exceptions, non-college-bound students have been willing workers in chemistry. Most of them are poor readers, poor in mathematics, and find abstract ideas difficult. However, they really do improve as the work progresses. Most delightful is their fresh imaginative approach to the work. They are genuinely interested in the chemistry for its own sake.

In the Northview program, no homework is required. The better students respond by doing extra work, often without regard for possible rewards. Very slow students are not discouraged by constnt failure. They can keep up with the others in the class activities.As the school year progresses, the number of students doing studying outside of class increases steadily.

Grading

Also in the Northview chemistry program, students are graded by a point system; each assigned exercise has a "points possible" score. Letter grades, A, B, C, D, are recorded only at the ends of grading periods when they are required for report cards. These grades are based on the total point distribution curve for all students in the program. The graph is posted. Each student is told his total-points-earned record and may find his place on the grading curve. This procedure is explained at the beginning of the course. Tension is relieved when students find that they are in competition only with each other and not with some seemingly impossible arbitrary standard. However, they do understand that a high point score does represent real achievement; they are very proud of good grades.

In evaluating semester grades and end-of-the course grades over the seven year period, it is found that the standard grade distribution curve has shifted to the left. The number of A's and B's has increased at the expense of the C's and D's. There have been only occasional failures, and these have been due to excessive absence. A student in regular attendance who does the work required in class as well as he is able may not earn a very high grade, but, at least, he will not fail. The twelve weeks grades for the group this fall, September to December 3, 1971, may serve to illustrate this point. There were A's - 30%, B's - 30%, C's - 25%, and D's - 15%.

Counseling

The counselors help in making clear to all students that "Vocational Chemistry" does not fulfill the college entrance requirement in laboratory science and that a grade of A or B in this course does not represent the same accomplishment as does an A or B grade in college-preparatory chemistry. However, it is also made clear that a number of vocational training programs in junior college and in service occupations accept the course as preparatory work, and a number of industries recognize the course as useful background for many entrance jobs.

EVALUATING OUTCOMES OF THE "VOCATIONAL CHEMISTRY"

This chemistry program was presented at the National Science Teachers Association convention in Los Angeles in October, 1969. In preparing the report at that time, it seemed important to find an objective way to evaluate the outcomes of the program. It has not been possible to follow up many of our graduates who do not go to college. However, all of the Northview counselors have been helpful. They prepared a report of their experience with the students they had programmed into vocational chemistry. Among the

VOCATIONAL CHEMISTRY

Post Graduate Plans of Forty Typical Students

Number of Students	Post Graduate Plans	Further Training Desired
7	beautician	beauty school
4	vocational nursing	junior college
1	dental assistant	junior college
1	radiology technician	junior college
1	teacher	junior college transfer
1	chemistry or other science work	junior college
1	astronomy work	junior college
1	airline hostess	junior college
1	Women's Army Corp	army training
1	career in the navy	navy training
1	model	department store training
2	forestry, non-professional	junior college
1	fish and game warden	junior college
1	police science	junior college
1	law	junior college transfer
1	draftsman	junior college
14	undecided	no plans

positive values noted were the following: (based on individual cases)

1. It would be difficult for the counseling department to program without this course, since it is one of the few courses in the entire curriculum which applies directly to the post graduate plans of a large number of girls who wish to become dental assisstants, LVN's, or cosmetologists. (We are also eager to have a vocational physics course added to Northview's curriculum. We feel this course would fulfill a similar need in other vocational areas.)
2. All of us agree that this course often provides an environment in which the "shot down", failure oriented student is able to achieve success in an academic area; we feel that it strengthens the student's feeling of self-worth. In addition, we feel that it often provides students with one of their few opportunities to discover that academic courses are enjoyable, that learning is fun. In the case of those students planning to enter careers in which a knowledge of practical chemistry is needed, it provides a feeling of competency in their chosen career plan. We have observed these specifics with many of the students who have taken this course.
3. It is an exceedingly helpful course for those students who have had more than their share of failure in school. Its concrete, tangible framework is a welcome change for poor readers and for students who have trouble in thinking in abstract terms.
4. No other elective at Northview offers a practical chemistry background for our students.

Another objective approach was a consideration of the students' academic progress in subjects other than the chemistry. A few students remarked in class that all of their grades had improved since they had been taking the chemistry. This suggested a study of grade point averages before and after taking the course. The study was made for all students who had completed the course during the five years it had been offered up to 1969. A random sampling of equal numbers of students in the same school grade, who had similar post graduate plans, and who were in the same grade point average range, was researched by the Northview registrar. The improvement made by the chemistry students, especially when compared with that of the random group, seems significant. It was more than had been thought possible, and much more than could have resulted from one good grade in chemistry. For the 116 students in the program, 1965 to 1969, the average of their grade point averages at the start of chemistry was 1.905 (C- to D). Of these, 81% made an average gain in grade point average of 0.202 during the one school year. Gains by individual students were often remarkable.

There were 89 students in the random group. The average of their grade point averages at the start of the year was 1.999, slightly higher than for the chemistry group. Of these, 41% made an average grade point gain of 0.065. A tendency to lose rather than gain in grade point was apparent in the group.

A study of the classes in the two years since 1969 show a similar trend. Chemistry students started with an average of their grade point averages of 1.986. Of these, 67% made an average gain of 0.200

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A study of grade point averages, GPA, of students who have completed "Vocational Chemistry", compared with a *random sampling of equal numbers of students in the same school grade, who have similar post graduate plans, and whose grade point averages are in the same range as the chemistry group. This is for a seven year period, 1964-1971.

*Random sampling made by the Northview High School registrar.

Year Groups	No. of students Boys	 Girls	Average GPA at the start of the year	No. of students who gained in GPA	Average gain in GPA per student
1964-1965					
*Chemistry		1	1.313	1	0.187
1965-1966					
Chemistry	11	7	1.850	84%	0.232
Random	9	10	1.854	73%	0.123
1966-1967					
Chemistry	9	26	1.983	82%	0.170
Random	19	16	2.021	34%	0.068
1967-1968					
Chemistry	3	18	1.912	89%	0.232
Random	13	8	2.018	25%	0.015
1968-1969					
Chemistry	18	24	1.878	70%	0.170
Random (#error)	8	6	2.102	36%	0.057
1969-1970 1970-1971					
**Chemistry	15	16	1.989	67%	0.200
Random (31,total)			2.188	49%	0.130

*The one girl was a junior. Records were not available on the seniors.

**Records for the starting GPA's for these two years are incomplete. Many are not available because of school transfers, etc.

grade point. The random group started the year with an average of 2.188 average grade points, essentially 0.100 grade point higher than the chemistry group. Of these students, 49% showed an average gain of 0.130 grade point. A summary of the study, year by year, is attached to this report.

Complete analysis of the study of the two groups is even more interesting than the summaries suggest. At least, the students are not being further discouraged by lack of success, but are finding some positive values in their school work.

PREPARATION OF THE PROGRAM FOR PUBLICATION

In the summer of 1967, I was asked by Holt, Rinehart and Winston, Inc. to undertake the principal authorship on a chemistry course for non-college-preparatory students. The first problem was whether to write a simplified revision of Modern Chemistry, Dull, Metcalfe, and Williams, or to work out an entire new program. The new program won. This was to be activity centered, with the laboratory manual the principal book and what we have called the "Reader" (a text) in support of the laboratory book.

Early in 1968, Elizabeth Lamphere, Chairman of the Science Department of Norwich High School, Norwich, New York, and Consultant in Science to the New York State Board of Regents, was asked to assume the primary responsibility for the Teacher's Guide and all testing materials. Miss Lamphere and I have worked closely together and closely with our editor in developing the program.

The first author chosen to write the "Reader" had to drop out of the team because of ill-health. In the spring of this year, 1971, Dr. Mario Menesini of Berkeley joined the team as textbook author. Dr. Menesini is a university instructor, a curriclum administrator, and the director of the Educational Research Bureau.

The program now has a tentative name, Action Chemistry. The first writing on the experiments and Teacher's Guide materials is essentially finished.

In September through November this year, 1971, Holt, Rinehart and Winston conducted a pilot study covering the first unit, Chapters 1 through 4, in selected high schools throughout the United States. The laboratory book, two versions of a textbook, all three illustrated with photographs, drawings, and cartoons, in paper back form, were supplied for the students. Teacher Guide material was furnished the teachers. An objective type test and a laboratory test for each chapter were provided. These tests, with the student responses, were returned to the publisher for analysis. Teachers were asked to answer questions in evaluation questionnaires at the end of each chapter and at the end of the unit. There was only one questionnaire for the students, at the end of the unit, over the four chapters. The pilot program has been carried out in two schools in the Covina-Valley Unified School District, Northview High School and South Hills High School. We found things that need changing, but the program was successful with the students for whom it was designed. Results from the whole study have not as yet been analyzed.

Miss Lamphere has used the pilot program in her classes in Norwich, New York. We agree that the overall arrangement is working out as we anticipated -- experiments, extensions for greater depth, and exercises to pin ideas down. The directions for experiments are simple and so far seem to be clear to the students. Wherever possible pictures are used instead of explanations in words. There is a minimum of mathematics, but that which is necessary is designed to improve mathematical skills. There is also a minimum of technical terms. Those used are carefully defined.

We have tried always to consider the busy teacher by making the pre-laboratory preparations as easy and un-time consuming as possible. We have also tried to plan for the use of equipment and materials usually stocked in a science department or familiar items easily obtainable.

In organizing the course we have begun with the unit on matter, energy, measurement, state of matter, and classes of matter. From there we have moved to Unit II on Water and Solutions, Unit III on Acids, Bases, and Salts, and then Unit IV on Atomic Structure. Even greatly simplified, this will be very difficult for the students. It is hoped that by this time, close to the end of the first semester, they will feel at home enough in the subject to grasp the essential concepts.

Unit V deals with Chemical Reactions, including the writing and balancing of equations, and the practical uses of some common reactions. Unit VI has to do with Organic Chemistry and Biochemistry. The last three units are practical, Unit VII, Chemistry in the Home, Unit VIII, Chemistry in the Environment, and Unit IX, Chemistry in Industry. A list of the chapter subjects and experiments is attached to this report.

Ours hopes for this program are perhaps best expressed in the preface to the student laboratory book.

Preface

"To the alchemists of long ago, chemistry was the stuff of magic. Today the ways of chemistry are less mysterious, but the excitement of magic is still there. In this chemistry course you will have the excitement and fun of finding out for yourself what things are made of and how they change; and that is what chemistry is all about.

"The whole world is full of things to wonder about. You will cut chemistry problems down to laboratory size. By building the small ideas you discover, into larger ones,you will begin to see patterns in nature. This is important because every part of your life is affected by chemistry.

"You will work as scientists have always worked, asking questions, guessing at answers, trying out ideas in experiments, and wondering what the facts you discover mean. You will learn by doing and not by memorizing countless rules and definitions. What about mathematics? Of necessity there are a few number problems, but simple arithmetic will get you by.In a little while you may be surprised by the amount of real knowledge you have acquired. You may be equally amazed by the number of things you have learned to do, such as weighing and measuring and making chemistry apparatus work. Step by step you will see the many uses of chemistry in everyday life."

Ruth P. Bolton
Covina, California
July 24, 1971

CHEMISTRY FOR THE NON-COLLEGE-BOUND HIGH SCHOOL STUDENT

Reported to the CACT, December 4, 1971, University of California at Irvine, by Ruth Bolton, Northview High School, Covina, California.

The report included a summary of the history, research, philosophy, and organization of non-college-preparatory chemistry at Northview High School, and a description of the chemistry program as presently prepared for publication. A pilot study of the first unit, Chapters 1 through 4, has been carried out in selected high schools all over the United States, September through November, this year, 1971.

The New Chemistry Program

Tentative title: ACTION CHEMISTRY
Authors: Ruth P. Bolton, Elizabeth V. Lamphere, Mario Menesini
Publisher: Holt, Rinehart and Winston, Inc., New York

Laboratory Book -- the central part of the program. (Hard cover)
Illustrated with diagrams, photographs, and cartoons.

Teacher's Edition of the Laboratory Book and Teacher's Guide
Probably two separate volumes due to large amount of material.

A "Reader"-text -- in support of the laboratory book. (Hard cover)
Profusely illustrated in four colors; language very simple.

The Laboratory Book and the Reader are designed for students with low reading ability and poor mathematical skills.

A set of tests -- written tests and laboratory tests

COURSE CONTENT (Presently going through final revisions)

Unit I. Matter and Energy THE PILOT PROGRAM

Chapter 1. Discovery, By Chance or Design

Experiment 1.1 Changes (plating an iron nail with copper)
Experiment 1.2 A Little Detective Work (comparing the copper copper on the nail with known copper - physical and chemical tests)
Experiment 1.2-A Extension Identity Can Be Mistaken (further tests comparing the copper on the nail with known iron rust and known copper)
Experiment 1.3 Telling It Like It Is (observing and describing the changes when copper chloride is dissolved in water and then aluminum foil added)
Experiment 1.4 What's the Action (testing the reactions of aluminum with a number of different reagents)

Chapter 2. Matter, What and How Much?

Experiment 2.1 How Much? How Big?
Experiment 2.1-A Extension Graduating a Test Tube

How to Use a Balance - Photos and diagrams

Experiment 2.2 What Are Some Kinds of Matter?
Experiment 2.3 The Density of Irregular Solids
Exercise Density

Chapter 3. Matter: Its Phases and Physical Properties

How to Light a Burner (Diagrams, full page)
How to Use a Thermometer (Diagrams, full page)

Experiment 3.1 Water - No Quick Change Artist
(ice → liquid water ⇄ steam)
Experiment 3.1-A Extension Project Deep Freeze
(graphing the freezing curve of water)
Experiment 3.2 A High Cal Experiment (melting properties of fats)
Experiment 3.3 Telling Metals from Nonmetals
Experiment 3.4 A Chemical Disappearance (solubilities)

Chapter 4. Classes of Matter

Experiment 4.1 The Look Alikes and Unlook Alikes
Experiment 4.2 A Chemical Merger (making copper oxide)
Exercise Word Equations
Experiment 4.3 Pure Substances Are Dependable
(comparing properties of laboratory reagents and grocery store products, as salt and NaCl, etc.)
Experiment 4.3-A What's in a Name? (identification tests and unknowns)
Experiment 4.4 Unscrambling (sorting out a mixture)

Unit II. Water and Solutions

Chapter 5. Water in Solutions

Five experiments: precipitates; tap water, distilled water, and deionized water (properties); hardness of water, qualitative and quantitative; distillation and deionization; fractional distillation
Exercise -- writing double exchange word equations

Chapter 6. Making Solutions

Six experiments: methods of speeding up dissolving; heat and dissolving; Benedict's Solution (more than one substance dissolved in the same solution); dilute and concentrated solutions; saturation; crystalization
Two demonstrations: solubility of gases; indicator dye solutions (solvent other than water)

Unit III. Acids, Bases, and Salts

Chapter 7. Acids

Five experiments: metals and acids; indicators; making an indicator from cabbage; strengths of acids; effervescence
Exercise: Using acids; word equations

Chapter 8. Bases and Salts

Seven experiments: properties of bases; strength of bases; bases of low solubility; neutralization; synthesis of a salt; effervescent substances; acid-like and base-like substances in the home
Exercise

Unit IV. The "Why" of Chemical Behavior

Chapter 9. Atomic Structure

Four experiments: mystery boxes; flame tests; making a spectroscope; using a spectroscope
Two demonstrations: electrical forces; spectroscope
Two exercises: making a periodic table; adding to the periodic table

Chapter 10. Chemical Bonding

Three experiments: electrons and energy levels; ionic and covalent bonding; predicting type of bonding
Exercise: writing electron dot formulas for atoms and ions

Chapter 11. The Mass of the Atom; The Mole and Mole Mass

Two experiments: atomic mass units; finding the number of moles in a sample
Exercise: Gram-formula mass; mole-mass; percentage composition

Chapter 12. Putting the Mole to Work

Four experiments: making a molar solution; making fractional molar solutions; more about pH; molal solutions, molecular and ionic, and freezing points

Unit V. Chemical Reactions

Chapter 13. Chemical Reactions

Four experiments: conservation of mass; group and regroup; replacement; redox

Chapter 14. Using Chemical Reactions

Six experiments: making a useful compound; family resemblances and predicting; how much can you make? (mole calculations); replacing hydrogen in acids; chromates; putting electricity in chemicals to work

Unit VI. Chemistry of Living Things

Chapter 15. Organic Chemistry
Four experiments: homologs; iosomers; alcohol vs base; polymerization
Exercise: organic groups

Chapter 16. Biochemistry
Six experiments: calories in foods; sugars; starches; fats; proteins; enzymes

Unit VII. Chemistry in the Home

Chapter 17. Foods
Four experiments: renin; hydrolysis of sugar; coagulating proteins; kitchen colloids
Demonstration: taking the plop out of ketchup

Chapter 18. Cleansing Agents
Three experiments: making soap; surface tension; soap or detergent
Two demonstrations: making a synthetic detergent; effect of disinfectants on bacterial growth

Chapter 19. Cosmetics
Five experiments: talc; tootpowder and toothpaste; cold cream; lipstick; hair cream (making the last four items)

Unit VIII. Chemistry in the Environment

Chapter 20. Pollution (incomplete)

Chapter 21. Agriculture
Exercise: plant nutrients
Four experiments: soil and water; moisture content of soil; how rich is the soil?; soil pH

Unit IX. Chemistry in Industry

Chapter 22. Fuels and Lubricants (incomplete)

Chapter 23. Rubber and Plastics
Two demonstrations: thiokol; making a plastic similar to bakelite
Four experiments: properties of natural rubber and synthetic rubber; saran wrap and plastic sandwich bags; thermoplastics and cold setting plastics; more about plastics - physical properties

Chapter 24. Fibers
Four experiments: natural fibers and synthetic fibers; what fibers are made of; how fibers react with certain chemicals; dyeing fibers

Chapter 25. Metallurgy
Four experiments: reduction of ore; refining copper; an electroplating problem; alloys
Demonstration: roasting a carbonate ore