INSTRUMENTATION

Stanley Watkins - Coe College

An attempt was made to analyze the question, "What is instrumental analysis in the undergraduate curriculum and where is it most effectively introduced?" Several general conclusions were drawn in stating the objectives of instrumental analysis. First, the topic should be presented to show the wide application of a particular instrument with emphasis on the theoretical basis, advantages (accuracy and sensitivity) and limitations. Second, the modern approach in chemistry should emphasize new and effective tools in solving complex chemical problems (structure determination, mechanisms of reactions, etc.) and should stress the evaluation and interpretation of data (IR, NMR, electrochemical, etc.). Third, in addition to practical applications the topic should develop an understanding of the fundamentals of instrumentation so that the instrument is more than a "black box" to the student.

In discussing whether instrumental methods and principles should be taught in courses other than instrumental analysis courses, several views were expressed. In order to understand the modern organic chemist approach to studying structures of compounds some mention must be made of IR spectroscopy. To postpone this important research method until an instrumental course would sacrifice some of its importance. Likewise, inclusion of potentiometry in beginning analytical chemistry when the theory of oxidation - reduction titrations is introduced would be ideal. Some schools in the MACTLAC group do not offer instrumental but have integrated the topics in other courses. Opposition to this trend is based partially on the difficulty of working with large classes and the costs of equipment. The availability of relatively inexpensive potentiometers and grating spectrophotometers might encourage inclusion of these instruments in basic analytical courses. Some felt that distribution of topics of an instrumental nature within other courses would result in inadequate presentation of the principles of the method and a lowering of standards (exactness and statistical treatment) normally emphasized by the professional analytical chemist.

The general opinion was that a special course in instrumental analysis was desirable although there was no agreement that the course should follow physical chemistry. Important topics would be absorption spectroscopy, electroanalytical measurements, chromatography and radiochemical measurements. Some felt that a more thorough introduction to the principles and application of instrumental analysis might best be accomplished in a course of this type than in an integrated course.

Additional topics that involve the use of expensive instruments such as IR, NMR, X-ray diffraction, mass spectroscopy, etc. could be introduced in any one of several advanced classes with emphasis on the interpretation of data.

In regard to instrumentation, several colleges build basic instruments to be used in the laboratory. Information about a set of instruments built for about $200 can be obtained from Dr. Fred Tabbutt, Reed College, Portland, Oregon. In a few colleges topics such as electrical measurement, optical methods, trouble shooting, and electronics are stressed before the student makes use of the instruments.

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PROGRAMED INSTRUCTION

DR. PAUL CARNELL presiding – Fri. Oct. 12 Room 103

What is it? - automated teaching
reinforced learning
auto-instruction with teaching machines

all represent the same thing

Publication - ~~Lunsdale~~ Lunsdale, University of California

Publication - Annual Meeting of the ACS - Dr. Cohen of Youngstown the first serious attempt to make teaching a science rather than an art.

One of the most important differences between the programed approach and the conventional manner, is much more latitude for differences in ability and background. In other presentations you set a fixed pace for the entire group. This is the main difference.

The psychologists have developed a special language which they use to describe the programed sequence.

Three steps
1. Stimulus (stimulate with a unit of information)
2. Response (to the statement or the choice of the answer)
3. Feed Back or Reinforcement (the student finds whether or not he has learned the information given in 1.

There may be different procedures in which this cycle is represented or a break for review but this is the general manner.

Units are called frames. You may have several hundred or several thousand frames (ie. Britannica on Math). They generally build up from simple concepts to more complicated. This technique is not new. It is a matter of working individually with different student abilities which is new and where the great advantage of programing lies. You have to deal with a tremendous range of abilities. The student works at his own pace. He can find out if he is learning. Those who are interested in research in teaching are vitally interested in this programing.

Different kinds of programs -

Prof. Skinner proponent of a linear type with a constructed response.
Pressey at Ohio State suggested that multiple choice was best.
Crowder called it Intrinsic programing - large units of information where the student has a multiple choice answer and depending on the answer he gives he moves through a specific sequence as indicated from the answer.

Publication - Programed Instruction in Schools and Industry
J.L.Hughes - Science Research Associates, Chicago.

An example from Crowder was read. It takes much more time and planning to write a program than a text. Essentially then there are really two systems that are evolving. Skinner and Crowder, the former less reading and more responding, and the latter more reading and less responding. Most programs are the Skinner type. It is indicated that it does not matter much which you use, you get approximately the same results. ~~Short statements and multiple choice seem to be the most acceptable.~~ Variety seems to keep the student from getting bored.

If you have the program and you have the frames, how are they communicated? Teaching machines answer this. There are many different kinds of machines and you can pay any price. Research shows the most important thing is not the machine but the quality of the program. The other important technique is the program text. Some programs are the textbook type and do not require a machine.

Presentations may be either horizontal or vertical. The more we read the more we here feel that perhaps the vertical is the best. This is much easier to write. ~~It has been discounted that it matters if the student sees the answer.~~ Some new programs put the answer right in beside the statement. The scrambled book is more complicated and requires a good deal of page turning according to the answer.

Some programs are communicated orally by lecture presentation at UCLA and the results are better than the conventional presentation. Machines are more cheat proof. The machine does a better job of maintaining a record of the student response. Machines may ~~have some difficulties~~ in terms of micro film. Micro film may be desirable because of the number of frames which need to be used. There is added motivation for learning this way because of the pin-ball effect. One disadvantage of the teaching machine is its cost. One problem is their storage.

Which is better, machine or textbook? There has been a large amount of research but I think the consensus is that if it is a quality program it does not matter how it is presented. There is a general feeling that this does do a job that is significant. There is much research going on. The chairman was impressed with the work going on at the Center for Programmed Instruction in New York. If you could see this technique in operation it is obviously worthy of our inspection. They should be carried beyond the program with outside reading.

One complaint was that the students missed the student-teacher reaction. Both students and teachers missed this in experiments where they tried to do without the teacher. Some of these procedures are being modified and they were trying different variations.

One other problem - testing. As the student is done, he wants to be tested. Too many tests!

What happens if someone finishes the course ahead of time? This has not yet been solved. What if they do not get done? Summer work is the answer to this. Has there been a study of the relative cost in comparison with formal teaching programs.

There has been an experiment at UCLA in a program on mathematical probabilities.

There ~~are~~ three ~~distinctions~~ $ Programmed texts
Teaching Machines
Programed lectures

Measured by a twenty item test, these are the results

1. Students learned quickly from all programed work.
2. There were no differences between different types of presentation.
3. Students did significantly better than those taught by conventional lectures.

How do you know the student has learned more?
How do you know this is better?

You just cannot ~~do it~~, there are too many variables. So much depends on how the test is constructed. Some areas would give better results than others. If you cannot tell, how are you going to know? By your teacher intuition. You know by the results in your own class. It does not take you long to discover the quality of the program. Turn a student loose and see what he says about it.

Why use programs? In Albion we are concerned with making our General Chemistry course less superficial,

How do you use programs? This depends upon your ingenuity. It depends on what fits best your need. Variety is important. A program should be alternated with other experiences. Although some have not had a variety and yet have seemed to do well. If the program does well then the teacher's place should be to do something beyond this. At Albion we are exploring and thinking about different ways of using these programs. It takes many, many hours to write a program and this is away behind schedule. This will be tried out in a number of colleges (Prof.Carnell referring to his own prog.on Chemical Equilibria) It takes at least one hour per frame to do the kind of job you need to do. It has to be very carefully evaluated to find out how it works. When we do get enough programs we will do certain things.

1. Extension of our ability grouping from two levels into three levels. We will expect the student to master the common core presented and then in the given ability group we will take the student into more significant experiences according to their ability.

2. We hope classroom experience will be more sophisticated and exciting.

3. We want to do more research on the best sequence of programs. There are not enough good programs.

We want to do more research on

1. What is the best sequence of chemical concepts for developing creative thinking?

2. Can we teach much more chemistry?

Albion plan for programs - one for the entire program in general chemistry at the college level
- kinetics
- equilibria will be next
- 12-14 units covering the fundamental areas

Another problem is how much overlap you should have. We hope this will stand alone but perhaps it won't. We ran a test on this. It was very interesting. 253 general chemistry students at Michigan State. They used about 3-4 of Prof. Carnell's text, instead of lectures. They could read the text. It was given under unfavorable conditions as the instructor was against it. We sent out a list of questions after they were done. The students were in the second term of chemistry, after the first term grades ran

	no.	Quest.A.	Quest B
A	22	86%	90%
B	80	80	70
C	93	82	80
D	15	80	85

Quest.A. Did the program succeed in teaching you the principles of equilibria?

Quest.B. Would you use other programs?

It seemed worthwhile continuing the project from these results.

We as scientists believe that we get answers better by experimentation, and I think if you do nothing else you should experiment with this to see how you react. You will be the one who has to decide. In response to your devotion to science (i.e. that experiments are necessary to get better answerw) then you should look into it. It may be over-rated, but I am inclined to think that it will ~~go on~~ simply because it represents a more careful analysis of the material to be presented than we have had before. Secondly, in case you are interested in writing programs it would be very beneficial. You have to think through the problems much more carefully .

Publication - Chemical Equilibria, Saunders, W. Washington St. Philadelphia (Carnell)

A number of other publications were mentioned CHEMISTRY I, Dawson. being one.

In dealing with the problem of students of widely differing abilities the Carnell text allows you to skip frames if you are familiar with the material given. Frams would not be dependent one upon the other. It was suggested that a few pertinent questions at the beginning of a section would enable the student to decide whether he needed that frame or groups of frames.

Dr. Cohen has done some good work in connection with programed laboratory experiments.

One complaint of the students at Albion was the laboratory. It was not challenging enough. They did not see the point of many of the experiments. We wanted more meaning put into the whole laboratory experience. This should be a most exciting area of the course and it is far from that.

Publication - Bulletin of the Center for Programed Instruction
Self Tutoring Machines.

COMMENTS FROM THE FLOOR

1. Fundamentally is there any difference between a program and a text book or a program and a series of lectures? Fundamentally there is no difference. A program is a well written textbook. I feel that the average author is not particularly concerned with the learner and is more concerned with getting the information down on the page, but the program is much more carefully organized and the student response is measured before it is published or used. There is the other question of the individual differences in students.
2. What is the difference in cost between a program and a text. You buy the response book. You might buy the texts only every three or four years but the student must buy the response book. The cost would depend on how you used them. We aim at $1.25 per unit. $12 or $14 per student. This does not disturb the publisher. Students will buy the book if it will help them to learn.
3. If you spend an hour per frame, it seems to me that the program work is going to be so much better presented because of the time that is going to be spent on it. A lecturer would be spending ten hours per presentation if he did likewise and of course he does not. In preparing a frame you must carefully think it out in a logical thought sequence and then you test it with your colleagues and some students before you publish.
4. How about the student's time. We had some complaint from Michigan students about the time factor. This may be where we must evaluate carefully. We feel that by breaking this up into units it may have helped because then some can be skipped. On the other hand, when you sit down and figure lecture time and study time, it amounts to 8 hours to go through the program and it is not too much. 8 hours was the average, some were less, some more.

5. Do you give excuses from class? We are toying with these ideas. Use less general class time and have more intimate experiences in terms of seminar application or other ~~things~~ so that you get to know your students better.
6. Compared with monographs, what do you think of programs. These are worked out very thoroughly. We feel that these complement the programed work. I would like to assign them as outside material and use paper backs to make a ~~larger~~ course, one that has more depth and more breadth than I now can cover.
7. What about the programed learning and the interrupted method of reasoning, segment by segment. This may be an advantage as you have to stop and think.
8. Is this new and better homework? Earlham tries alternating text and programed for variety. Is it a better correspondence course?
9. Is the program deeper than the text. Is it not more psychologically considered in presentation?
10. Where do you test the student. How do you work this. Do you work with individuals or groups?
11. Is there any real advantage to the small school. Yes.

Stratton from Earlham spoke of the developments there of this type of program.

1. They feel that short units make more sense, rather than a complete text. This on selected topics because of the change of pace value. Students complain about as many as 100 frames.
2. We have tended to feel that in order to make the best use of our resources (in utilization of faculty) we should be lecturing on some of the more significant ideas in chemistry. On the other hand some concepts you plot through and this might just as well be done by the students on their own by means of the frames. Some students get it quickly, some have to work really hard. A program frees us, the lecturers, for the other important things. They do not have to do everything in the program but they look into it to see what they need. They include pre-test questions at the beginning of the program, some of the key ideas. If the student can get these then he skips the frame. We do not always collect the answer sheets.
3. Systematic nomenclature of organic compounds is one of the things we use frames for. A series of six taking the various functional groups. Calculation of formal charges in calculating formulas.

How are these prepared.

1. Draft.
2. Given to colleagues and torn apart and talked about. Ensuing discussions very beneficial.
3. Then give the program to two or three students and ask them to go through and to criticize things that are not clear. Then we revise and try again on other students.
4. Results are sometimes surprising in finding the weak points in presentation. Some things that we thought obvious to students are not.

Jay Young and [illegible] answers.

You may say programed instruction in this case is like a work book. Question what about using these frames as helps for the student who is having problems with a particular concept. Is this legitimate or is this defeating your purpose? This is legitimate but it goes further than that. It enhances your work. In the small college the contact is much more significant. You can tell what level he is at. You can use it to bring students up to specific minimum levels. This may not work with the student with no chemistry but it might help the weak student. Intrinsic approach does not work for students because you cannot think of all the wrong questions a student can ask. Pre-testing is a good answer to the problem of the student who knows many of the answers. Occasionally the multiple choice questions are useful. Making the program interesting is a necessity. After using the program you feel a difference in the class. They make different mistakes. At least 30 percent of the students who have failed now pass, and other grades are correspondingly higher.

Do students really use these programs. You can tell whether they do or do not by the answer sheets. With this type of instruction you can use a more rigorous text.

Jay Young spoke of his publications. You will be a better teacher if you try to write a program yourself.

Group 3. WHAT MAKES A CHEMISTRY DEPARTMENT TICK?

Leader: Dr. Bill Deskin, Cornell College

The discussion of the administrative problems of the chemistry department was limited to a few topics. These included responsibility around the department, purchasing, storeroom and library. This discussion proved to be extremely valuable to most of the participants. New ideas were presented and methods of solving problems were exchanged.

Considerable discussion evolved around the advantages of purchasing supplies and equipment in one large order. This order is usually submitted in the late spring or early summer for bids to several supply houses. Often an advantage is gained by including needs of other departments, i.e. biology and physics, on the bid lists.

Under storeroom problems ideas were exchanged on methods of maintaining inventory. Various systems were explained and discussed.

Most of the colleges represented received approximately $20 to $30 per student per year for supplies, chemicals and equipment. In some cases additional funds are available for major items of equipment.

Some miscellaneous items:

Of the some 20 departments represented about half have part time storeroom help.

Four or five shcools have introduced standard taper glassware in organic laboratory.

Most of the departments spent from $400 to $500 annually on reference books for the chemistry library. This amount is separate from journals and abstracts.