

THE APPLICATION OF A LEARNING RESOURCE SYSTEM IN TEACHING UNDERGRADUATE CHEMISTRY

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This paper discusses a system we are developing at McMaster to extend the application of audio-visual aids outside the formal lecture and laboratory, to provide a continuous tutorial consultation service in our first year chemistry courses. The approach was initiated in response to the particular problems associated with the first year programme, but extensions could be readily made in a wide range of other courses.

The unique problems associated with the freshman chemistry programme arise mainly from the large number generally involved and the diversity of student ability and aim. Clearly we have to find a way of breaking down the structure of the course so that at least at some time it approaches the ideal teaching situation, involving personal selection of material and interaction between the professor and one or two students.

Particular difficulties which stem from the basic problem of the number and diversity of students are:

- (i) lack of individual personal contact;
- (ii) the difficulty in presenting material at a pace appropriate for all students;
- (iii) the need to provide remedial material for students with inadequate backgrounds in chemistry, or more advanced material for the good student planning to continue his studies to become a professional chemist;
- (iv) the problem of exposing students to the range of modern instrumental techniques used routinely by the chemist.

These problems can in principle be partially solved by good tutorial arrangements, assignments and appropriate reading. We have found in practice that the freshman tutorial itself becomes an additional problem to the student. We have tried a number of approaches in an attempt to make the tutorial a meaningful part of the course. However, it turns out that the conventional tutorial almost always degenerates into another lecture, but of somewhat lower standard. Students usually have to be tied to one group meeting at a fixed hour, which quite often fails to meet the diversity of need. They complain of being either bored or confused.

With smaller groups at a more advanced stage, where there is less diversity in background and aim, the conventional tutorial may still be an effective medium in chemical education. We have evidence that the substitution of one lecture by a small group tutorial (three to five students) in, for example, a third year inorganic course improves the students' understanding and performance. With larger more varied groups, however, we have found that

one or two instructors staffing a continuous audio-visual tutorial service can effectively overcome many of the problems outlined above.

AIMS AND PHILOSOPHY OF THE SYSTEM

In stating the aims of the audio-visual tutorial system it is important to recognize the basic philosophy behind the approach to chemical education at this level.

(i) The course has to be suitable for the majority, but form an adequate basis for later advanced study in chemistry,

(ii) The imparting of factual chemical information is not the only aim of the course. Even the modern high school programme (e.g. Chem Study and the Nuffield scheme in the U.K.) call for judgement and assessment rather than factual cataloguing of chemical information. The formal lecture should not, therefore, be expected to cover every detail the students are required to know. Professor Halliwell, Professor of Chemical Education at East Anglia, England, has written at length about this, posing the basic problem to which we believe the audio-visual tutorial system is at least a partial answer¹. 'How to weave practical work, personal communication and individual use of learning aids into a profitable programmed experience for the individuals of a large class is still comparatively unexplored'. It is certainly true that with the development of new audio-visual material and computer assisted instructional devices, the role of the lecture can change. The lecture can become increasingly a medium for stimulating interest and focusing attention on important areas. It can anticipate the student finding proper help in privately working out many details. With our learning resource area supplementing it, the lecture can be an interpretational presentation, with the lecturer acting as a guide assessing the significance of basic concepts.

With this background in mind the aims of the learning resource area may be summarized as a means of providing a multifunctional service to students which fills the following roles:

(i) automating the routine and mechanical aspects of the chemical course by providing an efficient way for students to obtain factual information easily;

(ii) providing what Professor A. I. Berman of the Hartford Graduate Centre described in a discussion on Autolectures² as a 'Wraparound' audio-visual medium;

(iii) providing a centre for personal interaction on specific chemical problems, both between teacher and student and between students themselves. This feature of student-student interaction fulfilling a self-teaching function was found to be an additional unexpected bonus of the system;

(iv) meeting the opposite needs of a mixed group by supplying both remedial material and extension material;

(v) allowing the student to pace himself and, because it involves selection of material, increasing personal responsibility for learning. This encouragement to active participation in the learning process is especially important in the first year course, which acts as a bridge between the high school type of course and the advanced course in chemistry. In this system the student selects from a mixed programme of material that most applies to his difficulty and level;

(vi) it allows immediate guidance the moment a problem arises. Since the audio-visual room is open 12 hours every day, a student is not required to wait until an instructor is free or a tutorial hour is scheduled. With an instructor on duty, as part of a total system, the student is saved from the uncertainty of having no guidance but, at the same time, encouraged to take initiative himself in finding an answer to his problem.

ARRANGEMENT AND FUNCTION OF THE SYSTEM

We have found that it is important in the application of audio-visual and other ancillary teaching aids to keep the technology and hardware simple, so that few people, apart from the chemistry teachers concerned, need to be involved in the production of programmes and material. The gain is not only in cost but in the amount of material produced and used. We have found this, for example, in the use of our instructor-operated closed-circuit television system, which has been discussed elsewhere³.

In principle, a sophisticated computer-assisted instruction (CAI) system is perhaps the best answer to many of the background problems presented in this paper. Such a system allows pacing, proper programmed instruction that forces student involvement and decision, and the possibilities of introducing a large amount of remedial material. However, the time, cost and expertise required to produce programmes covering all the topics in a comprehensive general chemistry course has until now prohibited widespread use outside a few pioneer colleges.

Now that it is becoming possible to modify branched programmes easily during use, CAI programmes will be used increasingly and will eventually be made to approach a true dialogue situation at modest cost.

Our system was set up in a relatively small area, partitioned off at the end of an existing laboratory, situated close to the area where freshman laboratory work is conducted and where teacher-operated television recording facilities are available³. These facilities which are normally used for pre-laboratory instruction are invaluable when it becomes obvious that a remedial programme must be made available quickly, e.g. a tape on precision accuracy and significant figures, or logarithms and indices, could be produced for instant presentation in the audio-visual room at the end of a laboratory period. Students may easily use the audio-visual centre before a laboratory to preview a technique tape.

The audio-visual room is staffed continuously by a graduate student selected from a number who request to act as audio-visual tutors instead of laboratory demonstrators. With this continuous operation even twelve study carrels may be adequate, with additional discussion areas, to meet the needs of several hundred students. The study carrels are of simple design, equipped with standard portable audio-visual devices—some with television monitors and headphones for video taped material, some with inexpensive film strip projectors, others with super 8 mm film loop projectors. The 'Audiscan' cartridge film strip projector with synchronized sound is particularly useful, but using it for teacher produced programmes involves considerably more time and effort. The best video material is that produced especially for the audio-visual room; e.g. concept review tapes, tapes showing modern techni-

ques or applications of chemistry in industry. We have used a trouble-free method of making lecture material available for review, involving a fixed television camera permanently focused on the overhead projector screen throughout the lecture. This is available immediately after the lecture and students can replay to themselves points that they found particularly difficult to grasp.

We now realize that to fulfil the need for small group interaction it is important to have a partitioned area where small groups can talk using an overhead projector or blackboard, or see tapes and other large screen projections without interfering with private study at carrels. Such discussion often develops from the use of material and it is the combination of ancillary aids with an easily approached instructor that is important. We found, for example, that putting a faculty member in a separate office for tutorial consultation drew very little response from the students. Although dialogue with a programmed computer is becoming possible, we feel that the well-chosen instructor must always be available since students often come to the audio-visual room without being able properly to articulate their basic problem. The instructor also produces reliable feedback on the course. Student evaluation sheets and an instructor comments book provide effective machinery for feedback and adjustment. With our continuous operation students can choose their instructor and we often find them building up a continuing contact with the same instructor.

The major technique in using the resource area is to highlight the specific topic which is being covered at that particular time in the lectures. We were initially tempted to put out everything we could find, mainly perhaps because of the sparcity of material. We have found, however, that it is more effective to set up the carrels each week with new and pertinent material. Other material available can be posted on a list to be seen when requested. There is a marked increase in the use of material when it is loaded and ready to use. For example, film strips which were left with the title showing on a front screen desk projector were used more than twice as much as those that had to be threaded in a conventional projector. Similarly with video tapes, when the tape of the week was left running instead of being available with others on request, it received considerably more use.

Examples of the type of standard material we have used in this chemistry learning resource area include:

- various types of molecular models;
- appropriate reprints from *Scientific American* and *Chemistry*;
- Xerox copies of particularly good treatments of specific topics;
- selected paperbacks and background monographs;
- programmed courses (e.g. 'Understanding Chemistry' by Barrow *et al.*);
- sample laboratory write-ups and extra problems;
- a collection of all assignments and problems given in the course with model answers;
- teacher written supplementary notes;
- alternative derivations of difficult equations and concepts;
- film loops that can be viewed on request;
- a summary board of the week's activities—laboratories, assignments, reading, films;

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commercially available films, film strips, film-loops, that can be viewed on request.

A great deal of useful material can be produced with minimum effort by re-using overhead projection sheets after the lecture, or with an audio-tape recorder and duplicated sheets. If the material is concentrated on a particular topic, pertinent to the laboratory and lectures of the week, students invariably use the room for solving particular problems they are having with the course. It does not then become a substitute for the library and a reasonably rapid turnover of students is observed, so that a minimum number of carrels serve the needs of a maximum number of students.

ASSESSMENT AND STUDENT RESPONSE TO THE SYSTEM

In one of our two first year courses 50 per cent of the 350 students filled out voluntary evaluation sheets. Of these 78 per cent used the learning resource area on the average for more than an hour per week. Students generally went to the room with a specific problem. Response was uniformly enthusiastic. Students especially appreciated the fact that help was always readily and instantaneously available when needed. They appreciated that its use was voluntary, did not involve any wastage of time and freed them from an imposed schedule. They used the discussion with the instructor as much as any other medium and felt a sense of liberty in approaching him in the fairly informal environment.

The use of graduate student tutors in this setting was generally appreciated, but keeping even twelve instructors fully informed about all aspects of the course was difficult. We had very little problem with loss of material even when the room was open unsupervised during a study week.

References

- ¹ H. F. Halliwell, *R.I.C. Reviews*, **1**, No. 2, 205 (1968).
- ² A. I. Berman, *Rensselaer Institute*, **68**, No. 9 (1968).
- ³ D. A. Humphreys and R. H. Tomlinson, *J. Chem. Educ.* (in press) (1969).