

# TEACHING CHEMISTRY WITHOUT LECTURES

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Australia is a large country with a small population. For this reason we have a history of teaching in situations which do not involve face to face contact between teacher and student.

The educational system involves attendance at primary school between the ages of 5 and 12 and at secondary school from 13 to 18. Education at these levels is available for children living in remote areas by correspondence courses supplemented in some cases by the 'School of the Air' where classes are conducted over two-way radio with hundreds of miles separating the teacher from his pupils and the pupils from one another.

Correspondence courses in selected disciplines in the humanities have been offered for a number of years in Australia to students by the University of New England and by the University of Queensland. The majority of students taking these external courses are employed throughout the country as teachers at the primary and junior secondary school levels. At the time of the foundation of Macquarie University in Sydney no such opportunity for undertaking university science courses existed for people working outside the large cities. The demand for such courses is great because a large number of the science teachers, who were trained at sub-degree level in teachers' colleges, wish to improve their qualifications.

## EXTERNAL COURSES

Macquarie University was founded in 1965 and began teaching in 1967. The Government of New South Wales gave the University a mandate to provide science courses for students living in country areas of New South Wales. As courses were to be offered for the first time, a unique opportunity was provided not only to rethink the methods of teaching chemistry from the beginning but also to consider the requirements of external teaching along with those of internal teaching. By this parallel development the basic structure of our courses has been built so that it is suitable for both internal and external courses. This has avoided subsequent problems of attempting to turn a fully developed course for full-time students into a correspondence course.

The traditional lecture method of teaching can be applied to external students using tape recordings or television but the latter is not possible in Australia because of the costs involved and because many prospective students live in areas where television is not available. In any case we had

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taken a decision to minimize the amount of lecturing in our courses because we believe that lectures have a very limited value.

Students can read the same books as the lecturer and, if the student were provided with a written copy of anything further the lecturer wished to say on the subject, what else is there to gain from a lecture? Some would claim that the lecture can inspire the students and a first-class lecturer can certainly do this. However, it becomes rather difficult even for a great man to inspire a group three times a week for each week of the year. The lecturer can simplify, emphasize the salient points and summarize vast quantities of materials, but this can be done also in written form. The lecture method can then be used as an occasional extra to the course to provide stimulation and inspiration for the students.

### **The study guide/assignment method**

It was as a result of trying to cater for external students that we replaced the lecture method by the study guide/assignment method of teaching. Teaching without lectures requires a teach-yourself hand-out, a study guide. The study guide is written to follow and enlarge upon a suitable textbook. Regular assignments are set as a method of establishing contact between staff and external students. These are completed by the student and sent to the university for marking. Appropriate comments are then made by the teacher and the assignment returned to the student. In this way the student is able to gauge his progress and the teacher can assess the student's performance. This method is in common use in external teaching in other subjects and at other universities, but the novelty in its adaptation to chemistry at Macquarie is that it has become the method of internal as well as external teaching. By making the material prepared for external students available to internal students, we were able to dispense with lectures as the primary teaching method and so make more time available for tutorials and laboratory work. But what could be done about laboratory work for external students?

Chemistry taught in a laboratory emphasizes the character of chemistry as an experimental science. Experiments must be made the centre of interest from the beginning of a study of chemistry for it is in the laboratory that a student comes to grips with the subject.

It would be possible to provide a set of chemicals and apparatus to each external student so that he could do the necessary practical exercises. However, a very important aspect of laboratory work is the face to face teaching situation that it creates. We do not believe that chemistry can be taught satisfactorily if the student is to be denied this experience. Therefore, it is necessary to devise some means whereby external students can come to the University for laboratory work. This is possible during vacations when external students can come to the campus for short periods of intensive instruction.

### **The on-campus school**

It is essential that external courses contain the same laboratory content as internal courses. The maximum period of time for which external students

can be expected to attend any given on-campus school is one week. This means working for nine to ten hours per day continuously for seven days for a course that includes about 65 hours of laboratory work. No one argues that this arrangement is ideal. However, experiments requiring the greatest mental effort can be placed early in the week and by careful ordering of the experimental work, a good deal of variety can be introduced. The total involvement with the subject for a full week, although mentally and physically exhausting for both staff and students, has some advantages. A close and open relationship develops between students and staff who work, eat and drink together during this chemistry marathon. Apparent barriers between them disappear and a feeling of 'being in it together' creates a very effective learning situation.

Because of the intensive nature of the work during on-campus schools, the students have difficulty in remembering some of the discussions and the concepts that come out of these discussions. We are developing a system of using tape recordings to assist in this respect. The discussion is recorded, and, without any attempt to edit the tape, a copy of it is sent to the student. When playing the tape and consulting the notes he made during the on-campus school, the student is assisted in recalling the whole atmosphere of the laboratory discussion by all the asides and the back-ground noises from the tape. By playing and replaying the tape, the student can digest the material fully and at his leisure resolve confusions and uncertainties that must result from the intensity of the course. The occasional lecture given during the on-campus school is treated in the same way. Using tapes in this way is preferred to the method of supplying recordings of internal lectures that the student has not heard delivered in a lecture room.

### THE SMALL GROUP TEACHING METHOD

Because we believe that a close relationship between teacher and student is desirable, we divide the students in each course into small groups of about ten and assign a tutor to each such group. With the elimination of lectures, the formal teaching involves laboratory work and tutorial assistance. The latter can be considered as a bonus for internal students although a limited amount of tutoring is possible for external students during the on-campus school.

#### Laboratory design

The conventional teaching laboratory is not suitable for conducting a course which aims at maximum integration between tutorial and laboratory work for small groups. In addition to providing laboratory benches and a blackboard, sufficient seating and writing space is required for the discussion and tutorial sessions. We have made two attempts at achieving these aims. In the first a conventional laboratory for sixty students was sub-divided into six cubicles with a common bench running along the outside walls. The laboratory benches in this design are used also for writing during tutorials. In the second attempt we sub-divided the same area into four independent small laboratories with benches around the walls leaving sufficient space to arrange for writing tables in a U-shape around the blackboard. These

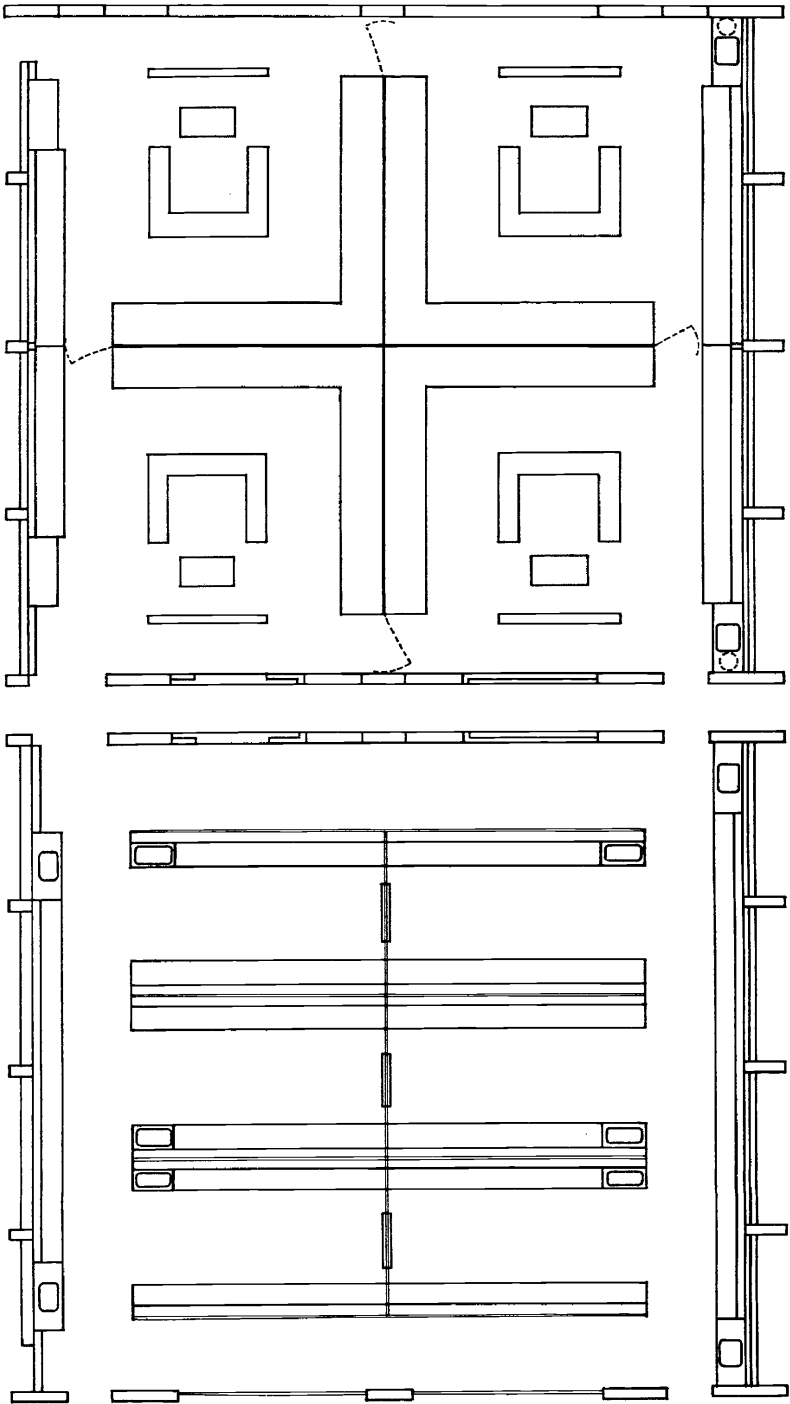


Figure 1. Two laboratory designs for small group teaching in an area of 2 500 ft<sup>2</sup>.

laboratories are illustrated in *Figure 1*. The second design, although it involves a greater floor area per student, provides better sound proofing and greater flexibility in its use.

### **Advantages of small group teaching**

The small group teaching method has a number of advantages. It is possible to divide a class into groups according to the abilities and past experiences of the students so that each group is reasonably homogeneous. It is then possible to treat each group somewhat differently both with respect to the method of teaching and the amount and depth of subject matter presented. The brightest group of students can be accelerated through the course and given a deeper treatment of the subject matter. The students in such a group can be expected to become more involved in the deductive and inductive discussions of subject matter than those of the slow or less well prepared groups. Greater emphasis can be given to remedial teaching with the less bright groups, and the groups with less well prepared students can begin at a lower level and can be taken through the course more slowly.

The experimental work for a small group of students with reasonably comparable abilities can be designed as a group exercise. Each student in the group makes a different measurement and the results obtained are put together and discussed by the group. For example, in measuring the rate of a chemical reaction each student can determine the rate of the same reaction under a different set of conditions from those studied by the other members of the group. In this way the order of the reaction is obtained with each student measuring the rate under only one set of conditions. With a better group of students the correlation and discussion of the group results can be carried out by the students themselves with one of them acting as a leader and the tutor keeping in the background.

Considerable emphasis is placed on the development of an ability to communicate ideas and on the improvement of the student's self-confidence in handling chemistry. To this end we include in the programme a system of student talks. Each student in turn is required to prepare a short talk on some topic related to the syllabus and to lead a discussion after he has presented the talk. This aspect of the course is tied in with a programme on the use of the library.

One further advantage of the small group method of teaching should be mentioned at this point. The close contact between tutor and student lends itself to the use of a method of continuous assessment rather than the traditional method of relying on a formal, written final examination. In cases where a doubt exists about the grade to be given to a particular student, use is made of interviewing and oral testing. However, we recognize that overemphasis on assessment can interfere with the teaching and learning process. We are experimenting in an attempt to reduce the emphasis on student assessment and to place it on the student learning process.

### **THE EXTERNAL PROGRAMME**

When we first undertook to provide chemistry to external students we doubted that we could proceed beyond first-year chemistry. Further, we

did not think it would be possible for students with no high school chemistry to undertake a study of chemistry by the external method. However, as we have gained experience and confidence in the external programme we have given courses for beginners, we have presented our full second year chemistry course and, in 1970, we intend to teach some third year courses.

The course for students with no previous experience in chemistry begins with a four-day, intensive, on-campus school. During these four days, the student gains some experience of the types of chemical substances and simple chemical reactions and is introduced to the concept of stoichiometry and energy change in a chemical reaction. He then studies the subject by correspondence for about ten weeks and returns to the university for a further seven days of intensive work. This course is a preliminary to the normal first year programme which consists of two half-year courses. One of these courses begins by correspondence and after about two-thirds of the time for the course has elapsed, the student attends on-campus for one week. In the second half-year course, the intensive school of one week is placed after about one-third of the course has been presented. The former arrangement is to be preferred but the organization of the academic year forces us to use both arrangements.

Second year chemistry consists of two half-year courses. The first is largely physical and inorganic chemistry. It begins with a four day on-campus school and has a further one week school towards the end of the course. The second course is concerned with physical organic chemistry. The on-campus schools for this course consist of one week after about one-third of it has been presented and four days at the end of the course. The extra time for the on-campus schools in these second year courses is necessary so that the students may gain the same laboratory experiences as the internal students.

We plan to present three third year courses in 1970 on electrochemistry, on spectroscopy and on chemical synthesis. The last one will have a large component of laboratory work while the other two will involve a minor experimental content. It is intended that these three courses shall run concurrently and involve on-campus schools of four days at the beginning and one week towards the end of the courses. We hope to present sufficient third year courses in 1971 to enable students to complete the minimum requirements for the pass degree with a major in chemistry†. However, this would be only half the third-year chemistry required of an internal student undertaking a double major in chemistry. We do not envisage at this point that it will be possible to provide external courses that would allow specialization to this extent. In any case, we would like to insist that external students taking a double major in chemistry attend the university full-time for at least one half of their third year programme.

We are hopeful that employing authorities will make this feasible by sponsoring the full-time attendance of external students for half a year. The State Education Department has given the lead by allowing school teachers this privilege, teachers comprising about eighty per cent of our external

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† Australian universities are based on the Scottish system with a three year pass degree and a fourth year for the honours degree in Arts and Science.

students. It is likely that the Department of Agriculture and the Department of Mines will follow suit and release the students working in the soil and water conservation service, the agriculture extension service and the mineral and geological survey service. This would leave about ten per cent of the external students most of whom are either housewives or are working in areas unrelated to their studies, to find ways of fulfilling this requirement of a half-year full-time attendance at the university.

Full-time attendance for half of the final year would help to overcome some of the disadvantages of undertaking a degree by external studies. The student would experience university life under normal conditions. He could take part in student activities that are virtually non-existent in vacation time and he could take some of the courses that cannot be or are not presented by correspondence. In the final year analytical chemistry is one such course. It is presented in the main by our Honorary Associates in their laboratories in industry, research establishments and Government agencies. One full day per week is devoted to the analytical chemistry course and it can only be conducted within the environs of a city university.

One important feature of our chemistry programme that we have not completely incorporated into our external courses is the development of a knowledge of the literature of chemistry, and experience in the use of the library. The central library and chemistry staff have cooperated enthusiastically in producing chemistry/library projects which form an integral part of a chemistry course in each year. The project increases in its coverage of the literature and in the course time allowed from four hours in the first year to twenty four hours in the final year. The final year project takes the student to a number of different libraries around the city and for convenience is presented as part of the course in analytical chemistry. The external student will get the chance to do this project in the half year he is in full-time attendance.

### CONCLUSION

External courses are most demanding of the student. His isolation becomes a cause of frustration. He can spend hours wrestling with a minor point that an internal student may have clarified in a minute by asking his tutor or another student. The successful external student requires maturity and above all strong motivation and often a sympathetic family. Students who are not highly motivated drop out early in the course.

Macquarie University is aware of the problems of external students and has appointed a Director of Part-time Studies to organize the whole external programme. In addition to routine administration, the Director and his staff take a special interest in the welfare of the students and make periodic visits to the country to discuss their programmes and their problems.

Academic staff tend to approach the task of teaching an external course with some trepidation and, in many cases, with scepticism. However, after teaching a course they have all agreed that, although external study is not the ideal method, chemistry can be taught successfully by external methods. Because of the maturity and motivation of the external students, the staff find teaching them to be a rewarding experience.

The small group teaching method when combined with a continuous assessment procedure requires a high percentage understanding of the material in the course by the students. It soon becomes obvious when the course contains too much or too little content for the time available. We have found that in all our courses we have tended to overload the curriculum which was drawn up in the light of our previous experiences with the lecture-laboratory-final examination method of teaching chemistry.

The small group teaching method has been referred to as the 'Chemistry Confrontation Policy'. The student in this situation cannot escape his tutor's attention, neither can the tutor ignore his students. There is a danger that this method can lead to a regimented approach by the tutor to teaching and too great a dependence by the student on his tutor. However, the method at its best results in the development of a friendly and cooperative attitude between the tutor and students and creates an excellent atmosphere in which the student can learn. The demands made of the tutor are much greater than those made by the more conventional lecture-laboratory method of teaching. The success of the method to a large extent is determined by the skills and knowledge of the tutor for he is the person who must guide the group in adopting a scholarly approach to the subject.

### DISCUSSION

**R. S. Nyholm** (*University College, London*)—I recently had the opportunity of seeing Professor Barclay's scheme for the teaching of undergraduates in groups largely without lectures and I was greatly impressed with the enthusiasm with which the students were encouraged to learn. A good measure of teaching efficiency is the extent to which it stimulates the desire to learn on the part of the students. It is fitting that the motto of Macquarie University is '*And gladly teche*' from the words of Chaucer.