Pure & Appl. Chem., Vol. 50, pp.529-538.
Pergamon Press Ltd. 1978. Printed in Great Britain.

0033-4545/78/0601-0529 $02.00/0

PRACTICAL WORK IN PRACTICE: AS I HAVE SEEN IT

E.C. Watton

Department of Chemistry, Macquarie University, Sydney, Australia.

Abstract - This paper summarizes the author's long experience in student laboratories in both developed and developing countries. After referring to problems associated with the use of untrained research students as laboratory demonstrators, he describes a number of successful projects in which the demonstrators have played a significant role in the early development of the courses. The Pilot Project for Chemistry Teaching in Asia, laboratory tutorials without lectures and a post-graduate course in Chemical Education at Macquarie University, and the development of laboratory courses in Jordan, have brought the author into close contact with High School teachers, to the mutual advantage of the people and the discipline.

"Only about the peculiar behaviour of our profession do we choose to remain naive."

Gunnar Myrdahl.[1]

This is a personal account of my experiences as a student and as a teacher in the chemistry laboratory. It extends back some forty years and, as they say in the flying business, I am still current. About ten years prior to the beginning of this period the American Chemical Society formed the Division of Chemical Education and began publication of the Journal of Chemical Education. Inspection of some of the early volumes reveals that it is very easy to rediscover gunpowder and that the habits of academia are highly resistant to both cure and quarantine.

Beginning with Vol. 2 (1925), I noted in passing that Thomas Paine had put forward a chemical theory for the propagation of yellow fever, that George Washington had been a whip on marsh gas and that the editor of the day was so depressed by the state of chemical education that he was looking forward to a second world war "..one more war may be necessary before all school authorities become conscious of the fact that chemistry is an essential subject in a complete system of education". Writers on laboratory teaching were concerned about the tenuous connection between laboratory and lecture, the supervision of laboratory work by young, inexperienced instructors, "over the phone" supervision by professors who still insisted on determining grades, cheating and its cures, the relatively poor credit earned by both staff and student in the laboratory and whether laboratory courses were intended to teach techniques or principles or both.

People were also unhappy about the lack of enthusiasm for teaching elementary laboratory courses. The President of the American Chemical Society in 1930 (William Macpherson) in fact said "men adequately trained seem to think it beneath their dignity to have anything to do with the beginner" and there were others who considered, for example, that "only if creative work in methods of freshman chemistry is properly rewarded will we have more young chemists devoting more of their time to it instead of neglecting it for research".[2] Fifty years on in 1975, among the contributed papers at a conference on laboratory teaching, one reads "we must necessarily teach through an interface of graduate student teaching assistants ..."[3], "it is impossible in most systems to correlate lecture and laboratory"[3] and "..I have never found any explanation why there are fewer credits in a laboratory course than in a lecture course..."[4] yet "..not a word has been said on this so far at this conference"[4], and again there was reference to the problem of cheating.

Perhaps things are moving faster than the average glacier though seemingly not because according to Eble[5] in his book "Professors as Teachers" the findings of the 1933 Committee of the American Association of University Professors studying the improvement of teaching were not very different from his own in 1972.

Just as many of the problems of today are not new, many of the innovative ideas of today bear a strong family resemblance to those of the past. Whereas a cursory observer might confuse the sounds of change with change itself there seems to be little risk of "future shock" in the undergraduate teaching laboratory.

In Britain in 1926 where a smaller and less diverse university community existed, Russell[6] deplored the "intrusion of technical schools into the haunts of true learning", and "a regrettable tendency (in the newer universities) to insist on attendance at lectures", which he saw as only there because they gave the appearance of work and so satisfied beady-eyed business men who otherwise would think people idle. He strongly supported research and regarded formal teaching skills as unimportant provided a teacher was knowledgeable and keen about his subject; a fair summary of the modern view (Note a). He had a gentle swipe at vocational training and consulting when he wrote "for example a learned man may improve his position by teaching brewing instead of organic chemistry; he gains but learning suffers". For my part, after sampling the brews of some of my chemist friends, I have doubts too, but for a different reason. Lord Bertrand need not have worried. The Eaborn[7] report of 1970 failed to reveal any substantial preoccupation with vocational training and a recent IUPAC-inspired survey indicated that the position was much the same in Australian universities. That the two situations are not dissimilar would not surprise anyone aware of the umbilical connection that has survived so long the formation of the Commonwealth nearly eighty years ago (Note b).

In 1939 Bernal[8] regarded lectures as anachronistic and a waste of time, doubted the value of lecture demonstrations or set laboratory experiments as contributions to either an appreciation of scientific method or the ability to solve problems, believed that the combined pressures of research and teaching characterized "changes in the curriculum or in the organization of laboratory work as unthinkable" and was critical of the treatment of Ph.D. students whom he considered were poorly supervised and otherwise exploited. He thought that universities should revert to a traditional teaching role in the sciences and move away from a system that inhibited curriculum changes not only in the university (Note c) but in the secondary schools as well.

By 1971 the Chairman of the British Council for Scientific Policy[9] was saying that there was probably no connection between teaching and research and that since Ph.D. numbers were on the decline they should be replaced by career research assistants who "would certainly each be worth a number of Ph.D. students in terms of research output". Who or what would replace this source of indispensable, since cheap, labour[10] in the undergraduate laboratory was not made clear although this phase of research student "training" was referred to in a couple of rather tart letters to Chemistry in Britain. The Chairman added that "this would be a retrograde step if we can regard the Ph.D. as an education process". An interesting "process" which varies from daily encounters with a mentor to an exchange of Christmas cards.

Without dwelling too much further on this it is important at least to consider the circumstances of research students as these bear upon their efforts in the teaching laboratory and, for that matter, their subsequent performance as tertiary teachers. From the U.S.A. (Note d) and other places there come reports of formal arrangements for the training of research students in teaching methods and in course development, though not without opposition. I know from personal experience that, while this is often welcomed by research students and as a result they begin to teach well and with enthusiasm, I am also aware that they can be placed under great strain as they try to balance their research commitment and demands of supervisors against an additional commitment to teaching.

Note a. It is of interest that present day students, even teacher trainees, agree with Russell (see H. Stanton, the Australian University (1972) p.15) as do present day British academics (see "Supporting Teaching for Change", The Nuffield Foundation, p.50).

Note b. The Chairman of the Commonwealth (of Australia) Scientific and Industrial Research Organisation in 1964 said "We are hampered (in Australia) by the traditional British attitude that academic progress requires a high degree of isolation from the practical affairs of the community".

Note c. Professor A. Hambly of the National University in an address to ANZAAS in 1968 expressed a similar opinion of conditions in Australian & New Zealand universities, see Proc. R.A.C.I. Sept. 1968, p.232.

Note d. Professor Marjorie Gardner of the University of Maryland, U.S.A., recently in Mexico, described to me such a system of training for teaching assistants for which course credits in either education or chemistry are awarded.

Perhaps it would be well to remind ourselves that, according to the Eaborn[7] report mentioned earlier, no more than 40% of these people are likely to have a strong interest in chemistry and in the U.S.A. at least, Ph.D. students taken together constitute the social group most prone to suicide.[11]

In 1972, one of the reports[12] given at a symposium in the U.K. showed a situation not unlike that in the U.S.A. There was little integration with lectures, little credit for up to 900 hours spent in the undergraduate laboratory on work not primarily in support of examinable material and a good deal of the supervision and nearly all the marking was in the hands of either post-graduate or post-doctoral demonstrators. Project work, the most self-indulgent of all forms of laboratory instruction, came out best in terms of student interest, but, sadly, this was found to threaten success in examinations as a consequence of enthusiastic students spending too much time at it.

There was again talk of cheating and of poor technique and of safety (Note e). An undergraduate at the same meeting reported a study at her university whereby she had found there was a poor chance of realizing the objectives of laboratory work unless students were informed of them in advance and, if this were done, things improved. Innocuous and self-evident as this may be it was followed by a disclaimer from someone that the views of this undergraduate were not those of the department and must not be seen to reflect upon the department. Sensitivity to criticism of teaching may well be due to a deep-down feeling that, although the reward system may be tied to research and scholarship, what we are paid to do is teach. In fact, it has been found[13] that academics are more likely to admit that their institutions are below average in research and scholarship than below average in teaching, and more, that a propensity to teach was an indicator of working class origins. Why then, since university chemists are known[14] to be an upwardly mobile social group, do we not always find them eager to get into the teaching laboratory?

I have dwelt to this extent on the U.S.A. and the U.K. for the fairly obvious reason that the influence of these countries upon educational practices and attitudes through colonial, ex-colonial, and other ties is considerable and widespread. The first course in chemistry in Australia was given in Sydney in 1840 based on "courses in the Scottish universities and at The University College London". It seems that the other places were under a cloud at the time.

My earliest recollection of tertiary chemistry here in Australia goes back to the thirties and is of a high ceilinged cavern where, as students, we alternated water fights and other nonsense with elementary qualitative and quantitative analysis watched over by two pleasant young men from a neighbouring institution. The lecturing staff rarely appeared but I was not too concerned as I convinced myself that a bunsen burner connected to a water tap was far superior to the conventional wash bottle of the day, especially in a defensive situation. On one notable occasion the application of this device led to a wonderfully spectacular demolition of a lecture-demonstration. The practical examination was a considerable shock. I assume it was based upon the Royal Institute of Chemistry syllabus and, if so, according to one view, it was designed "to test what the candidate could actually perform under the same conditions as he would find in practice and within reach of a good chemical library". As it happened the examination was a contest between student and examiner wherein any resemblance to the real world just had to be coincidental. Each sample was coloured orange by coating it with an organic dye which, when burned off, left them all a non-committal black. This crafty device made us entirely dependent upon our ability to apply the already one hundred years old art of Fresenius and so establish, according to Frankland (Foundation President of the Royal Institute of Chemistry), that we were "workers" not "mere readers". Things have changed more than somewhat since the days of the first President and one is reminded of the Haitian proverb: "If work was all it is said to be the rich would have cornered it long ago".

Note e. There has been considerable attention to safety of recent years and research student demonstrators must find this contrasts markedly with the spirit of high adventure that so often prevails in research laboratories.

I managed to jump this first hurdle and continued on to a laboratory programme almost totally devoted to quantitative analysis which we worked through in a desultory, largely unsupervised way. It could be described as "self-paced", perhaps one of the earliest examples. The inevitable practical examination was of four days' duration. Now the chances of completing this without disaster of some kind, and consequent recourse to the class average method, was virtually nil and so it proved for me. Part of the examination involved a Kjeldahl nitrogen determination something not one of us had ever done before. Panic instructions and dire warnings against "suck back" notwithstanding, mine did suck back. Two further failed attempts later, and becoming a little depressed with formal chemistry, a condition not entirely self-induced I feel, I withdrew my support from the discipline.

I returned to the study of chemistry at the Sydney Technical College a year or so after the end of the second World War. At this time, about when the physicists disappeared into the nucleus, a further glance at the Journal of Chemical Education showed that DDT and defoliants were being claimed as chemical credits, there were courses in chemical warfare, and the editor was a little disturbed by the left wing tendencies of the British. In Australia, young academics and some not so young, were resuming the trek to the U.K. for post-graduate studies, local Ph.D. programmes were being established, and the tertiary wing of the Sydney Technical College was in the process of transformation, under a series of titles, into The University of New South Wales. The Sydney Technical College was at that time directed by a German-trained Canadian chemical engineer named Murphy, who was notable on a number of counts, including the founding of the first chemical engineering course in the British Commonwealth, the erection of a new Chemistry building with a basement and an extra floor not shown on the architects' plans, and for the devious means by which he was able to support the research of Dwyer and Nyholm both destined for fame as inorganic chemists, the latter to become the Foundation Chairman of the IUPAC Chemical Education Committee.

In modern terms, it was a multi-versity with an enormous spread of courses and levels of training where, on the way through to the physical chemistry teaching laboratories, one could get a cheap haircut at the hands of a trainee hairdresser. Once, in return for repairs done on my ancient motor car by the automotive trades students, I developed a titration method for determining the volumetric capacity of cylinder heads as a check on their mensuration. It was a compatible and valuable mix which, as Veblen (Note f) would have predicted, disappeared fairly rapidly with the onset of the establishment of the university and the appearance of the customary archaic rituals and scholastic forms.

My first lecturer upon my return to chemistry was "Blue", now Emeritus Professor Barclay, who later, as Foundation Professor of Chemistry at Macquarie University, introduced a laboratory based tutorial system eliminating formal lectures and examinations entirely.[15] Those Barclay lectures were in preparation for a much-feared examination on qualitative analysis which demanded the recall of an enormous portfolio of chemical information. The catastrophe rate was considerable. The contest still went on in the laboratory now centred on a sequence of "unknowns". Some of my fellow students working in industry had access to mysterious instruments and exotic reagents that could help but often hindered since these more sensitive and sophisticated methods tended to provide far from unequivocal answers. The standard first approach was the comparative smear test whereby one compared the colour of the unknown with others already issued and correctly elucidated. There was one significant change from my previous experience. The demonstrators at these evening classes, often drawn from industry, had a tendency to mix it in the laboratory, modifying methods on the run and becoming quite involved as they demonstrated professional expertise. Later, with the emergence of the Ph.D. programme, there appeared the more familiar "sentinel" demonstrator about whom a colleague recently remarked "I thought they were just there to keep order and mark our books, it never occurred to me that they were there to teach us anything". This ties in with a comment from a young man not long out of his Ph.D., which was: "When I was an undergraduate I wondered why the demonstrators rarely came near me, when I became a demonstrator I realized why - they were frightened".

Note f. Thorsten Veblen who wrote in his "Theory of the Leisure Class" in 1899 "... Wherever schools founded for the instruction of the lower classes in the immediately useful branches of learning grow into institutes of higher learning the growth of ritualistic ceremonial and paraphenalia and of eleaborate scholastic functions goes hand in hand with the transition ...".

The battle was joined in earnest in the organic chemistry laboratory where on one occasion the Student Chemical Society challenged the staff to produce from among their ranks someone who could complete the practical course in the prescribed time. Very wisely the staff declined, the while operating a forensic melting point and refractive index service backed up by locker raids in pursuit of delinquent students driven to such short cuts as multiple quantities, label transfer, straight purchase, or in final desperation, simulation.

That faking or fiddling of results is still with us is obvious from references throughout the literature and from conversations with university teachers from many countries and one is forced to the conclusion that, like Portnoy's Complaint, whoever says "I have never done it" is probably still doing it. It is a pity that laboratory simulated chemistry is often organized and maintained in such a way as to not only encourage but indeed reward deceit. There surely is a considerable gap between the student laboratory and the real world of science of which Bronowski[16] wrote: "We can practise science only if we value truth". And it seems therefore fairly obvious that if laboratory teaching is to succeed there must be something done to remedy a situation where students who never cut corners are regarded either as naive or mentally retarded. Liebig, who some 150 years ago founded in Giessen the first ever instructional chemistry laboratory, said of it "At Giessen all was concentrated in the work and this was a passionate enjoyment". What would he say of it now, and for that matter, how would that master of marsh gas George Washington react? For my part, at that time I neither regarded the laboratory courses as good or bad but simply as obstacles to be negotiated on the way to an all-important badge. Nevertheless, as a consequence of desperately intensive study which now made written examinations somehow very easy, and the influence of Mr. L.W.O. Martin in charge of the physical chemistry department, I rediscovered an interest in chemistry absent since my school days. I developed an intense desire to teach at the "Tech.", and eventually I was appointed to the lecturing staff of the University of New South Wales, then called The New South Wales University of Technology.

It is a truism in academic circles that the best way to learn is to teach; indeed it would seem sometimes to be the only way. In my case I learned fairly quickly of the need to demonstrate the principles of chemistry (Note g) beyond what was achieved by the available laboratory courses. And more, that attempting to satisfy this need while being very instructive and amusing was also very time-consuming and especially mind-stretching in the variegated field of general chemistry. However, at this time I, along with others, was strongly advised not to worry too much about teaching, but rather to concentrate on research and the improvement of formal qualifications. Sound advice in an environment where the possession of two heads might well excite less comment than the lack of a Ph.D. But, as time went by, there were other opportunities to work off an interest in teaching not the least of which were the residential schools for secondary school teachers. Conducted annually, the proceedings were published under the title "Approach to Chemistry".[17] Originated by Nyholm (Note h) prior to leaving for the U.K., they were continued by Professor Aylward (Note i) and others for some twelve years.[17] On each occasion that I was involved, my task was to put together sequences of laboratory exercises that illustrated principles rather more than techniques. In the event, I experienced that great feeling that comes from showing off one's own work; an unheard of experience for most laboratory demonstrators. It was standard practice to share responsibility for preparation and supervision with an experienced school teacher and as a consequence of these and other contacts I came to value school teachers as colleagues in the business of chemical education and to appreciate some of their points of view.

Note g. It is perhaps noteworthy that about fifty years ago there was considerable controversy in the U.S.A. as to whether laboratory courses could or should take the place of demonstrations and more recently that there appears to be a revival of interest in lecture-demonstrations.

Note h. The late Sir Ronald Nyholm, F.R.S., was at this time Associate Professor of Inorganic Chemistry at the New South Wales University of Technology. He left to become Professor of Inorganic Chemistry in the University College, London, and subsequently Head of the Chemistry Department.

Note i. UNESCO Field Staff: Chief Technical Advisor to the Thai National Science & Technology Teaching Centre, Bangkok, Thailand.

In 1965 UNESCO established at Chulalongkorn University in Bangkok, Thailand, the Pilot Project for Chemistry Teaching in Asia[18] under the leadership of Laurence Strong (Note j). The Project was one of a number supported by the UNESCO regular programme in an imaginative attempt to assist in the establishment and maintenance of modern secondary science curricula in the developing countries. I took over from Larry in 1966 and it was a tough act to follow. During the first phase, in addition to the Director and Frank Halliwell (Note k) who was the senior consultant, there were many other luminaries of that boom time in chemical education who visited the Project to work with people from Asian teachers' colleges and universities; people who had or were expected to have some responsibility for curriculum development in their own countries.

At the Project the main thrust was towards the use of the laboratory as a concept-forming arena in such areas as stoichiometry, energy, rate and structure. Each area was analysed in terms of basic concepts and then chemical systems investigated in the laboratory as possible bases for illustrative laboratory exercises, programmed instruction, loop films or other teaching media. As I took over the running of the Project, I remember thinking how great it was to be able to devote all my time to this kind of work, and I especially wanted to try out some of these products and approaches with teachers. So, in conjunction with an associated Thai curriculum group, a one-month vacation school for forty Thai chemistry teachers was arranged[17]. If I had had any doubts about the interest that chemistry can arouse this summer school dispelled them forever as these teachers worked through the hottest part of the year, and in Bangkok that is very hot indeed, indefatigably, enthusiastically, and in good humour for a whole month. There were, I believe, four main contributing factors. Local group leaders and laboratory supervisors who had been extensively involved in the design and development of the laboratory exercises were as a consequence confident and enthusiastic, spoke the same language (Note l), and so were able to merge informally with their own small group; each participant was involved in contributing part of the data available to the whole group; the exercises were arranged as much as possible in a story telling sequence; and, for the Project, it was a mainline activity to which all our efforts and facilities were dedicated.

We let the ball do the work and proved that like some other visually attractive features of our existence, the lively art of chemistry will continue to titillate as long as it is artfully displayed. Working in this way with chemical systems commonplace in the teaching laboratory, it soon becomes obvious that it is a kind of chemists' no-man's-land, shunned or ignored or forgotten by research workers. It is an R. & D. activity that, as well as providing better background material for teachers, gives practice in problem solving of a real life kind, and for the research oriented opens up a view of new, even fashionable, research opportunities. Gordon Aylward, who was by then with Barclay at Macquarie and who had helped considerably with the vacation school, was also well convinced of the benefits of this kind of investigational development and was no doubt influential in installing it as a principal feature of the Macquarie post-graduate chemical education programme.

The Pilot Project continued on until the end of 1970 with the distribution of a regional Newsletter and a variety of prototype teaching materials. Jaroslav Zyka (Note m) followed me as Director and he was in turn succeeded by Art Campbell (Note n). Whatever else it may or may not have accomplished the Project certainly contributed much to the establishment of an informal regional network of people interested and influential at the operational level in chemical education.

Note j. Professor of Chemistry, Head of the Department of Chemistry, Earlham College, Richmond, Indiana, U.S.A., and one time Director of the CBA Project.

Note k. Professor F. Halliwell (retired), Organiser of the Nuffield O Level Project and Foundation Professor in Chemical Education in the U. of East Anglia.

Note l. Vacation schools where foreign "experts" are involved have been criticised on a number of grounds; one in particular being the failure to acknowledge the problem of language. See Everett Hafner in Physics Today (June 1967).

Note m. Professor of Analytical Chemistry, Charles University, Prague, and one-time Chairman of the Chemistry Education Section of the Czechoslovakian Chemical Society.

Note n. Professor of Chemistry, Harvey Mudd College, California, U.S.A., and Director of the CHEM Study Project.

More, it connected this to other movements around the world. It also seems fair to say that it paved the way for another UNESCO initiative; the formation of a regional natural products network; a reminder of the complementary relationships that exist between education, application and research.

At the end of 1968 and just prior to moving to Macquarie I went to Sri Lanka[17] to assist with a vacation school similar to the one held in Bangkok. The format and approach was much the same as the one in Thailand, calling on a very happy combination of university and research institute staff with a lively curriculum group from the Ministry of Education. There was a considerable bonus on the practical side provided by a tea researcher who arranged a workshop session in which the techniques of paper and thin layer chromatography were applied to the study of tea and other natural products. The teachers were considerably diverted by this environmental excursion and there were many suggestions for school projects and promises of professional assistance. Directing attention to the benignly utilitarian side of chemistry has become very popular of recent years but delving into this professional portmanteau without real professional help is beset with traps (Note o) even at the tertiary level when one seeks to translate talk into action, and I will return to this again.

I went to Macquarie at the end of 1968 where the application of what has been described as the "Chemistry confrontation policy" had eliminated formal lectures and examinations. This small group laboratory based approach has been appraised elsewhere in Australia only recently and though it will also be the subject of a contribution later in these proceedings I will make some reference to it now.

Unquestionably the system has enormous potential but it is not always easy for staff conditioned by more conventional teaching methods to come to terms with it. Some find it difficult to delegate the actual teaching and assessment function to tutors and, at the same time, distinguish a useful role for themselves. Tutors, unless aided and encouraged otherwise, can easily fall back on the conventional separation of lecture and practical although there still remains the small group benefit. Ideally, to my mind, a variable mix of "hands on" and "hands off" demonstrations, talk and discussion sessions and set piece exercises is needed, but this requires experience, experienced and sympathetic direction, considerable development and preparation, plus the informed co-operation of the technical staff. Usually, though not always, one settles for something less.

The main source of assistance in the developmental area has been the tutors themselves, and it is said that this untenured group have had to bear the whole brunt of recent staff adjustments whether as a consequence of financial stringency or the whim of policy is not quite clear. One therefore, awaits the future with some misgivings while a number of young people experienced in the relatively rare art of laboratory based teaching are consulting the help wanted columns.

Certain things may be said about the system with some confidence. It solves the problem of integration, it eliminates faking or at least confers no advantage on the faker who would surely find it difficult in such an intimate atmosphere; and it establishes and maintains good contact with students, and accordingly increases the opportunity to "learn from the learners".

Help in course development has also been available from a different group. Not so long ago teachers who were acting as part-time tutors on our external (Note p) introductory course and who were rather critical of parts of it, agreed to help us develop an alternative. We now have a better course, better taught, as a consequence of the interest of these professionals in something of their own creation (Note q). It has been good to see them at work. Most of this group were among the first participants in our post-graduate chemical education programme who as a combined exercise had helped to design and then run a summer school of the University of New South Wales "Approach to Chemistry" kind.

Note o. In 1971 Professor Robert Parry, Chairman of the IUPAC Chemical Education Committee, on the occasion of a meeting in Paris of the UNESCO advisory panel on chemical education warned strongly against pretentious environmental student projects.

Note p. External courses are correspondence courses except that students must come to the university for laboratory work during vacation periods or weekends.

Note q. About this time there was a bulge in external enrolments and we used school laboratories in addition to our own and they proved more than adequate.

This was the first of a continuing series with proceedings published under the title "Chemical Action" (Note r). Held annually "Chemical Action" is now a part of the formal post-graduate course offering which requires a candidate to develop a series of laboratory exercises on a theme and then supervise the evaluation of these by a group of high school teachers. This then leads on to a week long summer school for some 60 sixth form elect school students from metropolitan high schools in promotion of which we are joined by the Royal Society of New South Wales. The staff of this last affair are a melange of lecturers, full-time tutors, ex teacher-M.Sc. students who cannot stay away, and the M.Sc. students themselves. The school students, much to the original surprise of their own teachers who often come along and sometimes participate, work a long day in the laboratory for five days on end with evident enthusiasm. Whatever happens to it or them?

The early issues of "Chemical Action" were used as the basis for international co-operation in the form of four vacation schools held at the Institute of Technology, Bandung, Indonesia, for school teachers, inspectors and junior university staff. Our participation, which was essentially advisory, was UNESCO-sponsored and a direct outgrowth of the Pilot Project in Bangkok (Note s). Attempts to relate the chemistry to local needs uncovered opportunities for collaborative research and led to the submission of a joint proposal to UNESCO in early 1971 in favour of regional co-operation in the field of natural products. Apparently the suggestion was timely (Note t).

A few years ago we devoted two issues of "Chemical Action" to environmental and consumer chemistry and in preparation for these, more than once found ourselves right out of our professional depth. Fortunately, we were able to consult our honorary associates in analytical chemistry and they quickly set us straight (Note u). These honorary associates are senior chemists in governmental and industrial laboratories where the whole of our analytical chemistry course is conducted as a series of projects which they design and supervise. This arrangement has two main advantages. It eliminates the need to "keep up with the Joneses" in routine analytical equipment and establishes and maintains contact and communion with the outside world of the professional chemist. It was salutary to learn that pollution is as much a matter of law as of chemical fact and on a cautionary note where one is needed; that the cause of the environmentalist can be hindered as well as helped by the enthusiastic amateur. In practice we found it a difficult and rather sensitive area in which to work. One of our tutors was almost blasted off the end of the telephone by a detergent manufacturer public relations man and some of our students were urged away from where they were taking samples of river water. Perhaps our experience points to why some "relevant" (lovely word) tertiary courses as reported in the literature are entirely without laboratory work (Note v).

"Chemical Action" and the individual projects undertaken by teachers and others have provided a mine of material for undergraduate courses. Laboratory based courses need a considerable leavening of experiments that are quick, cheap, easy to set up, easy to perform, easy to vary, with a high probability of providing meaningful results in inexperienced hands. Some may question such an approach but teaching in the laboratory demands good concept "mileage" for the time spent therein and the longer, more demanding set-pieces are not always good value in this respect. This would also apply surely to the conventional lecture and separate laboratory arrangement wherever a reasonable degree of integration is sought. Collections of the required kind are not commonly available as packaged laboratory courses. Individual exercises have to be winkled out or developed from scratch, set to required themes and then orchestrated in the laboratory according to mood and circumstance. This seems to me to be the ultimate art of the game.

Note r. The show went on the road in 1970 when this first group participated in an R.A.C.I. function in Adelaide.

Note s. The co-operation was initiated on the Indonesian side by Professor Sjamsul Achmad of the Department of Chemistry of the I.T.B. who had worked at the Project in 1967.

Note t. A regional network is now in being with headquarters at Chulalongkorn University, Bangkok, Thailand.

Note u. Some four years ago I acted as supervisor of an impact assessment investigation by a group of professional people seeking Diplomas of Environmental Studies. I was enormously impressed by their specialised knowledge and the way they were able to impart this to me and to other members of the group. At the time I had the feeling that they gave rather more than they received from the university in their quest for further formal qualifications.

Note v. Yet by contrast analytical chemistry seems to be enjoying a revival at the elementary level; perhaps because the sound practice of analytical chemistry is what this is all about.

But laboratory teaching will never really succeed without the establishment of a good understanding between supervisor, demonstrators and technicians. The best way to ensure this is for such a combination to develop the course in the first place and to receive for this service some reward beyond the one allegedly attaching to virtue.

In 1975-76 I spent nearly two years as a member of the UNESCO field staff (Note w) assigned to the University of Jordan and while there I became responsible for the technical direction of the second UNESCO-inspired regional workshop on laboratory teaching. It so happened that Professor Freemantle (Note x) and I were at the time jointly in charge of a post - graduate offering in chemical education and we both agreed to put this into a form which would not only serve the participating students but also provide a testing ground for the workshop. The course, in effect, became an exercise in course development designed to evaluate a set of laboratory experiments as suitable components of a first year laboratory course and, at the same time, train the required demonstrators and technicians. In the event, although this preparation contributed greatly to the technical and organizational side of the workshop the real benefits emerged in pilot trials with first year students. Here now was a laboratory course manned by demonstrators who had been involved in the development of it and it showed. They were confident and interested and this rubbed off on the students. The best part of all was that in preparing the course the demonstrators had accrued course credits and Freemantle and I had "clocked up" some official teaching time. In other words, course development was a "built-in" part of the teaching process.

We used this formula in the development of an environmental fragment of an elementary analytical course and it again worked well.

Jordan has a fascinating environment not the least part of which, the Dead Sea, lies only some forty miles away from Amman where the university is situated. Student analyses of water from this and from around the Port of Aqaba opened up an entirely new field of interest for us, and ultimately led to an analytical survey of the waters of the Gulf of Aqaba in the port area. Details of the survey are now in the press[19] and provide a good example of laboratory teaching opening up an avenue of research. Aside from this but still on analytical chemistry, we introduced into the laboratory some study of the principles as well as practice in techniques and procedures. We did this mainly by challenging students and, for that matter ourselves, to demonstrate "the reason why"[20] for various procedural steps. Often this could be done successfully and sometimes it could not, mainly one suspects, because some prescriptions are only of consequence in rather more refined applications than those commonly prevailing in teaching laboratories. It was a lot of fun, and though quite reasonably analytical procedures are designed to produce a result rather than expose the chemistry that lies behind, it still seems a good idea to spare some time other than in front of the blackboard in an attempt to justify them. Indeed, it is a practice that if adopted more widely in the teaching laboratory might help to dispel some of the "cook book" image.

Returning to the Jordan workshop, it is worth noting that in that region as elsewhere, chemistry students can expect relatively small credit for the time spent at laboratory work, nor will this be especially well integrated with lecture courses. And having had little or no experience of laboratory work at school they will find the first year laboratory a rather strange place. It was this last condition coupled with the expressed need for low cost yet effective laboratory experiments that influenced considerably our initial selection of experiments and the contents of the draft manual. Significant as cost may be for the more affluent countries I know from my own experience in some poorer countries that the capital and recurrent costs involved in laboratory work can be almost totally inhibiting. In one country, for example, it can add two or more years to the prescribed minimum time for graduation because laboratory space, chemicals and equipment cannot be provided at the required rate. In another, 80% of the total departmental budget of one of the principal universities is used up providing first year laboratory courses only. It is a very serious business that whether done poorly or well, wastefully or gainfully, occupies around the world about one-third to two-thirds of the scheduled instruction time of an undergraduate student in chemistry.

Note w. UNESCO Professor in Inorganic Chemistry and Chemical Education.

Note x. United Kingdom Overseas Development Ministry Technical Assistance Officer, Professor of Physical Chemistry, Department of Chemistry, University of Jordan.

This means that in Australia, for instance, by the usual reckoning laboratory instruction "justifies" up to 50% of the total budget for teaching and research. UNESCO is to be congratulated, therefore, in drawing attention to laboratory teaching particularly when there are signs here and there that it may be dying though whether from lack of cash or conviction is not always clear. Yet done well and with conviction, it costs no more than when done routinely, and would appear to be still the best hope for the continuing health of university chemistry and its preservation as a separate sphere of learning. The UNESCO approach has been interesting for it has enabled international groups of "workers" to use Frankland's expression, to come together to exchange and discuss recipes and at least on two occasions to actually test these in company in the laboratory. Inasmuch as this is indicative of an international view that the status and quality of laboratory instruction is important and that there is a need to identify, develop, and nurture people skilled in the art, this must be very encouraging. But it is heart as much as art that is needed for "... unless about our profession we choose to remain naive..."[1] we must agree that the lot of the educational innovator within chemistry departments, as distinct from, say, someone in a curriculum centre, can in the absence of powerful friends, be lonely, difficult, and professionally hazardous.

Some 1500 years ago during the twilight of the Roman Empire an old Senator said: "We have changed the world but can we change ourselves?". We, as scientists, might well ask ourselves the same question.

REFERENCES

1. Gunnar Myrdahl, Asian Drama, The Twentieth Century Fund, p.6 (1968).
2. H. Hunt, J.Chem. Ed., 13, p.29 (1936).
3. J. Young, J.Chem. Ed. 52, No. 1 p.41 (1975).
4. B. Sen, J. Chem. Ed. 52, No. 1 p.43 (1975).
5. K. Eble, "Professors as Teachers", Jossey Bass, San Francisco (1972).
6. Bertrand Russell "On Education", Unwin London (1976) p.199, first published 1926.
7. Report of the Committee of Enquiry into the Relationship between University Courses in Chemistry and the Needs of Industry; Royal Institute of Chemistry (1970), pp. 75-77.
8. J.D. Bernal, "The Social Function of Science", George Routledge and Sons, London (1939).
9. F. Dainton, Chem. in Britain (1971) p.467.
10. Post-Graduate Training in the United Kingdom. 1. Report on Chemistry (1967).
11. B.T. Mead "Reactive Depression in Young Adults" in Depression in Medical Practice, A.J. Engelow ed. (1970) p.71.
12. R. Tietze. The Role and Nature of Experimental Work in Chemistry Courses. Report of an Education Division Symposium of the Chemical Society, Nottingham University, (1972) pp. 9-19.
13. A.H. Halsey and M.A. Trow, "The British Academics", Faber & Faber (1971).
14. A.L. Strauss and L. Rainwater, "The Professional Scientist", Aldine Publishing (1962) p.54.
15. G. Aylward and G. Barclay, Pure Appl. Chem. 22, p.29 (1970).
16. J. Bronowski, "The Identity of Man", Heinemann, London (1966), p.100.
17. E. Watton, "No Substitute for Scholarship", J. IUPAC. Chemical Education (1971), pp. 341-351.
18. Evaluation of the UNESCO Pilot Project for Chemistry Teaching in Asia. Ed. E. Watton and R. Maybury, UNESCO SC/WS/505 (1972).
19. M. Freemantle, N. Hulings, M. Mulqi and E. Watton, "Calcium and Phosphate in the Jordan Gulf of Aqaba", Marine Pollution Bulletin (in press).
20. G. Ala Eddein, M. Freemantle and E. Watton, "The Reason Why": And Volumetric Analysis. Ed. in Chemistry (1976), p.143.
