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INSERVICE TRAINING FOR LABORATORY COURSES

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Abstract - Most universities employ graduate students (Teaching Assistants) as laboratory instructors, but little is done to teach them how to conduct laboratory classes. A number of useful manuals on this topic are available, and the paper makes a strong case for a formal program of instruction, with academic credit for its completion. Details are given of a recommended course consisting of a two-week intensive introduction prior to the opening of the academic year, with weekly seminars throughout the year.

INTRODUCTION

While the inservice training given to laboratory instructors seems to vary in amount and substance from country to country and even within countries, one common fact seems evident. None of us do enough! In my own country, the preparation of laboratory personnel for their instructional responsibilities is definitely deficient. I have verified this as recently as December when I wrote to professors of chemistry in major departments across the United States and queried them about their program for training laboratory instructors at present. The response varied from no training or a brief one-two day orientation (most common) to a formal inservice course (least common) but to a man (and they were all men) they stated that they were not doing enough. As I have had opportunity to travel during the past decade and to observe practices in a substantial number of other countries, the same shortcoming is apparent. There is little or no attention being given to the type and extent of inservice training necessary for high quality instruction in the laboratory.

Hence, at this UNESCO International Congress I will attempt two goals:

1. To describe what presently is being done in my country, the United States, as an example of current inservice practices, and

2. To describe what I, as a chemical educator, believe could and should be done - in essence, a blueprint for action.

Let me hasten to state that I am fully aware that both needs and practices differ from country to country. In outlining inservice training - a plan for action - I will deal with principles - not specifics and ask each of you to think in terms of your own situation and apply those ideas that are relevant and useful to you.

PART I - PRESENT PRACTICE IN THE UNITED STATES

In the U.S., the graduate teaching assistant, a Ph.D. candidate, is the laboratory instructor in most universities. This is frequently a required part of his/her doctoral program as well as a source of financial support. The arrangement is, however, a source of a problem. The Teaching Assistant, known as the T.A., is under heavy pressure to accomplish three major responsibilities simultaneously:

1. Graduate course work

2. Research

3. Teaching

Since it is difficult to serve three masters, something always suffers as priorities are set. Often it is the quality of teaching since success in course work and research are required for graduate degrees and success in teaching, while paid lip service, too frequently is ignored in fact. High quality laboratory instruction is all too often 'low man on the totem pole' in the reward system of our universities.

If inservice training is given, what is it like? Two general sources of help for inservice training are available and used in chemistry departments, particularly in the larger universities. The one most widely used is "The Handbook for Teaching Assistants",[1] a small 27-page document produced by the Division of Chemical Education of the American Chemical Society. The first edition was developed in 1951 and the most recent edition in 1974. The coverage includes such topics as relationships with students, conducting recitations and laboratory classes, safety and first aid, and teaching tips and aids. Each of these topics is treated very briefly.

Another more recent source of help for chemistry departments is the material developed under Project TEACH.[2] This source of inservice assistance consists of eight modules concerned with objectives, questioning skills, reinforcement techniques, testing, tutoring, microteaching and interaction analysis.

These modules are packaged in 100 pages of printed material, 6 videotapes and one audiotape. The development work was done during the summer of 1975 by a group of experienced chemistry professors from ten of our large universities under the direction of David Brooks of the University of Nebraska.

In addition to these two general sources of help, the ACS Handbook and Project TEACH, some universities have developed their own materials in the form of manuals for the instructors. As an example, Cornell University has produced a Manual for Teaching,[3] that is used by teaching assistants in departments across the campus. It contains an extensive treatment of topics such as instructional objectives, teaching methods, evaluations and the sociology of the classroom.

At the University of Maryland, teachers' guides to complement the Laboratory Manuals for both general and beginning organic chemistry were developed and published in the early 1970's. These manuals, designed to be used in conjunction with the ACS Handbook and the department's own inservice program is directed to a specific series of laboratory experiments. They attempt to assist the laboratory instructor in achieving two aims:

1. To guide students successfully through the experiments in order to produce maximum learning of techniques and concepts, and

2. To integrate the meaning and purpose of each experiment with the lecture or theoretical phase of the course.

Now, let me cite some specific examples of inservice programs conducted by chemistry departments in the U.S. to further illustrate current practices. A common practice is a 2-3 day intensive orientation workshop or seminar prior to the opening of the academic year followed by weekly or bi-weekly meetings throughout the year. Often a handbook,[5,6] specific to the local situation is produced for the laboratory instructors. In some instances, the T.A.'s are being enrolled in a course where they receive credit for their inservice training. Brief descriptions of some of these inservice programs appear in Appendix I. More careful planning and evaluation of inservice training are on the minds of many professors responsible for the introductory courses as the importance of formal preparation for laboratory instruction is increasingly recognized.

Within the Division of Chemical Education and the ACS Council Committee on Chemical Education, concern has been expressed about the training of teaching assistants. To determine current status a questionnaire was circulated during the 1975-1976 academic year to 194 institutions granting Ph.D.'s and 120 institutions granting M.S. degrees in chemistry. The questionnaire sought information on :

1. Training required

2. Service required

3. T.A. responsibilities

4. Data on training programs.

The results[7] indicate that less than 50% of Ph.D.-granting institutions have a T.A. training program. The average work load for T.A.'s (preparation and instruction) is 15 hours/week. The most common requirements as preparation for teaching are attending lectures, doing the laboratory experiments and first aid and safety training. Little attention is given to such important aspects as instructional objectives, communication and interpersonal relations, teaching strategies or evaluation. The amount of training provided ranges from 6 to 100 hours but the average is about 20 hours. The most common approaches to inservice training include practice or microteaching, evaluation vists by senior professors, lecture attendance, the ACS Safety[8] and T.A. Handbooks and Project TEACH Materials.

One can conclude that the inservice training program in the U.S. for those who instruct in the laboratory is meagre and spotty at best. Colleagues in Canada report similar circumstances and problems. G.F. Atkinson of Waterloo University in Ontario points out that research supervisors tend to be very jealous of the time graduate students spend on demonstrating and the T.A.'s themselves perceive other activities as competing more strongly for their time and attention. Senior demonstrators have much of the responsibility of whipping T.A.'s into shape but there is no formal program. E.B. Robertson from Calgary University in Alberta reports that although members of the staff profess an interest in setting up a training program, to date nothing concrete has been done beyond a brief orientation session.

As I have talked with colleagues around the world, I find that there is little or no formal inservice training in effect. What is done at my University, Maryland, and generally in the U.S. seems to be at the upper limit of present day inservice training and yet we have barely scratched the surface of what could and probably should be done.

PART II - INSERVICE TRAINING: A BLUEPRINT FOR ACTION

In setting the stage for Part II of this paper and to help establish why it is important for laboratory instruction to be improved, I quote from a recent letter from Henry Bent, Chairman of the Division of Chemical Education, and an articulate spokesman for Chemical Education:

> "Students in general chemistry learn about chemical facts and theories, which soon they'll forget, and how to get a good grade, which soon becomes relatively unimportant. They do not learn much about honesty, perseverance, dependability, and how to communicate clearly - traits society desperately needs. More and more I'm coming to feel that the main message that ought to emerge from the laboratory in university teaching is that in science no mean means (lying, cheating) justify any ends (an elegant theory, a good grade, a big profit). In science, The Method is the Message.
>
> Astonishingly, it was not a scientist but a U.S. Senator, Edward Kennedy, who was recently quoted in Science [198, 1227 (1977)] as saying that 'Inaccurate Science, sloppy science, fraudulent science -- these are the greatest threats to the health and safety of the American people.'
>
> Kennedy wasn't referring to general chemistry laboratories (although he might have been). He was referring to preclinical testing of drugs. So bad have things become, the Federal Government is about to impose sweeping new rules, known as GLP: Good Laboratory Practice.
>
> Good grief! That shouldn't be necessary. Nor will it probably help very much. Good Laboratory Practice ought to be deeply ingrained in every graduate of a university laboratory. What profited it a nation if its students learn how to read spectrometers, but must be told under fear of financial penalty and job tenure that 'all data must be entered, signed and organized so that they are easily accessible to the appropriate laboratory specialists'?
>
> Perhaps I am being too severe on university laboratory programs. The problems identified by Kennedy do not begin there. But one might hope that they would terminate there.
>
> Nipping in the bud inaccurate, sloppy, fraudulent science perhaps needs to be elevated to the role of a major goal for laboratory instruction in chemistry."[9]

As Bent reminds us, good laboratory instruction results in much more than a knowledge of chemistry, manipulative skills and techniques. The attitudes and values learned in the laboratory will, in fact, remain with the student much longer and be more influential than the specific science content in shaping both the individuals and the society. We cannot afford insecure, careless, or unenthusiastic laboratory instructors either as role models or as purveyors of knowledge. And the cause of insecurity, carelessness and negative or defensive attitudes most frequently is lack of competence and confidence. A good teacher must have:

1. A solid knowledge of the facts, concepts, theories and techniques of chemistry;

2. A love of the discipline that is naturally and spontaneously evident; and

3. A concern for people enough to demonstrate a sensitivity to and fondness for students. When we as instructors know our students as individuals and clearly state our expectations, students rise to the attention and the challenge and rarely let us down.

Our laboratory instructors must be trained in pedagogy, in safety, in techniques, in interpersonal relations and communication. But how can we do this?

First, by recognizing the need. Second, by planning a course of action designed to meet the need; and third, by implementing (talk is not enough) inservice training. We've talked for too long in most of our institutions. Let's act now to put into practice a strong training program for our laboratory instructors.

As we proceed, I would request you first to establish a positive mind set. If we begin with the attitude, "That's not possible for me in my situation", very little of value will come of what I have to say now. If, however, you adopt the attitude, "I'll listen with an open mind - for anything is possible. I'll hear what is suggested, sift it and reshape it to our culture, our students, our educational goals and improve upon the suggestions", then we have much of value to accomplish.

The suggestions that follow are appropriate for senior staff as well as for the young laboratory instructor. Many of us need retraining. They are as applicable in settings where permanent laboratory personnel prevail as in the situation where an ever-changing parade of Ph.D. candidates provide most of the laboratory instruction.

Specifically, what kind of inservice training is needed?

Let me propose a syllabus for a hypothetical inservice course for laboratory instructors.

CHEMISTRY XXX: UNIVERSITY CHEMISTRY TEACHING

The purpose of this course is to provide a series of educational experiences that will enable an instructor to acquire knowledge and skills that will facilitate his/her teaching. The inservice program will comprise concurrent workshop/seminar sessions and related field experience. The field experience consists of normal teaching responsibilities in the laboratory, including the pre- and post-laboratory discussions. The format will be an intensive two-week workshop prior to the opening of the academic year and weekly seminars throughout the year. The content and methodology for the workshop/seminar phase will be drawn from the following broad areas:

1. Motivating learning through knowledge of:

    Characteristics of university students.

    Human development and behaviour.

    Learning theory.

    Communication theory.

    Priorities and goals of tertiary education.

2. Facilitating learning through skill in:

    Stating course aims and objectives.

    Demonstrating competence in the theory and procedures for the laboratory experiments.

    Monitoring health and safety and providing first aid.

    Guiding the reporting of data, results and interpretations.

    Promoting learning through questioning techniques.

    Leading discussions.

2. Facilitating learning through skill in: (Contd.)

Mini-lecturing.

Demonstrating.

Tutoring.

Procedures for assessing student performance.

Using media.

Managing the laboratory.

3. Personalizing instruction through skill in:

Interpersonal relations.

Classroom (laboratory) psychology and sociology.

Career counselling of students.

Understanding of individual differences.

Selected readings (see page 11 for some examples) will be assigned and discussed. Microteaching, interaction analysis and practical experience in constructing objectives, assessment measures, etc. will be provided. Performance of all laboratory experiments in advance and attendance at related lectures to facilitate integration of theory and practice will be expected. A log of teaching observations and interpretations will be kept to facilitate the processing of instructional experiences. Thus, teaching under supervision, the development of teaching techniques and analysis of instructional successes and failures will be combined to promote insight and the improvement of teaching. Four semester hours' credit will be awarded.

Designing an inservice syllabus and implementing it constitute only two-thirds of the necessary action. Evaluation - assessment of our efforts and revisions based on experience - is the essential third part. How shall we know if our efforts at inservice education have been of value? We must learn to measure our achievements through our products.

Do we now have laboratory instructors who are more competent? More confident? More enthusiastic? More caring? More influential in motivating students to high levels of achievement in the laboratory program?

Upon completion of the practical work, and at a satisfactory level, are our students able to:

Demonstrate manipulative skills and laboratory techniques,

Demonstrate science process skills (such as observation, prediction, design of an experiment),

Relate practical work to theory,

Report results with integrity and with reasonable precision and accuracy,

Interpret results and sources of error,

Communicate orally and in writing,

Demonstrate self-reliance in problem solving and decision making?

In the laboratory, the Method is the Message. Once we have taught students to think and act independently and rationally, we have endowed them with the competency to be successful life-long learners - that most precious and exciting of gifts for a human being. No-one has a better setting or opportunity to act as donor than the highly competent, well-prepared laboratory instructor.

In presenting this topic of inservice training for laboratory instructors, I have outlined a more extensive program than is ordinarily provided - in fact, a blueprint for action. As I requested earlier, I hope each of you have been seriously considering what you can do in your own situation. Laboratory instruction cannot be regarded as a second-class component of chemical education and treated in a cavalier manner if we are to develop the full potential of our discipline and fulfill the expectations of society.

Each of you, as experienced chemical educators, might have presented this topic of inservice training but in different form. Now, let's let our individuality be heard through comment and question. I look forward to your response to these ideas.

APPENDIX I

Tables of Contents for Samples of Inservice Materials

A. ACS Handbook for Teaching Assistants[1]

I Introduction
Relationship with Students
Tutoring
Relationships with Faculty and Fellow Graduates
Students

II Conducting a Recitation Section
Construction of Tests
Grading Practice
Discussion Sessions
End of Period
Special Situations

III Conducting a Laboratory Class
Before the Bell
The Laboratory Period
End of the Period
Special Situations
Reports
Grading

IV Safety Measures
Safety Rules
Emergency First Aid
Sources of Safety Information

V Teacher Training Programs
Preservice Training
Inservice Training
Teaching Aids
Scout's Motto
Check List of Responsibilities of Teaching Assistants
Check List of Responsibilities of Supervisors of Teaching Assistants
Bibliography

VI Concluding Remarks

B. Project TEACH[2]

I Introduction

II Performance Objectives

III Questioning Skills

IV Reinforcement

V Testing

VI Tutoring

VII Microteaching

VIII Interaction Analysis

C. Cornell's Manual for Teaching[3]

The purpose and Use of Objectives in Instruction
Types of Objectives
Planning and Writing Objectives
Bloom's Taxonomy

C. Cornell's Manual for Teaching[3] (Contd.)

Transmission of Knowledge
- Lectures
- Discussions
- Individualized Instruction
- Simulation
- Case Method
- Laboratory
- Field Trips
- Educational Media

Evaluation
- Measuring Student Performance
- Assessing Teacher Performance

Sociology of the Classroom

D. Maryland's Teacher Guide to the Laboratory Manual[4]

The following information is developed for each experiment:

1. Materials and Equipment

2. Teaching Tips and Strategies

3. Anticipated Results and Sources of Error

4. Suggestions for pre- and post-laboratory discussions.

APPENDIX II

Representative Inservice Programs

At the University of Maryland, new T.A.'s are given a 2-day orientation to teaching with heavy emphasis on laboratory procedures and safety. In addition to attendance at lectures and participation in the introductions to laboratory work that occur in lectures, the T.A.'s meet weekly with the Coordinator of the laboratory phase of the course. They also meet weekly with the lecture professor who is responsible for monitoring and improving their instruction in the laboratories. The T.A.'s are invited to attend and participate with senior faculty members in a weekly departmental seminar on the teaching of University Chemistry. If specially interested in extending their knowledge of teaching, they can register for credit in either education or chemistry and pursue pedagogical studies further under the direction of one of the chemical educators in the Department of Chemistry.

In the mid-west, at Purdue University in Indiana, a two-day seminar, "Teaching Methods for Chemistry Teaching Assistants" is conducted. Three of the Project TEACH tapes, "Questioning Skills", "Reinforcement Theory" and "Tutoring" are used. These are followed by small group discussion of teaching techniques, peer teaching sessions, and a general orientation to procedures and facilities. A session on safety is included. The workshop is evaluated in an attempt to improve it for the next year.

On the West Coast, at Oregon State University, Wendell Slabaugh reports that the Chemistry Department provides three days of orientation before classes begin. Topics include "Safety", "Campus Policies", "Recitation", "Laboratory Work", "Grading", "Testing" and "Professional Orientation". The ACS Handbook and Project TEACH tapes are used. Then, the T.A.'s register for one hour of credit for a course during the first semester of their teaching. The course focuses on analysis of actual TV tape recordings of the T.A.'s teaching to improve classroom performance.

In Minnesota, Robert Brasted directs the new T.A.'s through a week-long orientation program. This training program includes introduction to the laboratory, demonstration facilities, the stockroom and other services and service personnel, peer teaching in laboratory and recitation, safety, first aid, grading, proctoring, tutoring. Minnesota uses some Project TEACH tapes but is currently producing its own set as well as a series of colour-video tapes on laboratory techniques. The Minnesota T.A.'s have a teaching manual and a "Commons" room where T.A.'s can meet to exchange ideas on teaching.

At Brown University in New England, T.A.'s undergo a one-week training session where attention to laboratory procedures, safety, first aid and general teaching practices are emphasized under the guidance of Professors John Edwards and L.B. Clapp.

Bassam Shakhashiri reports that all new T.A.'s participate in a week-long training session followed by weekly meetings throughout the year at the University of Wisconsin. T.A.'s may also enroll in a graduate seminar, Chemistry 901 - The Teaching of Chemistry. In this course, interested T.A.'s delve much deeper into the pedagogy of university chemistry teaching. A series of colour videotapes of laboratory techniques have been prepared for use in training both T.A.'s and students. The T.A.'s are required to perform the experiments that they will later teach.

At the University of Florida, John Baxter conducts a training program for T.A.'s that requires formal registration in an inservice course that centers around:

1. Weekly meetings
2. Required attendance at all lectures
3. "Taking" the weekly quiz prior to grading
4. Performing all of the laboratory work and writing laboratory reports under supervision.

At Florida State University under the leadership of Greg Choppin, Department Chairman and Edward Mellon, Coordinator of General Chemistry, new T.A.'s complete a 12-week "Seminar in Chemical Education" prior to being assigned regular teaching duties. The course makes limited use of project TEACH tapes and visiting lecturers and focusses mainly on microteaching, teaching strategies, learning theory, grading, safety and liability, and professional ethics. The T.A.'s do limited internship teaching in the laboratories and also log one hour per week work with students on a tutorial basis prior to receiving a regular assignment as a laboratory instructor.

At Iowa State University, Wilbert Hutton conducts an intensive summer program in recognition of the fact that more than 70% of the instruction in the General Chemistry program is provided by T.A.'s. New T.A.'s enroll in a course, Chemistry 555: Chemical Pedagogy, which meets six hours per week for six weeks. While this course is voluntary, two-thirds of all new T.A.'s attend. The components include: classroom observation, orientation and administration, laboratory instruction, methods of instruction and teaching skills, practice teaching and the construction of an independent study instructional module for beginning students.

Ronald Collins, Chairman of the ACS Curriculum Committee and Professor of Chemistry at Eastern Michigan University notes that the "laboratory instructor", whether a senior faculty member or a beginning graduate teaching assistant, to be effective must be able to:

1. Define the major goals and objectives of the laboratory course.

2. Perform each and every experiment and report the results, and

3. Learn to deal with issues of laboratory safety, grading and trouble-shooting.

Henry Bent of North Carolina State University, and Chairman of the Division of Chemical Education of ACS, points out that as a T.A. under Hildebrand's direction at University of California he not only had to work through all of the experiments before the beginning of the term but also participate in a discussion of both quizzes and laboratory experiments with Senior Faculty prior to teaching. This was a course requirement for the Ph.D. program at Berkeley and carried credit in Inorganic Chemistry. He suggests that a "Capstone Course" in inorganic chemistry tilted toward the experiments performed in a department's general chemistry program could integrate nicely a T.A.'s work as a laboratory instructor with their work toward an advanced degree to the enhancement of both programs. "Evidently, however, that's an idea where time has not yet come".

The School of Chemical Sciences at the University of Illinois uses graduate teaching assistants as the classroom and laboratory teachers in its first year service courses in Chemistry. Each course is supervised by a professor who meets with T.A.'s each week to discuss the week's assignments. Professors and senior T.A.'s also oversee the classroom teaching by visiting classes or by viewing TV tapes of classroom activity.

T.A. training begins with a 3-4 day orientation program (before Fall registration) involving 75-100 new graduate students. They perform "teaching" assignments and learn of resources available to assist them in their teaching. Once term starts new T.A.'s are closely monitored and given assistance as needed. Aside from the weekly T.A. meetings, however, most T.A.'s develop as teachers by teaching. Good teaching is rewarded by extra salary increases and by annual prizes of $500. T.A.'s are treated like young professionals. As a group they accept responsibility, take pride in effective teaching and, I believe, do a creditable job. Gilbert Haight as director and other professors try to relieve T.A.'s of problems of disaffected students and take the blame for problems in the large program, freeing the T.A.'s to have good rapport with students and to concentrate their efforts on teaching.

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