REPORT RESUMES

ED 013 077 JC 670 575

INSTRUCTION IN GENERAL CHEMISTRY AND THE EXPANDING STUDENT POPULATION, A REPORT OF THE A.C.C.C. CONFERENCE ON THE LOGISTICS OF GENERAL CHEMISTRY TEACHING IN LARGE SECTIONS (WASHINGTON, D.C., OCTOBER 1963).

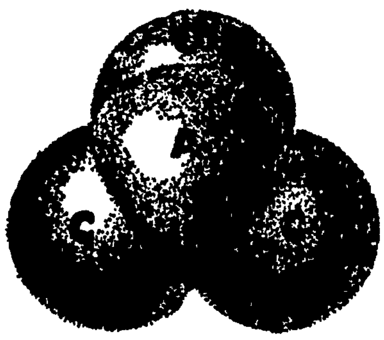
BY- BRASTED, ROBERT C.
ADVISORY COUNCIL ON COLL. CHEMISTRY

PUB DATE OCT 63
EDRS PRICE MF-$0.25 HC-$0.64 16P.

DESCRIPTORS- *JUNIOR COLLEGES, *HIGHER EDUCATION, *CHEMISTRY INSTRUCTION, *CLASS SIZE, CLASS ORGANIZATION, LABORATORY EQUIPMENT, SCIENCE LABORATORIES, STUDENT TEACHER RATIO, TEACHER AIDES, AUDIOVISUAL AIDS, SAFETY,

GROWING COLLEGE ENROLLMENTS HAVE BEEN ACCOMPANIED BY SIMILAR INCREASES IN DEMAND FOR GENERAL CHEMISTRY, WITH RESULTANT PROBLEMS OF MAINTAINING QUALITY OF INSTRUCTION. THIS PAPER IS A DISCUSSION OF SOME WAYS OF MEETING THE PROBLEMS OF NUMBERS. MULTISECTION COURSES MAY BE ORGANIZED AROUND COMMON GENERAL OBJECTIVES OR AROUND COMMON CONTENT. AN ALTERNATIVE APPROACH IS THE USE OF VERY LARGE LECTURE GROUPS. LABORATORY INSTRUCTION WITH LARGE NUMBERS OF STUDENTS REQUIRES IMPROVED STOCK CONTROL AND HANDLING OF SUPPLIES. SCRUPULOUS ATTENTION MUST BE GIVEN TO SAFETY PRACTICES. INSTRUMENTATION IN MAJOR AND HONORS CLASSES SHOULD VARY FROM THAT IN THE GENERAL CLASSES. LABORATORY ASSISTANTS MUST BE WELL TRAINED AND SUPERVISED. IMPROVED TECHNIQUES MUST BE DEVELOPED FOR DEALING WITH WRITTEN WORK AND STUDENT EVALUATION. TEACHING MAY BE IMPROVED BY USE OF INCREASINGLY EFFECTIVE INSTRUCTIONAL AIDS. (AL)

Instruction in General Chemistry and the Expanding Student Population



A report prepared by the

GENERAL CHEMISTRY PANEL

of the

ADVISORY COUNCIL ON COLLEGE CHEMISTRY

Instruction in General Chemistry and the Expanding Student Population

A Report of the A.C.C.C. Conference

THE LOGISTICS OF GENERAL CHEMISTRY TEACHING IN LARGE SECTIONS

WASHINGTON, D.C.
OCTOBER, 1963

This report, written by Robert C. Brasted, Director of General Chemistry and Professor of Chemistry, University of Minnesota, is one of a series designed to aid in improving the teaching of college chemistry. The activities of the Advisory Council on College Chemistry, including this report, are supported by a grant from the National Science Foundation, Washington, D.C.

All persons on the Council "Newsletter" mailing list are being sent copies of this report. A limited number of additional copies are available free of charge from:

Office of the Editor
A.C.C.C.
Department of Chemistry
Wabash College
Crawfordsville, Indiana 47933

TABLE OF CONTENTS

INTRODUCTION

There has been over the past several decades a spectacular increase in college enrollment. There have been, of course, fluctuations due to periods of national emergency. The state colleges and universities have felt the increase keenly and have taken many measures to accommodate ever increasing numbers of our youth seeking the advantages of a college education. Private colleges and privately endowed universities, through limitations not here discussed, are not in general able to participate in this expansion. Solution of the problem of increasing enrollment pressure by limiting the student population through such methods as entrance examinations and screening is not here considered.

For some disciplines the challenge is greater than for others. Laboratory sciences require, in a sense, triplicate facilities. There must be: (a) large lecture rooms equipped with demonstration facilities and capable of accommodating several hundred students; (b) sufficient small recitation rooms to provide for the necessary "give and take" of the discussion period, including blackboard drill work; and (c) laboratories with proper space, equipment, and safety features. In addition space must be made available for the storage, preparation, and dispensing of increasing quantities of chemicals and equipment.

Effective instruction in chemistry demands not only these facilities but also a staff knowledgeable in the subject matter and able to present it to large numbers of students in an inspiring and stimulating fashion. The laboratory must be offered in a manner that fosters a research attitude.

The Advisory Council on College Chemistry has directed a subcommittee of the General Chemistry Study Group to investigate the subject of instruction to large classes in introductory chemistry. To this end a panel of eleven persons was convened representing many of the largest of our state universities, as well as a selected group of private universities. The undergraduate 1963-64 enrollment of the institutions represented would total over 210,000. In most cases the person most responsible for the introductory chemistry program or the head of the department with a prior experience in the area of general chemistry represented the institution. Institutions are in general not referred to by name unless it is felt that the reader might desire additional information by direct contact. A list follows of the individuals and institutions represented.

University of Texas, Austin, Texas	Professor Robbin Anderson
University of Kansas, Lawrence, Kansas	Professor Clark Bricker
University of Wisconsin, Madison, Wisconsin	Professor Edwin Larsen
University of Michigan, Ann Arbor, Michigan	Professor Robert Parry
The Ohio State University, Columbus, Ohio	Professor W. T. Lippincott
Purdue University, Lafayette, Indiana	Professor Robert Livingston
Northwestern University, Evanston, Illinois	Professor Carroll King
University of California, Berkeley, California	Professor George Pimental
Tulane University, New Orleans, Louisiana	Professor Hans Jonassen
University of Pennsylvania, Philadelphia, Pennsylvania	Professor Charles Price
University of Minnesota, Minneapolis, Minnesota	Professor Robert C. Brasted (Chairman)

The report represents the considered opinion of these individuals and factual material relevant to instruction in their respective departments. The chemistry major as well as non-major student is considered. The report does not infer that in every item there was unanimity of opinion. Where real divergence existed more than one possible solution or suggestion is indicated.

I. CLASS SIZE AND QUALITY OF INSTRUCTION

Problems of increasing class size are in a sense relative. Institutions accustomed to a total student population in chemistry of 500 will be taxed by an increase to 750 or 1000 just as seriously as a large institution when the increase is from 3000 to 4000.

A. *Optimum Class Size.* The personality and enthusiasm of the instructor are important factors in deciding upon this number. Grouping of students according to disciplines is also an important consideration. It would be doubtful that a chemistry major group, even in the larger universities, would run in excess of 200 to 250. There is evidence that this is also an upper limit if some real student-instructor rapport is to be maintained. Above 250 the logistic of grade recording, recognizing individuals, conducting personal inerviews, and establishing a proper level of subject matter becomes most difficult. Some justification for the lecture room size of 250 was derived over a decade ago by studying the evaluation reports of students involved in closed circuit television. Any demonstration observed from more than approximately ten rows away from the demonstration table was found to be of doubtful benefit. To the end of maintaining such a size there seems to be no merit in the construction of auditoria seating 500 or more students.

Increasingly in large universities the total enrollment of non-majors taking general chemistry exceeds 250. These are attendent problems if a class size of 250 is to be maintained. The non-major group has every right to expect similar treatment to that received by the major group. They will probably need more personalized attention. There is now, and will be in the future, a need to increase the number of staff to fulfill the obligations of increased enrollments. For reasons that are not immediately apparent, much publicity has been given to teaching more and more students with fewer and fewer members of the senior staff. Perhaps this is a part of automation philosophy. It is on the other hand only reasonable that if we are training and educating more students in our colleges and universities, eventually there should be increasing numbers of outstanding end products. Amongst the post-graduate group, there will inevitably be competent teachers for our colleges and secondary schools. Admittedly, until some sort of an equilibrium is established, instruction will have to be carried on with unfavorable teacher to student ratios. Hopefully this report will suggest certain solutions to the problems associated with this ratio. The panel was not of the opinion that the bulk of teaching should be carried on by "a select few" or a "master teacher."

B. *Administration and Instruction of Multisection Courses.* On the assumption that a number of individuals drawn from a number of major disciplines or divisions of a department may teach a single course, a number of approaches present themselves. The panel, on examining several approaches, could see no single "best way."

1. The staff may function on a day by day basis of common lectures, presenting nearly identical material, and examining at a common time with a common examination. This procedure or one similar to it is followed with success in many large universities. The amount of time spent in staff meetings by both junior and senior staff is appreciable. It is usual in such a plan to have senior staff giving fewer lectures with a proportionately larger junior staff responsibility. This plan adapts itself to allowing a student to schedule his laboratory section irrespective of his lecture section. This freedom in registration becomes more important as enrollments increase and as the overall picture of class registration becomes more complex.

2. A very different approach to sectioning (Minnesota) is for lecturers to agree upon the major points of coverage within a total framework. Each lecturer then operates virtually independently as to details of coverage, depth, and examination plan. All students in a given lecture must attend the same recitation and laboratory sections. As long as class sectioning can be arranged to permit this kind of instruction, and where a relatively large senior staff is available, this plan has been found to be very satisfactory. The freedom of the individual lecturer in this kind of a program gives him an opportunity for more imagination, maintains his interest over a longer period of time, and encourages experimentation in new approaches in teaching. Where multisections exist the students tend to be divided according to their interests. Premedical students will be found in one section, agricultural students in another, etc. With this approach it is possible for lecturers to modify their courses slightly to introduce topics that may be of special interest to such selected groups of students.

C. *Participation of Senior Staff in General Chemistry Lecture Work.* It was felt by all members of the panel that except in unusual cases (Purdue, Ohio State) there should not be persons exclusively involved in the instruction of general or introductory chemistry. Senior staff from all disciplines should have the interest, and hopefully the ability, to instruct in this first course offering. There are many facets to this point of view. Senior staff should maintain a research and specialized field in order to retain a fresh and enthusiastic approach to teaching. The counterpoint is in turn important. A staff member's width and breadth of interest can be fostered by instructing in general chemistry. Modern introductory chemistry when properly taught proves to have real breadth. Unquestionably, there are individuals who can best make their major contribution only in restricted research fields or in graduate instruction in specialized subject matter. The department whose staff is greatly overbalanced in such specialization, however, is not carrying its fair share as an integral part of the university, nor is it playing fair with the over-all student body.

A compromise between total integration and total separation of upper division staff and general chemistry staff may be ideal. However, there may be situations arising that will necessitate the creation of a teaching faculty devoted entirely to the general chemistry program. If the supply of competent graduate teaching assistants becomes highly inadequate, then the creation of a permanent staff with few or no research interests may be the only solution. If favor of separation, the 100% general chemistry teacher will have the time and interest to keep abreast as there are drastic changes in and upgrading of introductory chemistry. Total separation is to be deplored because of the likelihood of the appearance of a second class permanent teaching staff within the university. In this regard the panel has gone on record (*Chem. and Eng. News,* October 28, 1963) recommending that agencies and foundations responsible for financial support of graduate students recognize the importance of teaching as a part of graduate chemical education.

II. LABORATORY AND ITS ADMINISTRATION

The administration of the laboratory is very likely to be the weakest part of the introductory course with respect not only to challenging experiments, but as well to proper physical facilities. The influx of more and more students compounds the problems attendant to this important phase of instruction.

A. *Laboratory Stations and Desking.* With few exceptions, even the largest universities are able to provide individual (non-shared) equipment. Each station represents an investment of between $30 and $50 in essential glassware and other equipment. When enrollments in introductory chemistry reach 2000 or more the total investment is appreciable. A desired change in technique requiring new or different apparatus may involve sums of money that are prohibitive. Several suggestions for the maximum use of space and equipment are noted below.

1. Increasing Drawer Space Available for Student Use. When the ratio of student lockers to bench space is increased, more periods can be scheduled in the laboratory. The laboratory can even serve two disciplines such as organic and general. The number of drawers can be increased by storing them outside the laboratory proper. It has also been possible to incorporate as many as 15 desk drawers within a single working space (Wisconsin). This number of lockers permits the establishment of three, three-hour periods, five days a week. Excluding the problems of stocking and staff, and assuming sufficient equipment, a very large enrollment could be accommodated in such a laboratory.

2. Issuing of Laboratory Equipment. A minimum of individual desk equipment is necessary in a system where the student daily withdraws all but the most common items of equipment from the stockroom. The disadvantages of such a system include the student's time consumed in "battling" lines and filling out forms and the possibility of the student returning improperly cleaned equipment.

3. Open Stock System. Some items not conveniently stored in a desk (e.g. burets) may be placed in wall racks, with return and cleaning on an honor system or monitored by the teaching assistants (Ohio State). Many items may be made available in the laboratory by way of this open stock system. Some type of honor system is assumed, with the added possibility of mechanical glass washing equipment to encourage the proper cleaning of apparatus. The total cost balance in such a system is not immediately apparent, but it is possible that savings in stock help and checking in and out time might more than balance losses through breakage or theft. The lack in uniformity reported in laboratory breakage fees makes it evident that no clear solution to the problems of equipment issuing is presently available.

4. Desk Equipment Replacement. A stock system should detect broken and missing apparatus at the end of each term so that the students responsible can be charged accordingly. If this is not done the department may find the cost of replacement distressingly high. Under most systems of checking in and out of the laboratory this loss is almost directly attributable to improper or careless checking on the part of the teaching assistant. It has been possible to cut the loss considerably by the expedient of each assistant placing a signed slip of paper in the desk drawer after checking it out and locking it, ready for the next term. Replacements needed by the next user can be matched to the assistant responsible, though the assistant need not be charged for the replacements. There seems to be a materially improved attitude in checking out of desks when a list is posted of teaching assistants and their cost to the department due to incompetent checking.

B. *Make-up Laboratories.* For institutions which are either not able or are unwilling for pedagogical reasons to allow students to work in laboratories at all hours, several avenues are open to accommodate the special cases of extra work or make-up for excused absence.

1. Certain times outside the regular periods may be set aside for laboratories to function with assistants present.

2. Honors students may be allowed to work with senior staff at near-by stations or offices. The accident rate for such students at one institution (Northwestern) has been zero over a period of some fifteen years using this system.

3. The total assigned experimental load may be adjusted to such a level that no extra time is needed. Any make-up then could be incorporated into the time of the regular term. This approach is in the spirit of requiring students to complete each experiment with great care and with a high degree of accuracy.

4. No make-up may be allowed and missing work prorated over the work that has been completed.

5. Special cases of excused absence may be adjusted into existing laboratory periods as space permits.

C. *Laboratory Safety.* One of the least exciting and yet most necessary items of laboratory administration is that of safety. Crowded conditions, multiple sections, and departure from routine experiments all provide an atmosphere for an increase in accident rate. Several recommendations relevant to this phase of laboratory are offered. (Also see *Journal of Chemical Education,* January 1964 and succeeding issues.)

1. Safety Training of Assistants. Where a division of environmental health exists within the university structure, such a group will usually be found most cooperative in establishing a safety instruction program. A lecture-demonstration course of one hour per week for eight weeks has been found most instructive and useful (Minnesota). Establishing a course number for this program allows the graduate teaching assistant to have this experience as a matter of his graduate record. Industrial interviews endorse this situation. Among topics included in such an existing program are: first aid (treatment of burns, cuts, inhalation and ingestion of noxious and poisonous substances, and artificial respiration), handling of high pressure gases, discarding of waste chemicals, handling and disposal of radioactive materials, safety equipment (showers, blankets, eye fountains, and gas masks), and analysis of atmospheres for combustible and poisonous materials. It is evident that such a program includes more than safety pertinent to the general chemistry laboratory.

2. Safety Goggles. For a very nominal sum, approximately 50 cents per student, all introductory chemistry students can have safety goggles. Though some loss in peripheral vision may occur, the protection offered even by inexpensive glasses seems worth the effort. Indoctrination of students and junior staff in the consistent use of safety goggles is essential, though not easily accomplished.

3. Laboratory Attire. For practical as well as safety reasons all assistants should provide themselves with white laboratory coats. In such attire the assistant can be spotted quickly in large laboratories both by the student and senior staff in cases of emergency. No strong feeling was evidenced for the use by students of lab coats or aprons as protective attire.

4. Communication with Health Service. There must be methods of rapid communication with and transport to the student health service. All staff members and assistants should be familiar with these methods. A warning call to the health service can advise that an injured person is on the way. Campus police can provide rapid transportation.

D. *Quantitative Experiments and Instrumentation for Large Laboratory Sections.* The chemistry major sequence and honors programs must be separated from the large service course when considering the matter of instrumentation. It is probable that the first two groups will not exceed two hundred in one case and thirty in the other. The large service course may involve several thousand students.

1. Automatic (Single Pan) Balances. Many universities have found that the use of single pan automatic balances with milligram accuracy has made possible savings in time permitting a wider latti-

tude of experiments. There is still the argument that teaching principles are lost in omitting instruction in double pan pulp-type balances. Those advocating the use of automatic balances assume that a student could, if necessary, within a short period of time familiarize himself with the mechanics and operation of double pan balances. An industrial laboratory is more likely to expect automatic balance familiarity. Experience shows that one automatic balance can serve as many as ten students, though a more favorable ratio is obviously desirable. Some waiting by the student for use at the 10:1 ratio is inevitable in the early weeks of laboratory until familiarity is gained. Instruction to teaching assistants as part of a pretraining program and to students by way of closed circuit television and/or personal demonstration will provide a smooth transition. The total investment in these balances, which may well total 20 to 30 thousand dollars, deserves protection in the form of a maintenance contract. The manufacturer provides a service which completely overhauls all balances each year. A small balance fee in the order of 40 cents per term per student to cover this service is considered fair for the advantages gained.

A more pertinent question is whether the balance used for general chemistry should be the 0.1 mg variety or the 1 mg (e.g. H4 or H5 or H15 Mettler). When the cost differential is contrasted with the gain in laboratory practice and theory, the 1 mg balance is favored.

2. General Instrumentation. Federal funds have provided a means by which instruments can be provided for the general chemistry students whether in a major or non-major program. The pH meter and spectrophotometer provide means by which quantitative information can be gained in areas such as kinetics, metal-ion determination, buffer systems, and weak acid-base titrations. Even a single instrument per section of 20 or 25 students can be of real teaching value.

It may be mentioned that few experiments are available for the early weeks in the introductory course which use as their theme atomic structure. One institution (Ohio State University) has profitably used simple spectroscopes. There is also need for proper lecture table demonstrations for the topic of atomic structure.

3. Quantitative Estimation Techniques at the Introductory Level. Amongst many facets of chemistry, quantitative estimations must be included in first year chemistry. What was part of sophomore or junior quantitative analysis is now becoming commonplace in the general chemistry laboratory. These operations are being properly performed at the introductory level even when large total enrollments are involved. Sufficiently precise gravimetric work is possible which will acquaint the student with the essential of quantitative chemistry. Often neutralimetry, redoximetry, and precipitimetry, each involving one or more unknowns, can be incorporated into the latter part of the first term or early part of the second term. Spectrophotometric apparatus (see above) provides lattitude in experiments when three-hour laboratory periods are available.

It is advised that the teaching assistant be made responsible for going to each student's desk, issuing unknowns, and collecting student results. Little time is then lost by the student in waiting at a stockroom for unknowns. Accurate and complete records of student performance over long periods of time will help to establish reasonable grading tolerances and help identify sources of error in student procedure.

E. *Length of Laboratory Periods.* A three-hour period seems more, or at least as productive as two, two-hour periods. The greater ease in scheduling two-hour sessions does not seem an adequate reason for their preference over the productive longer period.

III. THE GRADUATE TEACHING ASSISTANT

The teaching assistant has an important role in the general chemistry program as evidenced by the ratio of assistants to general chemistry students at the institutions represented on the panel. See TABLE I. It should be borne in mind that the ratio of teaching assistants to students does not indicate the size of recitation sections since one assistant may be responsible for several sections.

TABLE I

RATIO OF STUDENTS IN GENERAL CHEMISTRY TO GRADUATE TEACHING ASSISTANTS

Institution	Total Students in General Chemistry	Total GTA in General Chemistry	Students-GTA Ratio
B	1800	41	45
C	2400	60	40
D	400	13	31
G	956	26.5	36
H	3720	89	42
I	1750	26	66
J	2000	36	56
K	3300	64	52

The teaching of laboratory and recitation to large numbers of students by teaching assistants presents problems not entirely different from those involving the senior staff discussed in Section I. It is evident that the time demands on the senior staff (when research and administration duties are many) make it difficult to involve such persons for prolonged periods of time in the general laboratory. The involvement of senior staff in recitation sections was proven to be relatively uncommon. The need for maximum use of the graduate teaching assistants' talents arises. To this end several suggestions are offered.

A. *Pretraining of New Teaching Assistants.* An increasingly large number of institutions have found it advantageous to have training programs which will facilitate assistants' transition from students to teachers. The fundamental materials of both laboratory and lecture may be presented. Safety instruction also finds a place in the training of assistants as noted in Section II-C.

1. Refresher Work in Theory. Selected staff members are chosen to present several hours each of brief surveys of the more or less nontraditional topics of introductory chemistry. These are topics which might be treated in a fashion and level different from that of the assistant's home institution. It is further assumed that within the group of new assistants there will be many different levels of learning, levels of interest in teaching, and levels of familiarity with teaching principles. It is stressed that these sessions will treat material only at the general chemistry, and not an advanced, level. It comes as no surprise to most teachers of general chemistry that some of the more mundane topics need some review. Such a course of instruction does not preclude the assistant's attending the regular lecture presented by the senior staff in the course for which he is assisting.

2. Laboratory Familiarization. An opportunity is given the assistant to perform a selected number of the experiments as part of his regular schedule. The mechanics of checking in and out, dispensing of chemicals, issuing of unknowns and equipment, and in general, problems associated with the experiment become familiar to him before he actually appears before a recitation class. At several institutions the

assistant comes to the campus sufficiently far ahead of the normal start of classes to permit participation in this program. In at least one case (Tulane) the assistant receives a special stipend while taking part in this program.

3. Closed Circuit Television. The use of closed circuit television has permitted a more effective integration of the teaching assistant into recitation and laboratory work. By this medium the senior staff may introduce certain aspects of problem work which might be questionably treated by the assistant at least in his first year of experience. Demonstration work concerning not only laboratory techniques but lecture material may be presented in a more meaningful fashion using television than can be done either in a large lecture hall or by the assistant in a recitation room.

B. *Summary of Teaching Duties at Representative Institutions.* Teaching assistants' actual contact hours show little variation from institution to institution. There is a significant variation in such responsibilities as staff meetings, grading times, proctoring, and other normal duties. Some work is also expected with little or no credit given in the time schedule. TABLE II outlines the duties of teaching assistants at the institutions participating in the panel.

TABLE II

WEEKLY DISTRIBUTION OF HOURS FOR HALF-TIME GRADUATE TEACHING ASSISTANTS

Institution	Lab.[a]	Rec.[b]	Staff Meeting	Lecture Attendance[c]	Grading Tests	Other Grading[d]	Preparation[e]	Conference Hour
A[f]	6	3	¾	1	1	½	—	—
B[g]	6	2	½	Advised	3	1	—	1
C	6	4	1	2	5[h]	3	—	—
D	9	3	1	3	1	4	—	1
E[g]	6	2	1	2	1	?	—	—
F	6	0	½	Optional	5½		—	—
G	6	3[i]	1	—	1	2	—	1
H[j]	6	2	1	2	1	4	4	—
I	6 or 9	2	1	Optional	1	2	—	1
J	6	2	1	0 or 3	1½	1	6	—
K	7	2	1	4	2	4	—	—

a — Actual contact hours in laboratory.
b — Actual contact hours in recitation unless indicated otherwise.
c — These figures sometimes apply only to the first year of service as a teaching assistant.
d — Includes grading of homework and laboratory experiments. It should be noted that some schools employ undergraduates for test grading.
e — Preparation time is not specifically listed by every school.
f — Figures are averages; assistants usually have two sections in one semester and one section the other semester. Not all assistants attend lectures.
g — The indicated load is for about two out of three semesters. Every third semester (on the average) a given assistant has only 3 hours in lab and 1 hour in recitation.
h — Four hours are for quiz grading.
i — Includes two hours of attendance at recitations.
j — Figures are typical for most assistants; contact hours are lower in a few cases where extra duties (help sessions, quiz grading, etc.,) are assigned.

C. *Graduate Teaching Assistant Stipends.* TABLE III indicates the range of stipends available at the represented institutions. It should be noted that teaching assistants are frequently paid a higher stipend than research assistants.

Table III

Graduate Teaching Assistant Stipends—After Subtraction of Required Fees and/or Tuition (9 month basis)

Institution

B — $2000 (+ $200 and tuition scholarships to the experienced who qualify as Teaching Associates)

C — $2400 (1st year) and $2500 (experienced) Six assistants are paid $250.00 extra from industrial grant(s).

D — $1990, $2090, $2190, and two assistantships at $2500

E — $2200 (1st year), $2400 (2nd year), $2600 (3rd year), and 10 assistantships at $2800

F — $2100

G — $1800 to $2200

H — $2200 and $2720 (20% of assistants paid higher figure)

I — $1800-$2200

J — $2200

K — $2100 to $2300

Summer programs varied widely from institution to institution. One department guaranteed that each teaching assistant would have a summer research appointment with a stipend of $400 plus supplies. In another case one half of the summer could be devoted to assisting and the other half to research.

It is considered desirable for institutions to increase the stipend available to second year assistants who have performed in a superior fashion. An interesting mechanism in approaching this increase is the creation of a new academic level, that of Teaching Associate. Where tuition remittance is not automatic it is possible to increase "take home pay" by awarding a tuition scholarship.

D. *Selection and Retention of Teaching Assistants.* No lecturer would dispute the claim that the success of his course is determined in a large measure by the effectiveness of the teaching assistants. It is not reasonable that each year a completely new group of assistants move in with the experienced people moving to other divisions or to research assistantship duties. It is obviously equally improper not to give the graduate assistant a chance to assist in the area of his major interest. The recommendation is that a cadre of experienced assistants be carried from one year to the next and that new assistants be trained and indoctrinated as per the suggestion earlier in this section (III.A)

Selection problems in the appointment of teaching assistants have been compounded in recent years by acceptance of large numbers of graduate students from non-English speaking countries. This report in no way condemns this practice since our graduate students stand to gain by the healthy mixing of racial, political and ethnic groups in the research laboratories. The assumption is, of course, made that an applicant is accepted regardless of country only when all of the university's normal prerequisites have been met or exceeded. Communication problems do arise, however, when assistants with inadequate command of spoken English are put in charge of recitation sections. It is recommended that improved procedures be established in foreign countries for the testing of applicants' ability in using English in public speaking. It is inevitable that there will be cases of marginal or poor selection based on verbal English ability. In such circumstances it is possible to postpone actual contact duties (as in recitation or laboratory) until proficiency is gained in communication.

IV. EVALUATION OF WRITTEN WORK

The success of the student in the American system of education is inevitably measured by such items as problem sets, laboratory reports, and examinations (in short or long form). An excessive amount of staff time can be consumed in evaluating this material. Some suggestions are offered, though none will be a substitute for careful evaluation by the staff. There will inevitably be a compromise between the ideal and the practical when numbers of students are large.

A. *Laboratory Reports.* An item illustrating this compromise is that of laboratory reports. There is agreement amongst senior staff, responsible for administering and teaching introductory chemistry, that the blank-fill-in type of report is most undesirable. Many of the new experiments are designed to permit real freedom of thought on the part of the student and can be written up in a project form. The purpose, procedure, experimental data (in a form designed by the student), conclusions, and, most important, an analysis of results can be written in concise form. There is no question that the grading of this type of report is time consuming. Perhaps the logical answer is a smaller student to assistant ratio.

B. *Examinations.* Some mention has been made of grading practices. Additional procedures are suggested that have proven successful.

1. Subjective type examinations can be given almost exclusively when two or three hours of the teaching assistant's load are allocated for grading, and when advantage is taken of the manpower available from the junior and senior classes of chemistry majors. Students prefer more frequent testing rather than a single midsemester and a final examination. Challenging multiple choice examinations are available and can be produced. However, it is recommended that wherever possible the student be allowed the possibility of self expression inherent in subjective type examinations. Project type laboratory reports and subjective type examinations are recommended for the same reasons.

2. The subjective examination given at relatively high frequency serves the dual function of teaching mechanism and grading criterion. Because a student is a member of a large class does not mean that he should be deprived of every chance to express himself.

C. *Problem Assignments.* The need for intensive problem drill is recognized for the large class perhaps even more than for the smaller class where blackboard and special instruction may be possible. Honors sections and small classes of majors will probably not constitute a problem since unusual efforts will be made to provide personalized attention. For the thousands of others in the non-major classes several questions must be asked. Is it possible by any means to do justice in grading? Are problem assignments done independently enough to warrant bothering to grade in any detail? Will the performance on examinations serve as sufficient proof of the independence of work and be adequate evidence of learning?

Some approach to rigor in grading can be accomplished through the following procedure. The student is instructed to work all problems in a bound notebook. This notebook is examined by the teaching assistant while making his "rounds" during the laboratory session. At the same time there is oral quizzing to check procedure, apparatus, and data related to the experimental work. Some evaluation of the care with which the assignment has been carried out is possible. Only extremes in grade need be recorded, with the student given to understand that opportunity will be afforded him in examinations to prove more precisely the extent of his understanding.

V. DEMONSTRATIONS AND AUDIOVISUAL AIDS

The number of institutions large and small that are now prepared to offer the services of closed circuit television is increasing rapidly. It is recommended that certain demonstrations be reserved for this medium, though others can adequately be performed before 250 students. As mentioned earlier the recitation session can be profitably used to present certain demonstrations. A cooperative studio staff can suggest the proper use of overlays, split screen techniques, and the preparation of video tapes to provide a saving in time and energy when multiple sections are involved. Some demonstrations may be sufficiently well standardized so that a library of tapes may be accumulated on these subjects. Many state universities have now established campuses in centers of population throughout the state. It is desirable to connect these centers to the main campus by TV cable. Where this has been done it has been possible to project worthwhile demonstrations to chemistry classes in these centers.

The level and quality of the CHEMS films[1] are such that most if not all are suitable for the introductory college chemistry student. As other films are made available they will be shown at A.C.S. national meetings and reviewed by the *Journal of Chemical Education*. The subject matter of these films, in general, is not demonstrable to the same degree of perfection in the usual chemistry class, either because of lack of equipment or chemicals. Projection of demonstration materials by the overhead process has been adequately publicized and is certainly applicable to large lecture classes. An independent working group of the Advisory Council on College Chemistry is presently preparing a report on broader aspects of demonstration techniques.

When the student knows that he is responsible for not only the main theme of a film or demonstration but also for the peripheral features, he will usually view it with greater attention than if he assumes it is a time filler or amusing interlude.

There is no substitute for a well trained and interested full-time demonstrator. New demonstrations can be more readily devised with a corresponding saving of time on the part of the senior staff. The effect of a proper demonstration, however, is greater for the student when carried out by the lecturer rather than by a teaching assistant or even the full-time preparation-demonstration person. All three methods are in use in effective demonstrations in the institutions whose experiences have been drawn upon for this report.

VI. SUMMARY

An attempt has been made herein to investigate some aspects of introductory chemistry instruction. Consideration has been given to such topics as senior staff involvement, laboratory operation and curriculum, graduate teaching assistant involvement and training, and audiovisual aids. It is recognized that these topics are not all-inclusive. It is hoped that the suggestions may be applicable to local situations. The more time that can be devoted to working with principles and the less with logistics of making a course function, the better should be the final product.

The Advisory Council on College Chemistry welcomes constructive comments, suggestions, and criticisms. These should be directed to:

Professor Robert C. Brasted
Department of Chemistry
University of Minnesota
Minneapolis, Minn. 55455

[1] These are films produced by the Chemical Education Material Study. Further information is available from Modern Learning Aids, 3 East 54th Street, New York, N.Y. 10022.