A STUDY OF THE EFFECTS OF SINGLE CONCEPT LOOP FILMS UPON LABORATORY TECHNIQUES WHEN USED FOR PRE-LABORATORY INSTRUCTION IN THE INTRODUCTORY ORGANIC CHEMISTRY LABORATORY

By

HARRY BALDWIN HERZER III

Bachelor of Arts
The College of Emporia
Emporia, Kansas
1956

Bachelor of Science
The College of Emporia
Emporia, Kansas
1956

Master of Science
Kansas State Teachers College
Emporia, Kansas
1961

Submitted to the Faculty of the Graduate College
of the Oklahoma State University
in partial fulfillment of the requirements
for the Degree of
DOCTOR OF EDUCATION
July, 1970

A STUDY OF THE EFFECTS OF SINGLE CONCEPT LOOP
FILMS UPON LABORATORY TECHNIQUES WHEN USED
FOR PRE-LABORATORY INSTRUCTION IN THE
INTRODUCTORY ORGANIC CHEMISTRY
LABORATORY

Thesis Approved:

Kenneth E. Wiggins
Thesis Adviser

L. Herbert Bruneau

Ernest M. Hodnett

Gene L. Post

D. Durham
Dean of the Graduate College

ACKNOWLEDGMENTS

Research cannot take place in a vacuum. Any success incurred from this study is a direct result of the interactions of many individuals. I would like to take this opportunity to give my special thanks to a few of these people.

For my doctoral committee, each for his own specific talents and expertise. Dr. Kenneth E. Wiggins, committee chairman and thesis advisor, Dr. Henry P. Johnston, Dr. Ernest M. Hodnett, Dr. Gene L. Post, and Dr. L. Herbert Bruneau.

To Dr. Kenneth E. Wiggins, Professor and Associate Director, Research Foundation. Without Dr. Wiggins' frequent prodding I would not have left the security of full time teaching for the rigors of graduate study. I also thank Dr. Wiggins for his patience as well as keen interest and encouragement in seeing this project to fruition.

To Dr. Henry P. Johnston, Professor of Chemistry. Dr. Johnston's sage advice and council as well as providing the course in which to evaluate the films were sincerely appreciated.

To Dr. Ernest M. Hodnett, Professor of Chemistry. Dr. Hodnett's advice on laboratory techniques and suggestions for the JH_2S Examination were indeed appreciated.

To Dr. Gene L. Post, Associate Professor of Education. Dr. Post's knowledge and experience with instructional media was invaluable.

To Dr. L. Herbert Bruneau, Professor of Zoology. Dr. Bruneau provided a necessary service with his objective detachment from the specific aspects of organic chemistry and his warm and encouraging advice for the project as a whole.

To my good friend Mr. Calvin T. McBride, formerly of the English Department, Baker University, Baldwin City, Kansas, whose efforts to attempt to allieviate my horrendous grammer and awkward prose were deeply appreciated. For those errors which remain, I accept full responsibility.

To the Research Foundation, Oklahoma State University. For without their interest and encouragement in the form of a grant to produce the films, this project would not have been possible.

Finally, to the students enrolled in Chemistry 3015, fall semester 1969. For without these cooperative students the evaluation of this study could not have been successfully completed.

TABLE OF CONTENTS

Chapter	Page

LIST OF TABLES

Table | Page

CHAPTER I

INTRODUCTION

There are many problems confronting the chemistry teacher today. Part of these problems are common to the entire teaching endeavor. The burgeoning college enrollments are causing a variety of pressures upon the teaching community. Not only are more highly capable students entering college today but the student body encompasses a much broader range of talents and intellect. The trend today is for the students to continue their education beyond secondary school. This is causing the need for a more diverse educational program. The colleges cannot afford unlimited professional faculty--nor could the students and tax-payers afford to pay the expense which that would entail. Therefore the college and university must be able to cope with the increased student-teacher ratio as well as to be able to teach a diverse student body. Even in so-called homogeneous grouping there is a diversity of interests as well as intellect. The real question is simply how can we provide an educational program which will make more efficient use of the professor's time. The primary answers lie in freeing him from non-professional record-keeping which could be performed by a secretary or a computer, freeing him from repetitive duties, and allow him to use his time dealing directly with the students.

The demand for increased professional salaries further necessitates the more efficient use of time without depersonalizing the teaching-learning process. Whatever solution (or partial solution) to the problem the cost must be considered. It seems apparent that one possible answer lies in instructional media. The cost of either professional or para-professional personnel continues to increase. Presently the cost of hardware for computer assisted instruction is rather high, although the cost is dropping (3). Through technology the cost of equipment lessens as the device becomes widely used.[1]

There are problems which confront the entire teaching community. In chemistry not only do we have these problems but we also have others. The laboratory is an integral part of the teaching of chemistry. The problems related to mass teaching of techniques, procedures, safety precautions are but a few of the problems related to laboratory instruction. In lecture courses some feel that the answer lies in large group instruction, but this far no one has suggested large group laboratory sessions utilizing only one instructor.

This study deals with laboratory instruction using a media approach. Specifically the use of single concept loop films. The single concept loop film consists of a segment of motion picture film wound in a spiral, spliced end-to-end, so that it forms a continuous loop. Mounted in a special cartridge, the loop allows continuous running without the need (or capability) of rewinding. These loop films may be operated by the students themselves. It is not necessary to have the instructor supervise their operation.

The remainder of this study will focus upon the use of single

---

[1]Consider the decrease in long distance telephone rates during the past four decades as opposed to the inflationary costs of T-bone steak and other food items.

concept loop films and how they may be used to alleviate the problems encountered in laboratory instruction as well as provide more efficient use of the professor's time.

Nature of the Problem

It is generally agreed that significant learning is acquired through doing when the subject matter as understood by the learner is related to his own perceived needs or purposes (76). This is the basis for science because of the emphasis upon doing actual laboratory experiments. Regretably, however, much of the laboratory experience is reduced to following the directions and plodding step-by-step through the experiments. The laboratory instructor attempts to prod the slow while striving to keep the faster students busy in order that all will finish the experiment on time. This type of experience is no more valuable than sitting through a demonstration or a film (92).

The laboratory should be a place where the student is confronted with a question or a problem to solve. The most natural speed for the solution of this problem is the student's own pace, which may be rather slow while he becomes used to new surroundings, techniques and equipment. Later, as he gains in skill and expertise the pace should quicken. Some students will enter a given laboratory already possessing some of the necessary skills while others will be completely devoid of them. Some students will gain the requisite skills more rapidly than others. The individual student differences manifest themselves in varied learning rates as well as varied learning depths. Why should all of the students be forced into the same pattern? We should maintain minimum standards for a course, but why should we affix a limit?

No maximum should be considered if it is obtainable within the framework of the time and equipment limitations.

The question which must be answered is how much and when to teach those methods and techniques which are fundamental to a particular discipline. The conventional approach is for the instructor to show the entire group prior to the beginning of the experiment. This method has certain limitations. In order to concentrate upon a specific situation, consider organic chemistry. Students taking organic chemistry have already had a course in general chemistry. The techniques in general chemistry require little more than relatively simple techniques such as heating test tubes and flasks, collecting gases, and simple filtration. They have had some introduction into fundamental laboratory techniques and essentials of safety procedures, yet the course does present them with a great challenge. The laboratory techniques required are much more involved and complicated than in general chemistry. Organic chemistry confronts the student with a minimum of 500 new terms during the first semester.[2] This assumes that the student is already with some of the common terms such as "alcohol", "protein", and "carbohydrate". Although these terms will take on broader, less restrictive meanings which are related to their general structural classification, others which might be familiar to them might take on more narrow meanings. Together with the new vocabulary, the student

---

[2]This number is taken from Hart and Schuetz, 3d Edition (28), the textbook used in Chem 3015. This is one of the smallest organic chemistry textbooks consisting of only 353 pages. Presently the organic chemistry textbook which is one of the most popular throughout the United States and is being used in Chem 3053 for chemistry majors is Morrison and Boyd 2d Edition (42) which confronts the students with a minimum of 850 new terms in its 1204 pages.

must grasp new laboratory techniques as well as learn to manipulate new equipment in order that he will be enabled to prepare, purify, and elucidate his preparations. In organic chemistry the student encounters a formidable jigsaw puzzle of standard taper glassware which includes a kit of over a dozen pieces of interchangeable parts which may be put together in a myriad of combinations. In addition he may confront for the first time a variety of items such as filtering flasks and funnels, melting point apparatus, and steam lines.

The most common method of pre-laboratory instruction is for the instructor to demonstrate the necessary techniques for the experiment. Although teachers feel that all of their students should read the experiment prior to coming to class, it is all too common for the students to enter the laboratory ill-prepared. When they are shown some new technique they are not certain what it is for, therefore the demonstration has less meaning for them. The effective pre-laboratory demonstration requires that all of the students must be ready to view the demonstration at the same time. The students must be able to see the demonstration clearly, and for effective learning the student must feel that he heeds this knowledge. If he is uncertain as to its purpose, he may fail to grasp some of the essential features. Thus demonstrations require that all students be ready at a particular moment while single concept films are ready when the student feels the need.

The lack of visibility is a considerable problem when viewing a demonstration from across the laboratory. Single concept films provide each student with more than a front row seat. They provide him with as close a view as is necessary. This might be a long show of an entire apparatus or a laboratory or a close-up of a thermometer scale or the surface of a crystal.

Sole reliance upon demonstrations brings up several other difficulties. How does the student who has forgotten or could not see clearly receive reinstruction? How does the student who was absent receive the information? The single concept film provides instruction and reinstruction whenever needed. The only inherent weakness in this system is that it cannot duplicate the excellent teacher who provides reinforcement not by identical repetition but with a variety of examples and approaches. One explanation or example may capture the imagination of one student but not of another. This limitation of the single approach used in each film might be alleviated by producing a variety of films on the same topic.

One needs to consider the future design of laboratory programs. It is pedagogically sound for the student to be allowed to work at his own pace and learn all of the salient features, gaining understanding as he proceeds through a group of exercises merely hitting the high points in order that he might keep up, finish on time, and receive credit. Single concept loop films could provide the necessary instruction whenever needed. In those courses where the availability of individual items of equipment or facilities is limited[3] the films could be used to advantage to instruct the student on the use of the more specialized equipment. Written manuals provide some explanation but films could show the equipment in operation as well as point out difficulties, malfunctions, and point out trouble shooting procedures. The

---

[3]Examples would be such advanced laboratory courses as physical chemistry, organic analysis, inorganic preparations, and instrumental analysis. All of these courses primarily rely upon one item of each kind. Experiments are assigned on a rotating basis.

student when left to his own initiative or using a sketch in the laboratory manual (which frequently describes a different style of equipment from that which the student is using) may find that the results are not only disastrous to his equipment and his preparation but also to himself. It is necessary for efficient laboratory instruction to be given. In some cases the laboratory instructor may explain and show each step of the experiment thus robbing the student of the thrill of discovery. The students then resort to mimicing the instructor. However, even in these extreme cases, the unfortunate student on the other side of the room cannot see the smaller and more subtle details clearly. This is another of the disadvantages to the demonstration as the only pre-laboratory instruction.

The increased demand upon the time of the professor in charge of a laboratory course makes it exceedingly difficult to communicate all of the laboratory skills, techniques, and procedures that he deems desirable. An experienced teacher will pick up subtle little tricks which make the particular job easier or perhaps safer. The young graduate students do not in many instances, have the benefit of years of successful teaching experience. The periodic staff meetings are desirable in some instances to impart this information, however as schedules become crowded it becomes quite difficult to find a suitable time. The use of single concept loop films provides a uniform quality of information. In this manner the professor in charge can cantrol the quality of instruction.

Most laboratory courses have sufficient enrollment to require several sections. Scheduling a multi-sectioned laboratory is a logistic difficulty. At Oklahoma State University the laboratories are taught for the most part by graduate teaching assistants. The O.S.U. Chemistry Department allows its graduate teaching assistants to enroll in the courses they are taking first, after which their teaching assignments are scheduled to fit. The quantity of the graduate teaching assistants depends upon funds available as well as the pool of potential graduate teaching assistants. One can forsee a lack of qualified teaching assistants available. Is it possible to gird oneself for the event of such a possibility?

Another factor which should be considered arises when one instructor has two or more identical sections. It is possible to forget and leave out a portion of the explanation. One finds that he cannot remember whether he has shown this section or perhaps it was the other section. Film loops free the instructor from this worry. He then can concentrate upon the other important matters such as individual student problems.

Thus the nature of the problem is to determine if a series of single concept loop films (SCLF) can be used for the pre-laboratory instruction of techniques more effectively than the present conventional approach through demonstrations and verbal instructions.

Statement of the Problem

The specific problem to be explored by this study is to determine the effects of using single concept loop films to instruct the students in the basic techniques and equipment manipulation in the introductory organic chemistry laboratory.

Definitions

Control Group - Those subsections which are taught by the conventional manner without the single concept films. Also referred to as the "non-film group."

Experimental Group - Those subsections which receive the single concept film loop instruction. Also referred to as the "film group."

Chemistry 3015 - The designation of the course entitled Introductory Organic Chemistry at Oklahoma State University. The laboratory phase of this course was used for this study.

Chemistry Background - The semester hours of chemistry courses previously taken by the student.

Chemistry Lab Background - The semester hours credit received by the student from laboratory instruction only.

Chemistry GPA - The gradepoint average for the chemistry courses previously taken by the student computed on a four point scale.

Data Card - A 3x5 inch card completed by each student for each laboratory period. The card will contain information pertinent to the experiment. The student will give the card to the instructor prior to leaving the laboratory.

Entry Skills - The level of laboratory sophistication and self confidence as measured by the laboratory skills survey upon entering the course.

Exit Skills - The level of laboratory sophistication and self confidence as measured by the laboratory skills survey upon leaving the course.

Experiment Type - The experiments classified into direct, indirect, or non-filmed technique experiments.

GPA - The overall grade point average of the student as measured on a four point scale.

Direct Filmed Technique Experiments - The experiments in which a technique was initially encountered and taught via SCLF in the experimental group. (Also referred to as direct type.)

Indirect Filmed Technique Experiments - The experiments in which the techniques had previously been instructed via SCLF in the experimental group. Also referred as indirect type experiments.

Non-filmed Technique Experiment - Those experiments which involved techniques which were not instructed via SCLF because of previous chemistry training (i.e., general chemistry) or triviality.

Laboratory Accidents - The accidents which occur during an experiment from minor cuts and burns to severe accidents. These will be reported in brief detail on the data card.

Laboratory Breakage - The items broken during an experiment. This will not include equipment broken during washing. Laboratory breakage will be reported on the data card.

Laboratory Breakage Cost - The cowt of laboratory breakage computed from the equipment list given each student when he checked out his laboratory equipment.

Laboratory Technique Examination - A written five foil multiple choice examination dealing with laboratory procedures, setups, and techniques, but not theory. This examination was developed by Dr. H. P. Johnston, Dr. E. M. Hodnett, Mrs. M. R. Stephanik, and the author. It is also known as the JH_2S Exam.

Loop Film - A segment of super eight millimeter silent motion picture film wound in a spiral, spliced end-to-end, forming a continuous loop with a maximum of five minutes running time. The terms single concept loop film, SCLF, film loop, and loop film, may be considered synonymous in this study.

Laboratory Skill Survey - A written check list survey dealing with laboratory procedures, set-ups, and techniques.

Section - The entire group meeting at a given laboratory period.

Subsection - The group meeting in a particular laboratory. A maximum of 24 students can be accommodated in one subsection.

Treatment - The treatment refers to whether the students received instruction via SCLF or not.

Assumptions

1. The group involved in this study is assumed to be a random sample of undergraduates pursuing science related majors. It is assumed that their abilities will approach a Gaussian distribution.

2. The JH_2S examination is assumed to measure accurately the laboratory skills and techniques as learned in Chem 3015.

3. The laboratory skill survey taken upon commencing and completing the course is assumed to be an accurate reflection of their self-appraisal in laboratory skills (when allowance is made for carelessly completed forms.)

4. Placement of a given student into the experimental or control group is assumed to be by chance.

5. Assignment to a given laboratory section is assumed to be by chance.

6. Assignment to a given laboratory subsection is assumed to be by chance.

7. The Data Card is assumed to reflect accurate data as reported by the student.

8. It is assumed that no differences will occur as a result of placement in any one of the three laboratories (PS 356, 357, or 358).

Limitations

This study will be limited to determining if single concept loop films depicting laboratory techniques and set-ups have any effect upon the improvement of laboratory skills, the time required to perform an experiment, the number of accidents, and the equipment breakage in the laboratory and their attitude toward the experiments and the techniques.

Significance of the Problem

Any technique or method which will 1) provide uniform repetitive instruction of high quality; 2) free the instructor from the tedium of repetitive instruction in order to allow him to deal with individualized student problems; and 3) permit individual instruction to allow for varying student abilities and progress rates, should be worthy of consideration for inclusion in any course where needed.

CHAPTER II

REVIEW OF THE LITERATURE

The value of the science laboratory is not the question in this study. However, other studies indicate that the students gain more knowledge when they experience science either from demonstration or by actual experimentation rather than an explanation by lecture only (92). Another study was made by Bradley (15) in which various parameters were compared. The study was made between a series of lecture demonstrations and individual experiments in physical science. The results indicated that there were no significant differences between methods, because of sexes, instruction, or scientific backgrounds. The only case in which there was a difference (although not significant at the 0.05 level) was in classes of predominantly superior students regardless of method. This is a typical case of an educational study in which no significant differences were detected. (The problem of contamination, confounding variables, and instruments will be discussed in a later chapter.)

In industry it has been discovered that instructors seek out or produce visual aids and other instructional media on their own initiative yet many of them have had no professional teaching experience or training. They are merely practioners who are attempting to get across a point, method, process or idea. By trial and error, they have found their students understand better when they use an approach which stimulates them both visually and audibly (17). Industry's results with audio-visual media may not be immediately attainable in public and higher education. While industry generally restricts itself to teaching skills, schools, have multiple goals. Some courses teach few if any skills and most go beyond them to underlying theories, backgrounds, or affective behavior. Finally, industry enjoys working with smaller classes. But even though institutions of learning may face a radically more complex situation, they must make more and efficient application of instructional media.

In the search for methods of improving instruction, several kinds of media are receiving particular attention today. Those which are being used in chemistry include full length sound motion pictures, computer assisted instruction (CAI), programmed material, closed circuit television (CCTV), and single concept loop films.

Media Used in Courses

Dworkin and Holden (24) examined the differences between a series of sound filmstrips and lectures, but they found no significant differences between groups. This study did not, however, test the interest level of the students over a period of time, nor did it attempt to go beyond factual matter to communicate experimental techniques.

Motion pictures based in the classroom since 1920 (46), have sometimes yielded encouraging results. Hart (36) studied the U. S. Navy's use of these during World War II, in science and technology applications. He found students trained with films recalled 35% more factual material and remembered the material 55% longer than those students who were taught the same material without the films.

Findings such as these created a great deal of activity in the late 1950's with the John Baxter chemistry films (6,7,8,40,64,72) and the Harvey White physics films (5,59,60,64,71,72,90) as well as their respective Continental Classroom chemistry and physics courses on commercial television. Yet contrary to expectation, studies related to the use of these films to replace the lecture and the laboratory resulted in no significant differences even in those studies which were most favorable toward the film (or TV). A majority of the studies, in fact, revealed a significant difference in favor of the non-film (control) groups. In film groups, the interest of the student diminished throughout the semester (6). Wendt and Butts (89) exploring the matter, discovered a saturation point which is exceeded when 30 minutes of film is shown daily for a period of several months.

The Physical Science Study Committee (PSSC) and the Chemical Education Materials Study (CHEM Study) films though enjoying wide acceptance have produced relatively few studies (67). The CHEM Study films, for example, have received wide acclaim from chemists and teachers for their treatment of the subject matter (both live and animated), as well as having won a host of medals and awards from the film industry for artistic treatment and photographic quality.

McTavish (52) showed that repetitive viewing increases retention to a certain extent. Viewing a film twice increases achievement but forcing the students to view a film as many as four times resulted in a slight reduction in learning.

There is still a great deal of activity in film, although other media are receiving increasing attention. Computer Assisted Instruction (CAI) although expensive to initiate and operate, is being used to teach a variety of subjects. Many aspects of chemistry are being adapted to the computer for tutorial and computational purposes.[1] Studies using CAI for general chemistry (21) and organic chemistry (68) have been released. Both (at the University of Texas) have shown a significance in favor of CAI as an adjunct to the regular class.

It is probable that as mass production decreases the cost of computers, they will increasingly supplement instruction. For reasons found by Strum and Ward (84), it is doubtful, however, that CAI will replace the teacher. They cite 1) poor communication between man and machine (due in main to the author of the program); 2) the inability of the system to interpret the student's answers; 3) the immense amount of effort required to prepare the course material; 4) the high cost of hardware and actual programming; 5) the high proportion of down-time for repairs; and 6) the CAI's effectiveness for the superior student as opposed to their lack of effectiveness with remedial students.

Improvements in computer languages can enable the student to communicate with the computer more easily. Among these languages and tutorial systems, Alpert (3) feels that the PLATO III, and (subsequentally) the PLATO IV systems will provide solutions to many difficulties such as those described by Strum and Ward. High CAI costs, though, are still prohibitive, Alpert indicates PLATO III ranges from $2.00 to $5.00 per student-contact-hour when the costs are amortized over a five year period. He feels that through extensive use and redesigned consoles and systems (e.g., PLATO IV) the costs could be reduced to

---

[1]For an entire issue devoted to the use of computers in teaching chemistry see J. Chem. Educ. 1970 47 (2) (February, 1970).

between $0.34 and $0.68, which will make CAI competitive with present methods in public schools.

Programmed instruction, another medium, may be as sophisticated as a teaching machine or as simple as a printed booklet. Geller (30) concluded that students liked the programmed material (a unit on organic chemistry in a general chemistry class), but that they did not like the teaching machines (Koncept-O-Graph) themselves. Generally, teaching machines (not to be confused with CAI) are difficult to load and store as well as being quite unreliable mechanically. Hence, printed programmed booklets have almost completely replaced the machines (31).

These programmed materials have been used in a variety of situations with mixed results. Geller's study (30) found that the students using programmed material learned the basic concepts of organic chemistry just as well as those who were taught the same material by lecture. On factual examinations there were no significant differences between the groups.

Young (93) studied the effects of programmed booklets[2] as a supplement to general chemistry. He found no overall significant difference between the group using the supplementary material and the group which did not. However, the booklets were worthwhile, complementary study aids (93).

Television has been employed in chemistry instruction primarily for lectures (12,13,41,77). However, it is also being used for prelaboratory instruction (14). Although no statistical evaluations have

---

[2]The series of five booklets by Virginia P. Powell, "Programmed Units in Chemistry," Prentice-Hall, Inc., 1965, were used in this study.

been published, these programs have generally met with the approval of the faculties using them. Siegel (78) compared lectures both with and without discussion, closed circuit television, multiple sections taught by graduate students, and independent study in a variety of subject areas including chemistry. The results as measured by achievement tests showed no significant differences among the methods. Students preferred the smaller classes irrespective of the method. This study also showed that the instructor himself had more to do with the attitude of the student toward the class no matter whether the instructor lectured in person or on television.

Media Used for Laboratory Instruction

Various media approaches have been employed in laboratory courses. An attempt to alternate filmed experiments which involved either lengthy reactions or expensive equipment with actual experiments performed by the students was made by Brubacher and co-workers without statistical evaluation. Although no direct results were obtained from this approach, it was reported that the students did display a high degree of enthusiasm for this method (19).

A study of teaching biological sciences laboratory techniques through the use of tape recorded instructions and 35 mm colored slides was made by Requa (66). The results indicated no significant difference between the experimental and control groups; however, the experimental group demonstrated a positive attitude toward this method.

The Purdue Research Foundation (65) has shown that the presentation of lecture demonstration experiments by short motion picture films is as effective as the conventional method of presenting lecture demonstrations.

Barnard and Yingling (14) have produced films in modules of between one and five minutes for pre-laboratory instruction in general chemistry at Ohio State University. These are viewed by closed circuit television in each laboratory. The program has been well received by both faculty and students; however, no statistical evaluation has been reported.

Single Concept Loop Films

In recent years the single concept loop film (SCLF) has received considerable attention. As its name implies, this medium presents only one idea, topic, or technique in each film. Thus if one wishes to have a concept repeated, he need not wait while several minutes of irrelevant film pass through the projector as he must well multi-concept films.

SCLF cartridges have received much attention from classroom teachers since the Technicolor Corporation introduced their cartridge loop projectors in 1962 (20,46,47,81). The titles available have increased from 700 in 1964 to 3,000 barely two years later (73). By 1968 well over 6,600 titles were available with more coming each month. The quality of these loops does, however, vary. Many of them consist simply of segments clipped from existing footage instead of having them designed as SCLF (20).

Stein (82) in 1958 used SCLF in beginning typewriting classes. She found that although the film group typed more rapidly (but less accurately) than the non-film group, there was no significant difference overall.

Steiner (83) has used single concept loop films for pre-laboratory instruction in biology with success but without statistical evaluation.

The U. S. Air Force has used single concept loop films for teaching the operating procedures for some of their equipment. Since these training films have been employed, there has been a notable saving in the repair of the particular equipment (20,74).

In technical education Gaussman and Vonnes (29) have used SCLF for teaching a wide variety of topics including the proper use of tools, food preparation, and the operation of business machines. These films are being used to lend maximum flexibility to their instructional program. Students may view and review the films whenever they wish. It was discovered that 90 percent of their students enrolled in the business machines course received proficiency certificates from the manufacturer. Since the national average was only 50 percent these results indicate that the films were helpful in increasing manipulative skills.

Trinklein (86) used excerpts from the CHEM Study film on Bromine in his study. He found that these clips were useful as supplementary material because the group which viewed the full films plus the excerpts learned significantly more factual data than those viewing either the films or the clips once only. The confounding variable in this case is repetition, known to increase the retention (52).

Brandon (16) examined the quality of SCLF's produced by clipping segments from existing footage. He reported that a group of high school chemistry teachers in an NSF Summer Institute found that the existing 16 mm films provided few suitable single concept film clips with the exception of some of the CHEM Study films. The clips of reasonable quality included some of the animations of reaction mechanisms as well as some of the demonstrations from the CHEM Study films.

The major difficulty with the existing loop films appears to be that they do not fit the format of the single concept film. The Advisory Council on College Chemistry (AC_3) in an effort to upgrade the single concept films has sponsored workshops for producing single concept films (62). It is only when the single concept films are produced for a specific purpose by the teachers themselves that they will become the paperbacks of the instructional media (2).

The single concept format differs from that of the ordinary motion picture. Titles and credit lines are kept to a minimum. Explanatory titles and directions last only a few frames. If the viewer needs to read the directions he may stop the film. If he does not then little time will be wasted. Usually the demonstrator in a regular motion picture picture is considered the "star" because of his dominant role and frequent appearance in the scenes. In the single concept format, no more than the hands of the demonstrator may appear. Scenes of a particular operation are taken from "zero angle"[3] Showing the operation from the perspective of the one performing it. Thus, when zero angle films are used for pre-laboratory instruction there is no right-to-left transfer of direction necessary. Furthermore, the student has a close-up view of the operation.

Anderson (4) indicates that the single concept film will fill the void between lectures or demonstrations and self-instruction. At the

---

[3]The camera angle is coincident with the normal viewing angle. This is achieved by aiming the camera over the shoulder of the demonstrator.

proper moment in the instructional sequence, the student can view the film (46). He may even view the film a number of times and adapt the SCLF to his own learning rate.

Color Versus Black and White

The advantages of color over black and white presentation have yet to be adequately shown by research studies. It is axiomatic that films depicting color changes would be worthless if viewed in black and white. May and Lumsdaine (54) indicate that the only definite correlation (r=0.90) exists between the gain in knowledge for both color and black and white. Material which is effective in black and white will also be effective in color, whereas that which is not effective in black and white correspondingly will not be effective by color. Their study was limited to material in which color did not play an important part.

Vandermeer (88) reports that although there is no significant learning differences (factual) between color and black and white film, the recall of material from color film was greater (although not significant at the 0.05 level) in three out of five cases. All of the above tests were based upon factual knowledge and recall and did not indicate the interest or aesthetic value of the color.

Kanner (44) reported that black and white and color television yielded no significant differences in learning factual knowledge in 10 out of 11 cases. A subsequent report by Rosenstein and Kanner (70) indicated no significant difference between color and black and white. All of these studies, however, used color merely to illustrate a graph or a picture. Color was employed only to increase the discernability of the image, an end which can be accomplished in black and white with proper contrast control. The evaluations, achieved by factual multiple choice tests, made no attempts to determine the motivation or the attitude of the students.

Barnard and O'Connor (13) feel that in chemistry films, the appeal or interest value of color is sufficiently significant to warrent its use, but their opinion is not substantiated by statistical examination. The cost of color films frequently deters their use, and the cost of color television cameras is considerably higher than black and white. It is surprising to note, however, that the cost of amateur motion picture film and processing is not significantly different from that of black and white.[4]

---

[4]The average cost of Kodak Tri-X (black and white) super 8 mm film with processing is $4.49. Kodak Kodachrome II (color) super 8 mm film also with processing (by Kodak) is $4.46. Thus while almost the same cost, the color film is actually cheaper. It should be noted that these are discount prices which anyone can obtain by careful shopping. The processing of the color film was by Kodak Laboratories and the black and white by a reputable independent processor. The difference in cost is primarily due to the great demand for color film by amateurs as opposed to the relatively little use which black and white receives.

CHAPTER III

EXPERIMENTAL DESIGN

Preparation of the Single Concept Loop Films

Criteria for the Films

To insure that films for this study be related to the techniques needed for Chemistry 3015, it was necessary to determine which experiments were to be assigned. Dr. Henry P. Johnston (professor in charge of the course) selected and determined the order of experiments from the laboratory manual by Coleman, Wawzonek, and Buckles (22) and from those written by Dr. Johnston and others of the O.S.U. Chemistry Department. Table I shows the experiment titles (in assigned order) as well as those techniques, manipulations, and equipment setups needed.

The next step was to determine which techniques and experiments the students appeared to need most help with. To do so, the author visited a Chemistry 3015 laboratory for one semester (not as a teacher but ostensibly as a casual observer). It was found that techniques demonstrated were at times difficult to see. This situation, together with the fact that occasionally a student would allow his attention to wander, resulted in less than the total group's knowing what to do. And, while some students would ask their instructor, classmates, or the author for help, others would blunder ahead. Table II shows a list of techniques which students occasionally or frequently performed

TABLE I

TECHNIQUES NEEDED FOR ORGANIC CHEMISTRY LABORATORY EXPERIMENTS (CHEM 3015)

EXPERIMENT Number	Name / Techniques (setups, manipulations)	Source
1	Purification by Crystallization	CWB
	Seeding or scratching the supersaturated solution	
	Use of boiling chips	
	Use of decolorizing carbon	
	Folding Fluted filter paper	
	Suction filtering (Hirsch)	
	Reflux condenser	
2	Determination of melting points	CWB
	Preparation of the melting point capillary	
	Determination of melting point with Thiele-Dennis Tube	
	Calibrating a thermometer	
3	Distillation and the determination of boiling points	CWB
	Setting up and operating a simple distillation	
	Use of boiling chips	
	Placement of the thermometer bulb	
4	Fractional Distillation	CWB
	Setting up and operation of fractional distillation apparatus	
	Boring holes in corks	
	Thermometer bulb placement	
	Use of boiling chips	
5	Qualitative analysis for elements	CWB
	Sodium fusion tests--making the solution	
	Tests for nitrogen, sulfur, and halogens	
6	Hydrocarbons: Methane, Acetylene, Ethylene	CWB
	Use a side arm tube and gas collection*	
meta-Dinitrobenzene		HPJ-OSU
	Recrystallization	
	Suction filtering (Buchner)	
	Melting point determination	

TABLE I (Continued)

EXPERIMENT Number	Name Techniques (setups, manipulations)	Source
13	Cyclohexanol; Properties of Alcohols Steam distillation (set up and operation) Salting out Ether extraction Drying the ether extract Ether removal	CWB
11	n-Propylbromide Simple distillation Washing with a carbonate Drying with $CaCl_2$ Filtering through cotton Distillation range	CWB
Methylethyl ketone	Simple distillation Use of boiling chips Fractional Distillation	HPJ-OSU
Methyl salicylate	Reflux Use of boiling chips Neutralizing with bicarbonate (washing with carbonate) Separation	HPJ-OSU
Fermentation (Ethanol)	Fermentation lock* Fractional distillation Use of boiling chips	HPJ-OSU
16	Carbonyl Compounds Tollens test* Schiffs test* Bisulfite addition* Iodoform test* Phenylhydraxine*	CWB
17	Acids Simple distillation Freezing (melting) point determination* Use of boiling chips	CWB

TABLE I (Continued)

EXPERIMENT Number	Name / Techniques (setups, manipulations)	Source
20	Saponification of Isoamylacetate	CWB
	Reflux	
	Use of boiling chips	
	Simple distillation	
	Washing with carbonate	
	Separation	
	Filtering through cotton	
Butter and Oleomargarine		HPJ-OSU
	Reflux	
	Use of boiling chips	
	Simple distillation	
35	Aspirin (Acetylsalicylic acid)	CWB
	Reflux	
	Rapid filtering (Buchner)	
	Decolorizing, fluted filter, and recrystallization	
	Melting point determination	
26	Properties of Amines	CWB
	Melting point determination	
	Preparation of anilides*	
	Preparation of benzanilides*	
	Preparation of benzenesulfonamide*	
	Preparation of picrates*	
30	Diazo compounds	CWB
	Preparation of diazonium salt (diazotization)	
	Coupling reaction	
29	Sulfanilamide	CWB
	Gas trap	
	Rapid filtering (Buchner)	
	Decolorizing, fluted filter, recrystallization	
	Melting point determination	
36	Carbohydrates	CWB
	Benedicts or Fehling's test*	
	Osazone test*	
	Periodic acid test*	

*Technique not covered in films.

TABLE II

OBSERVED MISTAKES OR DIFFICULTIES ENCOUNTERED IN EXPERIMENTS

Technique	Common Problems or Errors
Seeding a supersaturated solution:	
	Did not know what to expect
	Did not know how to seed a supersaturated solution
	Did not know how to scratch the inner surface
Use of decolorizing carbon:	
	Could not see the demonstration
	Did not comprehend the difference between filtering and decolorizing action
Folding fluted filter paper:	
	Could not follow directions
	Did not fold the paper properly
Suction filtering:	
	Used incorrect size paper
	Did not properly support or clamp the flask
	Did not know how to remove precipitate (Some scraped precipitate from paper before removing paper from funnel.)
Reflux:	
	Did not support the flask properly
	Clamped the apparatus inefficiently
	Used a stopper to close the system
	Reversed the water inlet and outlet
	Did not add boiling chips
Use of boiling chips:	
	Lacked the knowledge of why chips are used
	Had not experienced bumping of solution--until too late
	Did not know the proper size of chips
Melting point capillaries:	
	Sealed capillaries improperly
	Experienced difficulties in filling capillaries
Thiele-Dennis tube:	
	Heated oil too fast
	Allowed rubber retaining ring to become immersed in oil
	Did not place capillary next to thermometer bulb
Calibrating a thermometer:	
	Had the incorrect belief that all laboratory thermometers yield a correct reading

TABLE II (Continued)

Technique	Common Problems or Errors
Simple distillation:	
	Set up the apparatus inefficiently
	Clamped the apparatus improperly
	Reversed the water inlet and outlet
	Used improper methods for holding receivers
	Placed thermometer improperly
	Did not add boiling chips
Fractional distillation:	
	Set up the apparatus inefficiently
	Clamped the apparatus improperly
	Reversed the water inlet and outlet
	Used improper methods for holding receivers
	Used inefficient methods for changing the receivers
	Failed to use boiling chips
	Placed a thermometer improperly
Sodium fusion tests:	
	Used too much sodium
	Waited too long before placing sodium fusion mixture in water
	Used tap water instead of distilled
	Did not heat unknown long enough with the sodium
	Did not boil solution before filtering
	Did not know what results to expect
	Did not know what results were positive, inconclusive, or negative
Steam distillation:	
	Used too long a steam line between the trap and flask
	Allowed the trap inlet to be higher than the outlet
	Bled steam line then turned off steam and closed system thus allowing precious preparation to be forced back into the trap and down the drain
	Did not know how to go about setting up apparatus efficiently
	Confused the difference between steam distillation and distillation using steam as a heat source.
Salting out:	
	Did not know the purpose of salting out
	Did not know how much salt to use
Washing with a carbonate:	
	Used too much carbonate thus allowing the effervescent solution to spill over

TABLE II (Continued)

Techniques	Common Problems or Errors
Use of separatory funnel:	
	Did not know which layer to save and which to discard
	Did not know how to properly relieve the pressure generated in the closed funnel
	Did not know when to stop the stopcock
Ether extraction:	
	Did not understand the reasons for extraction
	Did not understand the use of several small applications of extracting solvent rather than one large one
	Placed subsequent aliquots of ether with the ether layer rather than the aqueous layer
Drying the ether extract:	
	Did not know how to remove the moisture from the ether extract
	Did not know how much drying agent to use
	Did not know how to tell if too little drying agent was used
	Did not know how to effectively remove the solid drying agent
Removing the ether from the solution:	
	Used unsafe procedures such as flame
Diazotization:	
	Added nitrite solution too rapidly or in too large amounts
	Did not keep the temperature cool enough
Use of a gas trap:	
	Did not understand the purpose or function of the HCl trap for sulfanalimide experiment

It was noted that some of these difficulties continued each time a particular technique was used. In time, with patient prodding, some managed to overcome their original difficulties.

incorrectly, haphazardly, or dangerously.

In accordance with the experiments assigned by Dr. Johnston and the needs of students observed by the author, each film was designed to demonstrate any one of the following: 1) a laboratory setup of standard taper glassware, 2) a technique or process which the students were likely to have difficulty executing; 3) a technique or process implied by some of the experiments, although not specifically demonstrated by the teacher.

Producing the Films

Films were designed to require minimal adaptation to the intended tasks. They were planned in accordance with the objectives shown in Table III and keyed to the experiments shown in Table IV. Films were photographed on location in the laboratory showing the same equipment to be used by the students. Scenes indicate faithfully the locations of facilities such as water, gas, sinks, steam, aspirators, and fume hoods. In addition, films were shot from zero angle, permitting emphasis upon the task rather than the demonstrator. Films conforming to these criteria show setups and techniques as students will view them while performing the experiments.

Because this study was a pilot project, only two copies of each film were needed: an original and a duplicate to replace damaged loops. Super eight millimeter film was chosen for two reasons. The cost of filming the same scenes twice directly on super eight is considerably less than producing a master print on sixteen millimeter for

TABLE III

FILM TITLES AND OBJECTIVES

The objectives for the films were to show the following:

1. Crystallization (Supersaturation)
   A. The effect of "seeding" a supersaturated solution.
   B. The effect of rubbing or scratching the inner walls with a glass rod.

2. Decolorizing
   A. Filtering through paper does not remove colored impurities.
   B. The approximate amount of decolorizing carbon to use.
   C. The decolorizing effect of decolorizing carbon.
   D. The sequence of procedures in decolorizing.
   E. Fluted filter paper being used as a matter of simplicity and speed.

3. Folding Fluted Filter Paper
   A. Folding fluted filter paper properly.
   B. Folding fluted filter paper improperly.

4. Rapid Filtration
   A. Both Hirsch and Buchner funnels and filter flasks.
   B. The filtering operation.
   C. The proper method of supporting the filtering flask.
   D. The selection of the proper size of filter paper.
   E. The procedures for washing the precipitate.
   F. The procedures for removing the paper from the funnel.
   G. The circumstances in which each of the funnels should be used.

5. Reflux
   A. A reflux column in operation.
   B. A systematic method for setting up a reflux column as well as supporting and clamping the entire assembly, and proper placement of the water inlet and outlet hoses.
   C. The filling of the flask (and not overfilling) and the addition of the boiling chips.

6. The Use of Boiling Chips
   A. Proper even boiling
   B. Bumping without boiling chips.
   C. The effects when boiling chips are added to a hot solution.
   D. The bubbles eminating from the chips.

TABLE III (Continued)

---

7. Methods of Heating
   A. Heating a flask (round bottom) with and without a wire screen and burner.
   B. Heating with steam.
   C. Heating with hot or warm water.
   D. The proper methods of support with different heating methods.

8. Thermometer Correction
   A. A group of laboratory thermometers do not give the same reading when placed in a bath of uniform temperature, thus each must be calibrated to standard or known values.
   B. The procedures to determine correct temperature values.

9. Melting Point Determination (Capillary Preparation)
   A. How to prepare and seal a capillary by cutting and sealing.
   B. How to prepare a capillary and seal it by heating and pulling.
   C. How to fill and cause the sample to reach the bottom of the capillary.
   D. The difference between good and bad capillaries.
   E. Proper methods for affixing capillary to thermometer.

10. Melting Point Determination (Thiele-Dennis Tube)
   A. The Thiele-Dennis Tube in operation.
   B. The melting of the wax (or oil).
   C. The proper amount of oil.
   D. Where to heat the tube.
   E. Where to place the thermometer bulb.
   F. The vent for pressure release.
   G. That the melting point is the range between the initial melting and the final melting.
   H. That the heating rate should not exceed a degree per minute.
   I. That the thermometer should be read to the nearest 0.1 or 0.2°C.

11. Boring Holes in Corks
   A. The set of cork borers.
   B. The proper method of selecting the proper size of borer.
   C. The selection of the proper size of cork.
   D. The cork borer sharpener.
   E. The proper method of sharpening a cork borer.
   F. Moistening the cork borer.
   G. Drilling the cork (with a twisting motion) from both ends toward the middle.
   H. The effects of improper boring such as "blown" corks.
   I. The proper method of putting the cork on a glass tube.

TABLE III (Continued)

---

12. Simple Distillation (Setting Up)
    A. The distillation in operation.
    B. Setting up the simple distillation apparatus in a logical order (flask, column, hoses on condenser, condenser, adapter, receiver).
    C. The proper placement of clamps.
    D. The proper placement of water inlet and outlet on condenser.
    E. Proper methods of attaching the receivers with two methods of clamping.

13. Simple Distillation (Operational Hints)
    A. The proper methods of filling the flask.
    B. The proper thermometer bulb placement.
    C. The effect if proper attachment of adapter is not used.
    D. The effect if the proper attachment of the receiver is not used.
    E. The proper method of changing the receivers.

14. Thermometer Placement
    A. The proper placement of a thermometer bulb in distillation.
    B. That the temperature of the boiling liquid is slightly higher than the vapor in the column.
    C. The temperatures as read by the thermometer when the bulb is slightly higher, at, and slightly lower than the outlet to the condenser.

15. Fractional Distillation
    A. Two alternate types of distilling columns.
    B. Methods of changing receivers.
    C. A distillation in operation boiling smoothly.
    D. Flooding in the column from too rapid heating.

16. Sodium Fusion Tests 1-Solution Preparation
    A. Placement of soft glass tube in the transite square.
    B. How to judge the appropriate volume of distilled water.
    C. The proper size piece of sodium.
    D. The proper treatment of the sodium by absorbing the kerosine with filter paper.
    E. The proper sequence of events; a) melting the sodium, b) adding a small quantity of unknown, c) strong heating of the unknown with the sodium, and quickly plunging the hot tube into the distilled water.
    F. The proper method of plunging the hot tube into the distilled water thus breaking the tube.
    G. Boiling the solution to insure dissolving.
    H. Filtering the solution to remove glass and insoluble materials.

TABLE III (Continued)

17A. Sodium Fusion Tests. II - Nitrogen Test
- A. The proper sequence of operations in the nitrogen determination.
- B. Positive results.
- C. The lack of color which may occur at first but slowly the color develops into a bluish or greenish color of the positive test.
- D. The result of filtering an indistinct result thus showing the traces of blue precipitate.

17B. Sodium Fusion Tests. III - Sulfide Test
- A. The proper sequence of operations in the sulfur (sulfide) test.
- B. Both positive and negative results.

17C. Sodium Fusion Tests. IV - Halogen Test
- A. The proper sequence of operations in the halogen tests.
- B. The acidifying and boiling of the solution to remove HCN and H_2S which interfere.
- C. Both positive and negative results.
- D. The use of a blank test.

18. Steam Distillation
- A. A steam distillation in operation.
- B. The assembling of a steam distillation apparatus.
- C. "Bleeding" of the steam line prior to commencing.
- D. The use of a short distance between the steam trap and the distilling flask.
- E. The use of the steam trap.
- F. How to start the steam distillation.

19. Separation and Purification 1: Washing with a Carbonate
- A. How to use a saturated sodium carbonate solution to remove the excess acid.
- B. The use of solid sodium carbonate.
- C. The proper method of small applications with shaking rather than one large application.
- D. The proper handling of the separatory funnel.

20. Separation and Purification II: Salting Out
- A. The use of sodium chloride.
- B. How to estimate the amount of salt to use.
- C. The proper method of shaking a separatory funnel.

TABLE III (Continued)

---

21. Separation and Purification III: Ether Extraction
    A. The use of small applications with ether.
    B. Determining which layer is the ether.
    C. The proper method of shaking and relieving the pressure of the evaporated ether with the separatory funnel.
    D. The proper method of stopping the level at the interface.
    E. Saving the ether extractions together.
    F. The addition of a fresh aliquot of ether to the aqueous layer.

22. Separation and Purification IV: Drying Ether.
    A. The application of anhydrous potassium carbonate (as well as calcium chloride and other drying agents).
    B. Allowing the solution to stand for a period of time.
    C. What to do in case the potassium carbonate dissolves.
    D. Filtering through cotton, pressing the cotton with a glass stopper and rinsing with dry ether.

23. Separation and Purification V: Ether Removal
    A. The safest method of removing the ether is by distilling off the ether with a steam bath and an ice packed reciever.

24. Fume and Vapor Removal
    A. The use of the fume hood. (Shows the effect of pulling out nitrogen dioxide vapors.)
    B. The use of the water aspirator and a funnel to improvise the removal of small amounts of noxious noncorrosive vapors at ones desk.
    C. Vapor removal in distillation columns, and vapor traps for reflux columns.

25. Diazotization
    A. The diazotiazation procedure using a three neck flask and sulfuric acid. This is useful when followed by steam distillation.
    B. The use of a steady drip of the nitrite solution rather than intermittant larger amounts.

26. Diazotization II
    A. The diazotization procedure using a single neck flask and hydrochloric acid.
    B. Using a steady drip of the nitrite solution rather than intermittent larger amounts.

TABLE IV

FILMS KEYED TO THE EXPERIMENTS

Experiment	Title	Film Numbers
1	Crystallization	1, 2, 3, 4, 5, 6, 7
2	Melting Points	8, 9, 10
3	Distillation	12, 13, 14, (6)
4	Fractional Distillation	11, 14, (6), (14)
5	Qualitative Analysis	16, 17A, 17B, 17C
6	Hydrocarbons (Procedures used in general chemistry)	None
	m-Dinitrobenzene	(2), (4), (9), (10)
13	Cyclohexanol	18, 19, 20, 21, 22, 23
11	n-Propyl Bromide	(12), (13), (14), (15), (6)
	Methyl Ethyl Ketone	(12), (13), (14), (15), (6)
	Ethanol (new techniques quite easy to follow in directions)	(6), (15)
16	Carbonyl Compounds (tests quite easy to perform, results not confusing)	None
16	Acids	(6), (12), (13), (14)
	Methyl Salicylate	(5), (6), (19), (20)
20	Isoamyl Acetate	(5), (6), (12), (13), (14)
	Butter and Oleomargarine	(5), (6), (4), (1), (2), (3), (9), (10)
35	Acetylsalicylic Acid	(5), (6), (1), (2), (3), (9), (10)
26	Amines (Tests easy to perform, results not confusing)	None (9), (10)

TABLE IV (Continued)

Experiment	Title	Film Numbers*
30	Diazo Compounds	25, 26
29	Sulfanalimide	(1), (2), (3), (4), (5), (9), (10)
36	Carbohydrates (Tests easy to perform, results not confusing)	None

*Film numbers in parentheses indicate titles for review only if needed. The techniques have been covered in previous experiments.

reduction copying onto eight or super eight millimeter.[1] In addition, super eight's format of 21.5 mm^2 provides 50 per cent greater image area than eight's 14.3 mm^2 and, hence, sharper resolution for the same viewing image size.

Equipment for filming included the following:

Beaulieu 2008S, super eight millimeter motion picture camera equipped with an f/1.4 Angineaux 8 to 64 mm variable focus (zoom) lens. The camera employs through-the-lens focusing and viewing as well as an automatic diaphragm control with manual override capabilities.

Three Smith-Victor lighting stands equipped with 3200^{o}K quartz-halide lamps to provide proper color balance with Kadachrome II film.

Quick Set Husky elevator tripod.

Backgrounds of textured surface poster board in pastel shades.

Titles provided by rub-off letters on matte finish poster board; credits and titles provided by adhesive backed three dimensional plaster letters mounted on orange burlap.

Following processing by Eastman Kodak's Chicago Laboratory, the editing was accomplished with a Vernon action viewer and a Kodak Press-tape splicer. (Tape splices hold eight millimeter film better than cold cement (53).) Finally, the edited films were placed into Technicolor Magicartridges for projection in Technicolor 800 projectors.

Experimental Design

The experimental design for this study required that it be

---

[1]Duplication without reduction copying results in a significant loss of contrast and detail.

adaptable to the existing class schedules and procedures for Chemistry 3015 with a minimum of disruption. Therefore the evaluation will, of necessity, be a comparative method design. To overcome the obvious shortcomings of comparative method studies, and yet provide a maximum of individuals, the following plan was used.

The 170 students of Chemistry 3015 were assigned as randomly as possible to the experimental and control groups. This was done during pre-enrollment by the Registrar's office. Schedules are frequently re-arranged during pre-enrollment course balancing. The only student bias involved in section assignment is that created by time conflicts with other courses. Thus, while a student may indicate preferences, his assignment to a laboratory section is not directly determined by the student himself, but indirectly as a result of his other schedule in view of the schedule readjustments made by the Registrar's office during pre-enrollment. Assignment to subsections is normally by alphabetical arrangement. However, to achieve maximum randomization, the class cards for a given section were shuffled seven times and dealt into the appropriate number of stacks face down for assignment to a subsection. Because the three laboratories which were being used for Chemistry 3015 are essentially identical, it was arbitrarily determined to designate PS-356 for the experimental subsections. Locating all three of them in one laboratory permitted keeping the films and projectors there facilitating student access to them during class, at other times they could be kept in locked drawers.

Because the individual teacher or time-of-day differences might possibly contaminate the results, the schedules as presented in Table V will allow for these differences, if present, to be statistically determined.

General instructions, any modifications in the basic experiment, and safety precautions, were written and given to the instructors in lieu of staff meetings. The instructors in the experimental groups were cautioned to omit from their pre-laboratory discussion anything which was covered in the films. The students in the experimental groups were shown how to use the Technicolor Projectors and the film cartriges. They also were instructed in what to do in case a film jammed. Finally, they were given a list of films keyed to the experiments (Appendix G) and informed that they could look at the films at any time during the laboratory period except during discussions or quizzes.

TABLE V

ASSIGNMENT OF GROUPS AND INSTRUCTORS

Room: Section:	PS 356	PS 357	PS 358
Section 1 MW 1:30-4:20	Subsection 1 J. Tai Teacher A Film Group (Group 100)	Subsection 2 H. Herzer Teacher C Non Film Group (Group 600)	Subsection 3 P. Mooney Teacher B Non Film Group (Group 500)
Section 2 10:30-2:20	Subsection 1 P. Mooney Teacher B Film Group (Group 200)	Subsection 2 J. Tai Teacher A Non Film Group (Group 400)	
Section 3 2:30-5:20	Subsection 1 H. Herzer Teacher C Film Group (Group 300)	Subsection 2 R. Lyeria Teacher D Non Film Group (Group 700)	

Control groups were taught in the conventional manner. The laboratory instructor began with a brief discussion of the theory underlying the reactions, a description and demonstration of the techniques involved, plus any deviations from the instructions in the laboratory manual. Emphasis was given to safety procedures and handling of hazardous materials. Students in both groups were required to have their equipment setup checked before they began their experimentation.

Experimental groups were handled in the same manner except the instructor did not demonstrate the equipment setup or the techniques which are covered in the films. In those cases where a student had an incorrect setup, it was suggested that he review the film rather than the instructor telling him how to correct his error.

Instruments

1. Data Card. Each student was asked to submit pertinent data on a 3 x 5 inch card and hand it to the instructor prior to leaving the laboratory. These cards were provided for the students and a specimen of one completed was posted in the laboratory. Data requested varied from day to day (depending upon the nature of the experiment), and instructors received directions before each session. Items recorded included name, date, subsection, experiment number, time spent on the experiment exclusive of clean up or prelaboratory discussion (calculated to the nearest five minutes), name of partner (if any), percent yield, melting point, breakage (exclusive of clean up), and accidents (each briefly described).

2. Laboratory Skill Survey. A self appraisal in organic laboratory procedures was determined by a laboratory skill survey given at

the commencement and conclusion of the course (Appendix G). The students were informed that the results would have no effect upon their grades for the course. The care with which each instrument was completed was ascertained by checking those items which involve techniques which they should know (such as lighting a bunsen burner and simple filtration) and those techniques which they should not know (such as vacuum distillation) and by the consistency with which they responded to duplicate items.

This instrument was adapted from a form used at Michigan State University in Physiology (42). The Michigan State form was used in conjunction with a media approach to the preparative laboratory in Advanced Mammalian Physiology. Techniques such as muzzling a dog and pithing a frog were listed with response choices related to the knowledge or ability required to perform the particular operation.

3. Attitude Survey. A survey of ten selected experiments five of which (2, 3, 4, 5, and 13) involved films directly and five of which (11, 16, 17, 26, and 35) did not. The survey administered near the semester's close asked their opinion of these ten experiments in terms of time requires, how interesting, value or usefulness, academic value, difficulty, directions, techniques, manipulations, and overall opinion. These nine categories were arranged in Likert-type scale choices (Appendix E). The attitude survey was anonymous (although responses were segregated by subsection) in order to increase the reliability (25).

4. JH_2S Examination. In the absence of a direct measuring instrument for laboratory techniques, it was necessary to prepare a laboratory examination which covered laboratory techniques, procedures,

setups, but no theoretical aspects. Rather than drawings or diagrams, the examination employed photographs of equipment used by the students in their experiments. Students were asked fifty multiple choice questions about equipment shown properly and improperly set up. Because of the possibility of awareness and the lack of a sufficiently large sample for split group technique, it was not administered as a pre-test, post-test instrument. The reliability of the instrument was determined by Kuder-Richardson Formula 21 which is widely accepted for this purpose (32). For future work, an item analysis was run in order to determine which questions need to be rewritten.

Hypotheses

The following major null hypotheses were tested.

Ho 1: There will be no significant differences between the background of the students in the experimental and control groups.

Ho 2: There will be no significant differences in the time required to perform the experiments between the experimental and control groups.

Ho 3: There will be no significant differences in the breakage parameters between the experimental and control groups.

Ho 4: There will be no significant differences in the number of accidents occurring between the experimental and control groups.

Ho 5: There will be no significant differences in the self appraisal of laboratory techniques as measured by the laboratory skill survey between the experimental and control groups.

Ho 6: There will be no significant differences in the attitude toward the experiments between the experimental and control groups.

Ho 7: There will be no significant differences in the laboratory proficiency as measured by the JH_2S Examination between the experimental and control groups.

Each of these major hypotheses was subdivided in order to ascertain the location and extent of the statistical differences.

CHAPTER IV

DATA, STATISTICAL ANALYSES, AND RESULTS

Prior to establishing whether significant differences occur between treatment groups, it was necessary to determine if differences might, indeed, be attributed to the differences in the groups themselves. For this reason if the groups are found to be randomly distributed with respect to factors which might affect the results, than it is more likely that significant differences discovered will be due to treatment differences and not to a non-random distribution of the subjects.

Following a description of the statistical measures used in this study will be the determination of the random distribution of the subjects and finally the data, analyses and results of the study.

Statistical Measures

In this study the null hypothesis form is used throughout. For convenience the alternate hypothesis form is not stated in order to prevent confusion. Because the related studies (20,29,74) indicate trends in favor of the use of SCLF the alternate hypothesis would be stated in a directional form in favor of the experimental group. For this reason, one tail probabilities will be used throughout.

Siegel (57,60) attributes the lack of significance in educational studies of the comparative type of the other variables interacting in supposedly balanced groups. Using analysis of variance or covariance designs, Seigel feels, should yield more significant results.

The analysis of variance is a more robust test than the covariance. That is to say, the former will yield reliable results even though all of the rigid assumptions are not strictly adhered to, whereas in the latter the reliability tends to suffer when more deviations occur. (62)

Tukey (66) indicates that there is no real need for the artificial limitations of the 0.01 or the 0.05 level of significance. In the testing of a new drug, perhaps the 0.001 level might not be sufficiently significant, whereas for a gambler, the 0.45 level would be suitable in order to net him a steady profit. In educational situations the 0.20 or some other level might be just as appropriate as the widely used 0.05 level.

For this study the significance level for the purpose of rejecting the null hypothesis will be set at the 0.10 level.

Parametric statistical evaluation is based upon samples drawn from a normal population. Samples which deviate from normality decrease the effectiveness of the statistical tests. Non-parametric tests can be employed in instances where the data lacks some of the rigorous assumptions demanded by parametric statistics. Also different types of data lend themselves to different statistical tests.

Hence, a variety of statistical tests were used in this study. All of these tests are widely accepted and included in some of the commonly employed educational statistics reference works such as Siegel (80), Popham (62), and Guilford (33). However, because the formulas and symbols vary slightly, Appendix I contains a compilation of each of the statistical formulas and their respective terms which were used in this study.

The following statistical tests were employed. Included is a brief description of their respective uses, strengths and weaknesses.

Mann-Whitney-U Test. The Mann-Whitney U is frequently employed when scores of two similar groups are ranked together. If the two groups are from essentially the same population there will be considerable intermingling of the two groups. If one group significantly exceeds the other, then the ranking of the superior group will be significantly higher than the inferior. The Mann-Whitney U is frequently employed in place of the parametric t test (Student's t test) with little loss in power (62). The Mann-Whitney U has one of the highest power efficiency of the nonparametric tests, approaching 95 per cent even with moderate size samples (79).

Friedman Two Way Analysis of Variance. When two or more groups are compared in which the items are matched or related, the Friedman Test is conveniently employed. This technique involves a ranking of treatments within a set of data. The formula into which the squared sum of the ranks are inserted yields a value which may be interpreted from a table of chi square values. The exact power of the Friedman Test is now known (79), but it compares favorably with the most powerful parametric test, the F test. Friedman (79) reported that in 45 out of 56 cases, the probability levels between the Friedman Test and the F test were the same. Friedman has also made comparisons between chi square values (commonly used to interpret the results) and calculated values from the z test. The results indicate that as either k (the number of columns) or N (the number of rows) increases, the difference between the two values diminishes to zero. For example, at the 0.05 level when k equals three, the chi square value will be 5.991, as N increases from 10, to 20, and to infinity, the value from z increases from 5.959 to 5.983, to 5.991 respectively (28).

Randomization Test for Two Independent Samples. The randomization test for independent samples is a powerful nonparametric test which requires much less stringent assumptions than are required for the parametric t test. The exact probability can be determined without assuming a normal distribution or homogeneity of variance (79). When n_1 and n_2 are large, the computation becomes tedious and unwieldy. Pitman (79) has shown that if the kurtosis of the combined sample is small and if the ratio of the size of the two groups does not exceed five, then the distribution closely approximates the t distribution, thus:

$$t = \frac{\bar{X}_1 - \bar{X}_2}{\sqrt{\left(\frac{\Sigma(X_1 - X_1)^2 + \Sigma(X_2 - X_x)^2}{n_1 + n_2 - 2}\right)\left(\frac{1}{n_1} - \frac{1}{n_2}\right)}}$$

Which is essentially the same formula as the pooled variance formula of the t test. Thus in this study the t test will be employed, not as a parametric test but as a nonparametric test, so that a normal distribution need not be assumed. The form of the t test will be

$$t = \frac{\bar{x}_1 - \bar{x}_2}{\sqrt{\left(\frac{\Sigma x_1^2 + \Sigma x_2^2}{n_1 + n_2 - 2}\right)\left(\frac{1}{n_1} + \frac{1}{n_2}\right)}}$$

The power efficiency of the randomization test for two independent samples is 100 per cent because of the definition and the fact that it uses all of the information in the samples (79).

Chi Square. The chi square test is a goodness of fit test which can be used to determine if a distribution varies significantly from a random distribution. The magnitude of the chi square statistics depends upon the disparity between the actual frequencies and the expected frequencies. The power efficiency cannot be computed for chi square because there is not alternative parametric test.

Spearman Rank Order Correlation. The Spearman rank order correlation coefficient is the nonparametric alternative to the Pearson Product Moment correlation. The Pearson correlation requires homoscedastisity (equal scattering) and the Spearman does not. The Spearman also is much easier to compute. The efficiency of the Spearman rank order correlation is 91 per cent when compared to the Pearson Product moment (80).

Wilcoxon Matched-Pairs Signed-Ranks Test. The Wilcoxon test is based upon the premise that if most of the major differences favor one group then it follows that it should be significantly superior to the other (62). This test is based upon the rank of the magnitude and its direction. The Wilcoxon Matched-Pairs Signed-Ranks test compares favorably with the power of the t test when parametric assumptions are met. For small samples the efficiency approaches 90 per cent (80).

Kruskal-Wallas One Way Analysis of Variance. This test determines whether a group of independent samples are from different populations on the basis of their rank order. The test assumes that the variable under study has a continuous distribution. The Kruskal-Wallas test has an efficiency of 95.5 per cent when compared to the F test (80).

Distribution of the Group

Because one major difficulty in educational studies is determining what factors are responsible for success with the measuring instruments, the treatment samples were examined. It was assumed that each group contains a random sample of the pre-medical, pre-veterinary, pre-dental, agricultural, and arts and sciences students who usually enroll in Chemistry 3015. (See Chapter III for assignments to sections and subsections.) The question whether sections also contained a random distribution according to classification, college, and sex generated the following three null hypotheses.

Ho 1.01 There will be no significant difference in the distribution of the students by classification among the sections.

Ho 1.02 There will be no significant difference in the distribution of the students by college among the sections.

Ho 1.02 There will be no significant difference in the distribution of the students by sex among the sections.

These hypotheses may be tested by chi square analysis, is essentially a curve-fitting formula, which will serve to determine if the observed distribution deviates from that expected in a random distribution. The data is tabulated in Table VI and the chi square analyses follow in Tables VII, VIII, and IX.

The rejection of Ho 1.01 but not the Ho 1.02 or Ho 1.03 tended to support the assumption that the group had indeed been randomly

TABLE VI

DISTRIBUTION OF STUDENTS BY SUBSECTIONS (CLASSES)

Classification	100	200	300	400	500	600	700
Male	22	17	18	21	20	17	22
Female	2	7	6	2	0	4	2
Sophomore	14	14	10	10	10	11	12
Junior	6	6	13	6	8	8	9
Senior	3	4	1	7	2	1	3
Graduate	1	0	0	0	0	1	0
College/Major							
Agriculture:							
General Agriculture	0	1	1	1	0	1	1
Pre-Veterinary	5	7	6	6	7	3	9
Animal Science	5	1	5	0	3	1	4
Agronomy	2	2	1	2	1	0	0
Agri-Economy	1	0	0	0	0	0	0
Dairy	1	1	0	0	1	0	0
Subtotals:	(14)	(12)	(13)	(9)	(12)	(5)	(14)
Engineering:							
Chemical Engineering	3	2	1	2	2	4	1
Arts and Science:							
Physical Science	0	0	1	0	0	0	0
Chemistry	0	0	0	1	0	0	0
Pre-Medical	1	4	3	4	2	1	0
Zoology	0	0	2	2	1	2	2
Pre-Dental	2	0	1	0	0	2	2
Botany	0	1	0	0	1	1	0
Microbiology	1	1	0	0	0	0	1
Medical Technology	1	3	1	1	0	1	1
Physiology	0	0	0	2	1	1	0
Wildlife Ecology	0	1	1	1	0	0	0
Biological Sciences	0	0	0	1	0	0	0
Psychology	0	0	0	0	0	1	0
Undecided	0	0	0	0	1	0	0
Subtotals	(5)	(10)	(9)	(12)	(6)	(9)	(9)
Business:							
General Business	0	0	0	0	0	1	0
Home Economics:							
Nutrition	1	0	1	0	0	1	0
Graduate:							
FNIA	0	0	0	0	0	1	0
Agriculture	1	0	0	0	0	0	0

distributed by college and by sex, but not by classification. Table VII shows a fairly even distribution of sophomores and juniors, but section 2 (Tu-Thu 11:30) has a higher proportion of senior-graduate students. (Table VI shows these are all seniors.) It is then necessary to determine the distribution between the experimental and control groups. This generated the following set of null hypotheses.

TABLE VII

CHI SQUARE ANALYSIS OF LABORATORY SECTIONS BY CLASSIFICATION

	MonWed 1:30	TuThu 11:30	TuThu 2:30	Totals
Sophomores				
observed	35	24	22	81
(expected)	(32.91)	(23.79)	(24.30)	
Juniors				
observed	22	12	22	56
(expected)	(22.75)	(16.45)	(16.80)	
Senior/Graduate				
observed	8	11	4	23
(expected)	(9.34)	(6.76)	(6.90	
Totals	65	47	48	160

$X^2 = 7.2607$
df = 2
**significant at 0.05 level
Ho 1.01 rejected

TABLE VIII

CHI SQUARE ANALYSIS OF LABORATORY SECTIONS BY COLLEGE

	MonWed 1:30	TuThu 11:30	TuThu 2:30	Totals
Agriculture				
observed	31	21	27	79
(expected)	(32.09)	(23.21)	(23.70)	
Arts & Science				
observed	20	22	18	60
(expected)	(24.38)	(17.63)	(18.00)	
Engineering				
observed	9	4	2	15
(expected)	(6.09)	(4.41)	(4.50)	
Other				
observed	5	0	1	6
(expected)	(2.44)	(1.76)	(1.80)	
Totals	65	47	48	160

$X^2 = 10.20$ df = 6 NS Ho 1.02 not rejected

TABLE IX

CHI SQUARE ANALYSIS OF LABORATORY SECTIONS BY SEX

	MonWed 1:30	TuThu 11:30	TuThu 2:30	Totals
Male				
observed	59	38	40	137
(expected)	(55.66)	(40.24)	(41.10)	
Female				
observed	6	9	8	23
(expected)	(9.34)	(6.76)	(6.90)	
Totals	65	47	48	160

$X^2 = 2.4665$ df = 2 NS Ho 1.03 not rejected

Ho 1.04 There will be no significant difference in the distribution of the students by classification between the experimental and control group.

Ho 1.05 There will be no significant difference in the distribution of the students by college between the experimental and control group.

Ho 1.06 There will be no significant difference in the distribution of the students by sex between the experimental and control group.

TABLE X

CHI SQUARE ANALYSIS OF TREATMENTS BY CLASSIFICATION

	Sophomore	Junior	Senior/Grad.	Totals
Experimental				
observed	38	25	9	72
(expected)	(36.45)	(25.20)	(10.35)	
Control				
observed	43	31	14	88
(expected)	(44.55)	(30.80)	(12.65)	
Totals	81	56	23	160

$X^2 = 0.4429$ df = 2 NS Ho 1.04 not rejected

TABLE XI

CHI SQUARE ANALYSIS OF TREATMENTS BY COLLEGE

	Agriculture	Arts and Science	Engineering	Other	Total
Experimental					
observed	29	25	6	3	73
(expected)	(36.04)	(27.38)	(6.84)	(2.74)	
Control					
observed	40	35	9	3	87
(expected)	(42.96)	(32.63)	(8.16)	(3.26)	
Totals	79	60	15	6	160

X^2 = 1.5483 df = 3 NS Ho 1.05 not rejected

TABLE XII

CHI SQUARE ANALYSIS OF TREATMENTS BY SEX

	Male	Female	Totals
Experimental			
observed	57	15	72
(expected)	(61.65)	(10.35)	
Control			
observed	80	8	88
(expected)	(73.35)	(12.65)	
Totals	137	23	160

X^2 = 3.8205 df = 1 (Yates Correction used) *significant at 0.10
Ho 1.06 rejected

Thus Ho 1.04 and Ho 1.05 were found to be tenable, but Ho 1.06 untenable and must be rejected. Therefore the distribution of the students between the experimental and control groups was random by college and classification but not by sex. Examination of the data show that the experimental group has a higher proportion of female students. It was necessary to determine the effect of the imbalance of the sex distribution. This effect will be shown in subsequent analyses. It was necessary to determine whether the distribution of students by sex, college, and classification was random among the individual classes (subsections). This generated the following null hypotheses.

Ho 1.07 There will be no significant difference in the distribution of the students by classification among the subsections.

Ho 1.08 There will be no significant difference in the distribution of the students by college among the subjections.

Ho 1.09 There will be no significant difference in the distribution of the students by sex among the subsections.

Thus Ho 1.07 and Ho 1.08 were found to be tenable but Ho 1.09 was not. This has confirmed the random distribution of the students by classification and college but not by sex. It was necessary to determine the effect of this imbalance of female students. Because the distribution of the students into subsections was accomplished by randomization techniques, the randomization would be destroyed if some of the female students were redistributed. Therefore it was necessary to examine the statistical results both with and without female students and observe the differences.

It was then necessary to determine the distribution of the chemistry semester hours, semester hours of chemistry laboratory courses,

TABLE XIII

CHI SQUARE ANALYSIS OF CLASSIFICATION BY SUBSECTION

	100	200	300	400	500	600	700	Total
Sophomore								
observed	14	14	10	10	10	11	12	81
(expected)	(12.15)	(12.15)	(12.15)	(11.64)	(10.13)	(10.63)	(12.15)	
Junior								
observed	6	6	13	6	8	8	9	56
(expected)	(8.40)	(8.40)	(8.40)	(8.05)	(7.00)	(7.35)	(8.40)	
Senior/Grad								
observed	4	4	1	7	2	2	3	23
(expected)	(3.45)	(3.45)	(3.45)	(3.30)	(2.88)	(3.02)	(3.45)	
Totals	24	24	24	23	20	21	24	160

$X^2 = 12.5831$ df = 12 NS   Ho 1.07 not rejected

TABLE XIV

CHI SQUARE ANALYSIS OF COLLEGE BY SUBSECTION

	100	200	300	400	500	600	700	Total
Agriculture								
observed	14	12	13	9	12	5	14	79
(expected)	(11.85)	(11.85)	(11.85)	(11.36)	(9.88)	(10.37)	(11.85)	
Engineering								
observed	3	2	1	2	2	4	1	15
(expected)	(2.25)	(2.25)	(2.25)	(2.16)	(1.87)	(1.97)	(2.25)	
Arts and Science and Others								
observed	7	10	10	12	6	12	9	66
(expected)	(9.90)	(9.90)	(9.90)	(9.49)	(8.25)	(8.66)	(9.90	
Total	24	24	24	23	20	21	24	160

X^2 = 12.5116 df = 12 NS Ho 1.08 not rejected

TABLE XV

CHI SQUARE ANALYSIS OF SEX BY SUBSECTION

	100	200	300	400	500	600	700	Total
Male								
observed	22	17	18	21	20	17	22	137
(expected)	(20.55)	(20.55)	(20.55)	(19.69)	(17.13)	(17.98)	(20.55)	
Female								
observed	2	7	6	2	0	4	2	23
(expected)	(3.45)	(3.45)	(3.45)	(3.31)	(2.88)	(3.02)	(3.45)	
Totals	24	24	24	23	20	21	24	160

$X^2 = 12.2287$ df = 6 *significant at 0.10 level Ho 1.09 rejected chemistry grade point averages, overall grade point averages among the subsections. The distribution of these factors was not a random sample from a normal population. The distribution of these values is skewed, polymodal, platykurtic, and homoscedastic. This precludes the use of regression, hence analysis of covariance. However, it can be determined if the distribution of these factors is randomly distribution among the subsections. Thus the following null hypothese were considered.

Ho 1.10 There will be no significant difference in the distribution of the mean chemistry semester hours among the subsections.

Ho 1.11 There will be no significant difference in the distribution of the mean semester hours of chemistry laboratory experience among the subsections.

Ho 1.12 There will be no significant difference in the distribution of the mean chemistry grade point averages among the subsections.

Ho 1.13 There will be no significant difference in the distribution of the mean overall grade point averages among the subsections.

Thus, all four null hypotheses were found to be tenable, confirming that the chemistry hours, laboratory hours, chemistry grade point averages and overall grade point average do not deviate significantly from one another. Perhaps the distribution of the hours or the grade point averages within a class or a group might not be randomly distributed. The following null hypotheses were considered next.

Ho 1.14 There will be no significant differences in the frequency distribution of the chemistry semester hours between the experimental and control group.

Ho 1.15 There will be no significant difference in the frequency distribution of the chemistry laboratory hours between the experimental

TABLE XVI

CHI SQUARE ANALYSIS OF MEAN CHEMISTRY SEMESTER HOURS BY SUBSECTION

	100	200	300	400	500	600	700	Total
Mean chemistry semester hours								
observed:	9.4545	8.6087	9.6818	10.6316	9.1250	9.1000	8.3810	64.9826
(expected)	(9.2832)	(9.2832)	(9.2832)	(9.2832)	(9.2832)	(9.2832)	(9.2832)	

$X^2 = 0.3592$ df = 6 NS Ho 1.10 not rejected

TABLE XVII

CHI SQUARE ANALYSIS OF MEAN CHEMISTRY LABORATORY
SEMESTER HOURS BY SUBSECTION

	100	200	300	400	500	600	700	Total
Mean chemistry laboratory semester hours								
observed	4.2727	3.9130	4.0909	4.8947	3.8125	4.1000	3.9048	28.9886
(expected)	(4.1412)	(4.1412)	(4.1412)	(4.1412)	(4.1412)	(4.1412)	(4.1412)	

$X^2 = 0.1945$ df = 6 NS Ho 1.11 not rejected

TABLE XVIII

CHI SQUARE ANALYSIS OF MEAN CHEMISTRY GRADE POINT AVERAGES BY SUBSECTION

	100	200	300	400	500	600	700	Total
Mean chemistry grade point averages								
observed	2.7218	2.7983	2.7709	2.9011	2.3706	2.6579	2.6666	18.8873
(expected)	(2.6982)	(2.6982)	(2.6982)	(2.6982)	(2.6982)	(2.6982)		

$X^2 = 0.0620$ df = 6 NS Ho 1.12 not rejected

TABLE XIX

CHI SQUARE ANALYSIS OF MEAN OVERALL GRADEPOINT
AVERAGES BY SUBSECTION

	100	200	300	400	500	600	700	Total
Mean overall grade point averages								
observed	2.8005	3.0265	2.7950	2.9700	2.6119	2.8553	2.9681	20.8610
(expected)	(2.8610)	(2.8610)	(2.8610)	(2.8610)	(2.8610)	(2.8610)	(2.8610)	

$X^2 = 0.0383$ df = 6 NS Ho 1.13 not rejected

and control groups.

Ho 1.16 There will be no significant difference in the frequency distribution of the chemistry grade point averages between the experimental and control groups.

Ho 1.17 There will be no significant difference in the frequency distribution of the overall grade point averages between the experimental and control groups.

TABLE XX

CHI SQUARE ANALYSIS OF DISTRIBUTION OF CHEMISTRY SEMESTER HOURS BY TREATMENT

	Experimental	Control	Total
0 - 5 hrs			
observed	5	3	8
(expected)	(3.57)	(4.43)	
6 - 10 hrs			
observed	57	77	134
(expected)	(59.84)	(74.16)	
11 - 15 hrs			
observed	6	4	10
(expected)	(4.47)	(5.53)	
16 or more			
observed	3	4	7
(expected)	(3.13)	(3.87)	
Totals	71	88	159

$X^2 = 2.2348$ df = 3 NS Ho 1.14 not rejected

TABLE XXI

CHI SQUARE ANALYSIS OF DISTRIBUTION OF CHEMISTRY LABORATORY HOURS BY TREATMENT

	Experimental	Control	Total
2 to 3 hrs			
observed	9	4	13
(expected)	(5.81)	(7.20)	
4 hrs			
observed	54	75	129
(expected)	(57.60)	(71.40)	
5 to 6 hrs			
observed	4	6	10
(expected)	(4.47)	(5.53)	
7 or more hours			
observed	4	3	7
(expected)	(3.13)	(3.87)	
Total	71	88	159

$X^2 = 4.1069$ df = 3 NS   Ho 1.15 not rejected

TABLE XXII

CHI SQUARE ANALYSIS OF DISTRIBUTION OF CHEMISTRY GRADE POINT AVERAGES BY TREATMENT

	Experimental	Control	Total
1.99 and below			
observed	4	5	9
(expected)	(4.04)	(4.96)	
2.00 to 2.49			
observed	16	28	44
(expected)	(19.77)	(24.23)	
2.50 to 2.99			
observed	18	19	37
(expected)	(16.63)	(20.37)	
3.00 to 3.49			
observed	16	18	34
(expected)	(15.28)	(18.72)	
3.50 to 3.99			
observed	10	10	20
(expected)	(8.99)	(11.01)	
4.00 and up			
observed	7	7	14
(expected)	(6.29)	(7.71)	
Totals	71	87	158

$X^2 = 1.9245$ df = 5 NS Ho 1.16 not rejected

TABLE XXIII

CHI SQUARE ANALYSIS OF DISTRIBUTION OF OVERALL GRADE POINT AVERAGES BY TREATMENT

	Experimental	Control	Total
2.49 and below			
observed	16	19	35
(expected)	(15.73)	(19.27)	
2.50 to 2.99			
observed	27	31	58
(expected)	(26.06)	(31.94)	
3.00 to 3.49			
observed	16	26	42
(expected)	(18.87)	(23.13)	
3.50 and up			
observed	12	11	23
(expected)	(10.36)	(12.66)	
Totals	71	87	158

$X^2 = 1.3399$ df = 3 NS Ho 1.17 not rejected

Thus all four hypotheses are found to be tenable and cannot be rejected which further substantiated the random distribution of the backgrounds of students. However, as a further test these distributions were compared among the subsections.

Ho 1.18 There will be no significant difference in the frequency distribution of the chemistry semester hours among the subsections.

Ho 1.19 There will be no significant difference in the frequency distribution of the chemistry laboratory semester hours among the subsections.

Ho 1.20 There will be no significant difference in the frequency distribution of the chemistry grade point averages among the sub-sections.

Ho 1.21 There will be no significant difference in the frequency distribution of the overall chemistry grade point averages among the subsections.

Again these null hypotheses were found to be tenable. This confirmed the random distribution of this phase of the background of the students. Perhaps the high school chemistry background or the lack of it might have an effect upon the results of this study. The following null hypotheses were considered.

Ho 1.22 There will be no significant difference in the distribution of the high school chemistry background of the students among the sections.

Ho 1.23 There will be no significant difference in the distribution of the high school chemistry background of the students between the experimental and control groups.

Ho 1.24 There will be no significant difference in the distribution of the high school chemistry background of the students among the subsections (classes).

The data is compiled in Table XXVIII and the analysis by chi square in Tables XXIX, XXX and XXXI.

Again these three hypotheses were found tenable which confirming the random distribution of their backgrounds. From all of these data may be assumed that a random distribution of students exists in each of the classes and between the experimental and control groups with respect to classification, college or major, high school chemistry

TABLE XXIV

CHI SQUARE ANALYSIS OF THE DISTRIBUTION OF CHEMISTRY SEMESTER HOURS BY SUBSECTION

	100	200	300	400	500	600	700	Total
0 to 5 hours								
observed	1	2	2	0	0	2	1	8
(expected)	(1.21)	(1.26)	(1.11)	(1.16)	(1.01)	(1.06)	(1.21)	
6 to 10 hours								
observed	20	21	16	20	18	17	22	134
(expected)	(20.23)	(21.07)	(18.54)	(19.38)	(16.86)	(17.70)	(20.23)	
11 or more hours								
observed	3	2	4	3	2	2	1	17
(expected)	(2.57)	(2.67)	(2.35)	(2.46)	(2.14)	(2.25)	(2.57)	

$X^2 = 7.3680$ df = 12 NS Ho 1.18 not rejected

TABLE XXV

CHI SQUARE ANALYSIS OF THE DISTRIBUTION OF CHEMISTRY LABORATORY SEMESTER HOURS BY SUBSECTION

	100	200	300	400	500	600	700	Total
2 to 3 hours								
observed	3	4	2	0	1	1	2	13
(expected)	(1.96)	(2.04)	(1.80)	(1.88)	(1.64)	(1.72)	(1.96)	
4 hours								
observed	18	19	17	20	16	18	21	129
(expected)	(19.47)	(20.28)	(17.85)	(18.66)	(16.23)	(17.04)	(19.47)	
5 or more hours								
observed	3	2	3	3	3	2	1	17
(expected)	(2.57)	(2.67)	(2.35)	(2.46)	(2.14)	(2.25)	(2.57)	

$X^2 = 7.0862$ df = 12 NS Ho 1.19 not rejected

TABLE XXVI

CHI SQUARE ANALYSIS OF THE DISTRIBUTION OF CHEMISTRY GRADE POINT AVERAGES BY SUBSECTION

	100	200	300	400	500	600	700	Total
1.99 and below								
observed	1	0	3	2	1	2	0	9
(expected)	(1.37)	(1.42)	(1.25)	(1.31)	(1.14)	(1.14)	(1.37)	
2.00 to 2.49								
observed	5	8	3	4	6	6	12	44
(expected)	(6.68)	(6.96)	(6.13)	(6.13)	(6.41)	(5.57)	(5.57)	
2.50 to 2.99								
observed	6	6	6	6	6	4	3	37
(expected)	(5.62)	(5.85)	(5.15)	(5.39)	(4.68)	(4.68)	(5.62)	
3.00 to 3.49								
observed	9	3	4	5	5	4	4	34
(expected)	(5.16)	(5.38)	(4.73)	(4.95)	(4.30)	(4.30)	(5.16)	
3.50 to 3.99								
observed	3	3	4	2	1	4	3	20
(expected)	(3.04)	(3.16)	(2.78)	(2.91)	(2.53)	(2.53)	(3.04)	
4.00 to 4.49								
observed	0	5	2	4	1	0	2	14
(expected)	(2.13)	(2.22)	(1.95)	(2.04)	(1.77)	(1.77)	(2.13)	
Totals	24	25	22	23	20	20	24	158

X^2 = 31.2087 df = 30 NS Ho 1.20 not rejected

TABLE XXVII

CHI SQUARE ANALYSIS OF THE DISTRIBUTION OF OVERALL GRADE POINT AVERAGES BY SUBSECTION

	100	200	300	400	500	600	700	Total
2.49 and below								
observed	7	3	6	5	8	6	0	35
(expected)	(5.32)	(5.54)	(4.87)	(5.09)	(4.43)	(4.43)	(5.32)	
2.50 to 2.99								
observed	7	12	8	7	5	4	15	58
(expected)	(8.81)	(9.18)	(8.08)	(8.44)	(7.34)	(7.34)	(8.81)	
3.00 to 3.49								
observed	6	4	6	7	6	6	7	42
(expected)	(6.38)	(6.65)	(5.85)	(6.11)	(5.32)	(5.32)	(6.38)	
3.50 and up								
observed	4	6	2	4	1	4	2	23
(expected)	(3.49)	(3.64)	(3.20)	(3.35)	(2.91)	(2.91)	(3.49)	
Totals	24	25	22	23	20	20	24	158

X^2 = 24.8312 df = 18 NS Ho 1.21 not rejected

background, semester hours of chemistry, semester hours of chemistry laboratory, chemistry grade point average, and overall grade point average.

TABLE XVIII

TABULATION OF HIGH SCHOOL CHEMISTRY GRADES

		100	200	300	400	500	600	700
High School Chemistry								
Grade:	A	5	7	3	9	7	3	3
	B	12	14	11	9	7	11	10
	C	3	1	3	2	3	4	6
	D	0	0	0	1	0	0	1
None:		4	2	7	3	3	3	2

TABLE XXIX

CHI SQUARE ANALYSIS OF HIGH SCHOOL CHEMISTRY BACKGROUND BY SECTION (TIME OF DAY)

	MonWed 1:30	TuThu 11:30	TuThu 2:30	Total
A				
observed	15	16	6	37
(expected)	(15.13)	(11.17)	(10.70)	
B				
observed	30	23	21	74
(expected)	(30.25)	(22.34)	(21.41)	
C or below				
observed	10	4	10	24
(expected)	(9.81)	(7.25)	(6.94)	
No high school chemistry				
observed	10	5	9	24
(expected)	(9.81)	(7.25)	(6.94)	
Totals	65	48	46	159

$X^2 = 8.6207$ df = 6 NS Ho 1.22 not rejected

TABLE XXX

CHI SQUARE ANALYSIS OF HIGH SCHOOL CHEMISTRY BACKGROUND BY TREATMENT

	Experimental	Control	Total
A			
observed	15	22	37
(expected)	(16.75)	(20.25)	
B			
observed	37	37	74
(expected)	(33.51)	(40.49)	
C or below			
observed	7	17	24
(expected)	(10.87)	(13.13)	
No high school chemistry			
observed	13	11	24
(expected)	(10.87)	(13.13)	
Totals	72	87	159

$X^2 = 4.2797$ df = 3 Ho 1.23 not rejected

TABLE XXXI

CHI SQUARE ANALYSIS OF HIGH SCHOOL CHEMISTRY BACKGROUND BY SUBSECTION (CLASS)

	100	200	300	400	500	600	700	Total
A								
observed	5	7	3	9	7	3	3	37
(expected)	(5.58)	(5.58)	(5.58)	(5.58)	(4.65)	(4.89)	(5.12)	
B								
observed	12	14	11	9	7	11	10	74
(expected)	(11.17)	(11.17)	(11.17)	(11.17)	(9.31)	(9.77)	(10.24	
C or below								
observed	3	1	3	3	3	4	7	24
(expected)	(3.62)	(3.62)	(3.62)	(3.62)	(3.02)	(3.17)	(3.32)	
No high school chemistry								
observed	4	2	7	3	3	3	2	24
(expected)	(3.62)	(3.62)	(3.62)	(3.62)	(3.02)	(3.17)	(3.32)	
Total	24	24	24	24	20	21	22	159

$X^2 = 19.5154$ df = 18 NS Ho 1.24 not rejected

Experimental Data and Results

This study measured a variety of parameters in order to ascertain the particular types of changes, if any which would result from the use of single concept loop films. The time required to perform the experiment, the amount of breakage in kind and cost, the number and kinds of accidents, the results of the self concept of laboratory techniques profile, the attitude of the students toward selected experiments, and the success of the students on the JH_2S examination were explored and will be dealt with individually and in depty in this chapter.

Time Spent

The time spent on the experiment was measured from the time each student commenced his experiment after the pre-laboratory discussion and quizzes and concluded his experiment exclusive of clean up. The time was measured to the nearest five minutes. The students in the experimental groups who viewed films during the laboratory period did not deduct the viewing time. The increased data keeping on the part of the student might have resulted in less film viewing because of the added details.

A perusal of the mean times spent by students in the seven classes will show that there is a greater time difference between instructors than between experimental and control groups for any given experiment.

The research questions which need to be answered include 1) Is there a difference in the time spent between the film group and the non film group? 2) Is there a difference in the mean time spent for a given group between those experiments which directly showed the necessary techniques using loop films (direct filmed technique experiments: 1,2,3,4,5,13), those experiments which indirectly relied upon those techniques (indirect filmed technique experiments, e.g. all others except 6 and 16) and those experiments which required no techniques covered in the films? 3) Does the time of day for the experiment have any effect upon the time spent? 4) Does the instructor have any effect upon the time spent?

The preceding questions generated the following null hypotheses. For convenience, the hypotheses are stated in a group, followed by the table of data and statistical results.

Ho 2.01 There will be no significant difference in the mean times spent on each experiment in the seven subsections (classes).

Ho 2.02 There will be no significant difference in the mean times spent on each experiment in the seven subsections on the direct filmed technique experiments. (Experiments 2,3,4,5, and 13.)

Ho 2.03 There will be no significant difference in the mean times spent on each experiment in the seven subsections on the indirect filmed technique experiments. (All experiments except the above and 6 and 16.)

Ho 2.04 There will be no significant difference in the mean times spent on each experiment in the seven subsections on the experiments which utilize no filmed techniques. (Experiments 6 and 16 only.)

Ho 2.05 There will be no significant difference in the mean time spent on each experiment by the students of each teacher for all experiments.

Ho 2.06 There will be no significant difference in the mean times spent on each experiment by the students of each teacher for the direct filmed technique experiments.

Ho 2.07 There will be no significant difference in the mean times spent on each experiment by the students of each teacher for the indirect filmed technique experiments.

Ho 2.08 There will be no significant difference in the mean times spent on each experiment by the students of each teacher for the non-filmed technique experiments.

Ho 2.09 There will be no significant difference in the mean times spent on each experiment by the students in a laboratory section (time of day) on each experiment.

Ho 2.10 There will be no significant difference in the mean times spent on each experiment by the students in a laboratory section for the direct filmed technique experiments.

Ho 2.11 There will be no significant difference in the mean times on each experiment by the students in a laboratory section for the indirect filmed technique experiments.

Ho 2.12 There will be no significant difference in the mean times spent on each experiment by the students in a laboratory section for the non-filmed technique experiments.

Ho 2.13 There will be no significant difference in the mean times spent on each experiment between the students in the experimental group and the control group on all experiments.

Ho 2.14 There will be no significant difference in the mean times spent on each experiment between the experimental group and the control group on the direct filmed technique experiments.

Ho 2.15 There will be no significant difference in the mean times spent on each experiment between the students in the experimental group and the control group on the indirect filmed technique experiments.

Ho 2.16 There will be no significant difference in the mean times spent on each experiment between the students in the experimental group and the control group on the non-filmed technique experiments.

Ho 2.17 There will be no significant difference in the mean times spent between the students in the experimental group and those of the control group taught by the same teachers as the experimental group on all experiments.

Ho 2.18 There will be no significant difference in the mean times spent between the students in the experimental group and those of the control group taught by the same teachers for the direct filmed technique experiments.

Ho 2.19 There will be no significant difference between the mean times spent by the students in the experimental group and those of the control group taught by the same teacher for the indirect filmed technique experiments.

Ho 2.20 There will be no significant difference in the mean times spent between the students in the experimental group and those of the control group taught by the same teachers on the non-film technique experiments.

Because the time spent on each experiment varied considerably from one experiment to another, as well as the times within a particular class not conforming to a normal distribution, and not being homoscedastic, the Friedman Two Way Analysis of Variance Test was employed. Tables XXXII, XXXIII, XXXIV, and XXXV show the data which has been taken from individual data as shown in Appendix C.

TABLE XXXII

MEAN TIMES SPENT ON EACH EXPERIMENT BY SUBSECTION (CLASS)

Expt Nr.	Group 100	Group 200	Group 300	Group 400	Group 500	Group 600	Group 700
1*	149.79(6)	115.40(1)	131.09(5)	150.65(7)	117.78(2)	130.00(4)	122.83(3)
2*	153.04(7)	112.83(3)	131.30(5)	136.30(6)	110.75(2)	125.71(4)	102.08(1)
3*	126.25(6)	95.21(2)	104.13(4)	128.54(7)	101.05(3)	104.76(5)	74.57(1)
4*	119.16(7)	90.60(2)	105.00(5)	108.96(6)	103.00(4)	97.62(3)	87.50(1)
5*	141.04(6)	107.83(1)	131.67(5)	145.71(7)	111.71(3)	111.67(2)	129.17(4)
6#	120.26(5)	98.88(2)	120.23(4)	142.50(7)	92.50(1)	129.52(6)	100.87(3)
13*	224.09(4)	202.60(1)	248.70(7)	230.87(6)	210.88(2)	215.71(3)	228.70(5)
11	226.09(6)	208.40(5)	234.58(7)	198.70(2)	200.63(3)	204.75(4)	195.83(1)
MeSal	224.78(5)	215.00(3)	235.91(6)	243.26(7)	206.05(2)	205.00(1)	220.43(4)
Ethanol	150.21(6)	107.08(3)	144.09(5)	154.13(7)	96.43(2)	144.05(4)	95.21(1)
16#	119.05(5)	95.83(1)	120.22(6)	98.04(2)	107.35(4)	128.37(7)	102.17(3)
MEK	182.08(5)	155.65(1)	197.73(6)	168.48(2)	168.61(3)	198.81(7)	181.04(4)
17	118.70(7)	96.25(2)	111.67(5)	109.05(4)	101.07(3)	114.47(6)	96.30(1)
20	136.00(7)	116.20(2)	133.41(5)	137.39(6)	123.33(3)	131.80(4)	111.70(1)
26	127.38(7)	102.50(4)	101.00(3)	125.00(6)	97.63(2)	105.00(5)	95.68(1)
30	81.25(5)	65.28(1)	69.70(2)	86.25(6)	73.53(3)	76.11(4)	86.43(7)
35	104.78(7)	80.42(2)	95.95(4)	97.95(6)	81.84(3)	96.47(5)	53.50(1)
B&O	176.36(6)	161.04(1)	165.68(4)	205.71(7)	162.50(2)	163.10(3)	175.00(5)
MDNB	150.00(4)	125.00(3)	188.10(7)	153.96(5)	124.33(2)	163.75(6)	105.24(1)
29	200.42(3)	174.57(2)	201.59(4)	214.35(5)	214.74(6)	226.19(7)	171.11(1)
Sum of ranks for all experiments:	114	42	99	111	55	90	49
Sum of ranks for direct filmed technique experiments (*):	36	10	31	39	16	21	15

Sum of ranks for all experiments: $X_r^2 = 59.37$ **significant at 0.001 Ho 2.01 rejected

Sum of ranks for direct filmed technique experiments (*): $X_r^2 = 27.36$ **significant at 0.001 Ho 2.02 rejected

TABLE XXXII (Continued)

Expt NR.	Group 100	Group 200	Group 300	Group 400	Group 500	Group 600	Group 700
Sum of ranks for indirect filmed technique experiments:							
	68	29	58	63	34	56	28
X_r^2 = 31.94	**significant at 0.001		Ho 2.03 rejected				
Sum of ranks for non-filmed technique experiments (#)							
	10	3	10	9	5	13	6
X_r^2 = 2.69	NS		Ho 2.04 not rejected				

TABLE XXXIII

MEAN TIMES SPENT ON EACH EXPERIMENT BY TEACHER

Expt Nr.	Teacher #A (100+500)	Teacher #B (200+500)	Teacher #C (300+600)	Teacher #D (700)
1*	150.22(4)	116.59(2)	130.54(3)	122.83(1)
2*	144.67(4)	111.79(2)	128.51(3)	102.08(1)
3*	127.40(4)	98.13(2)	104.45(3)	74.57(1)
4*	114.06(4)	96.80(2)	101.31(3)	87.50(1)
5*	143.38(4)	109.77(1)	121.67(2)	129.17(3)
6#	131.38(4)	95.69(1)	124.88(3)	100.87(2)
13*	227.48(2)	206.74(1)	232.21(4)	228.70(3)
11	212.40(3)	204.52(2)	219.67(4)	195.83(1)
MeSal	234.02(4)	210.53(1)	220.46(3)	220.43(2)
Ethanol	152.17(4)	101.76(2)	144.07(3)	95.21(1)
16#	108.55(3)	101.59(1)	124.28(4)	102.17(2)
MEK	175.28(2)	162.13(1)	198.27(4)	181.04(3)
17	113.88(4)	98.66(2)	113.07(3)	96.30(1)
20	136.70(4)	119.77(2)	132.61(3)	111.70(1)
26	126.19(4)	100.07(2)	103.00(3)	95.68(1)
30	83.75(3)	69.41(1)	72.94(2)	86.43(1)
35	101.37(4)	81.13(2)	96.21(3)	53.50(1)
B&O	191.04(4)	161.71(1)	164.39(2)	175.00(3)
MDNB	151.98(4)	124.67(2)	175.93(3)	105.24(1)
29	207.39(3)	194.66(2)	213.89(4)	171.11(1)
Sum of ranks for all experiments:	72	32	62	34
$X_r^2 = 36.24$	**significant at .001	Ho 2.05 rejected		
Sum of ranks for direct filmed technique experiments (*)	22	10	18	10
$X_r^2 = 10.80$	**significant at .02	Ho 2.06 rejected		
Sum of ranks for indirect filmed technique experiments	43	20	37	20
$X_r^2 = 20.90$	**significant at .001	Ho 2.07 rejected		
Sum of ranks for non-filmed technique experiments (#)	7	2	7	4
$X_r^2 = 5.40$ NS		Ho 2.08 not rejected		

TABLE XXXIV

MEAN TIMES SPENT ON EACH EXPERIMENT BY SECTION (TIME-OF-DAY)

Expt Nr.	MonWed 1:30PM (100+500+600)	TuThu 11:30AM (200+400)	TuThu 2:30 PM (300+700)
1*	132.52(2)	133.03(3)	126.96(1)
2*	129.83(3)	124.57(2)	116.69(1)
3*	110.69(2)	118.88(3)	89.35(1)
4*	106.59(3)	99.78(2)	96.25(1)
5*	121.47(1)	126.77(2)	130.42(3)
6#	114.09(2)	120.69(3)	110.55(1)
13	216.89(2)	216.74(1)	238.70(3)
11	210.49(2)	203.55(1)	215.05(3)
MeSal	211.94(1)	229.13(3)	228.17(2)
Ethanol	130.23(3)	115.85(1)	119.65(2)
16#	118.24(3)	96.94(1)	111.20(2)
MEK	183.17(2)	162.07(1)	189.39(3)
17	111.41(3)	102.65(1)	103.99(2)
20	130.38(3)	126.80(2)	122.56(1)
26	109.67(2)	113.75(3)	98.34(1)
30	76.96(2)	75.77(1)	78.10(3)
35	94.36(3)	89.19(2)	74.73(1)
B&O	167.32(1)	183.38(3)	170.34(2)
MDNB	146.03(2)	139.48(1)	146.67(3)
29	213.78(3)	194.46(2)	186.35(1)
Sum of ranks for all experiments:	45	38	37
X_r^2 = 1.90 NS	Ho 2.09 not rejected		
Sum of ranks for direct filmed technique experiments (*)	13	13	10
X_r^2 = 3.01 NS	Ho 2.10 not rejected		
Sum of ranks for indirect filmed technique experiments	27	21	24
X_r^2 = 1.40 NS	Ho 2.11 not rejected		
Sum of rank for the non-filmed technique experiments (#)	5	4	3
X_r^2 = 1.00 NS	Ho 2.12 not rejected		

TABLE XXXV

MEAN TIMES FOR ALL EXPERIMENTS BETWEEN EXPERIMENTAL GROUPS AND CONTROL GROUPS

Expt Nr.	Control Group 400+500+600+700	(Rank)	(Rank)	Experimental Group 100+200+300	(Rank)	(Rank)	Control Group 400+5-0+600
1*	130.31	(1)	(2)	132.09	(1)	(2)	132.81
2*	118.71	(1)	(2)	132.39	(2)	(1)	124.25
3*	102.23	(1)	(2)	108.53	(1)	(2)	111.45
4*	99.27	(1)	(2)	104.92	(2)	(1)	103.19
5*	124.57	(1)	(2)	126.85	(2)	(1)	123.03
6#	116.35	(2)	(1)	113.12	(1)	(2)	121.51
13*	221.54	(1)	(2)	225.13	(2)	(1)	219.15
11	199.98	(1)	(2)	223.02	(2)	(1)	201.36
MeSal	218.69	(1)	(2)	225.23	(2)	(1)	218.10
Ethanol	122.46	(1)	(2)	133.79	(2)	(1)	131.54
16#	108.97	(1)	(2)	111.70	(2)	(1)	111.24
MEK	179.24	(2)	(1)	178.49	(1)	(2)	178.63
17	105.22	(1)	(2)	108.87	(1)	(2)	108.20
20	126.06	(1)	(2)	128.54	(1)	(2)	130.84
26	105.83	(1)	(2)	110.29	(2)	(1)	109.21
30	80.58	(2)	(1)	72.10	(1)	(2)	78.63
35	82.44	(1)	(2)	93.72	(2)	(1)	92.09
B&O	176.58	(2)	(1)	167.69	(1)	(2)	177.10
MDNB	136.82	(1)	(2)	159.37	(2)	(1)	147.35
29	206.50	(2)	(1)	192.19	(1)	(2)	218.43

Sum of ranks for all experiments:

25	35	31	29

X_r^2 = 5.00 **significant at 0.05 — X_r^2 = 0.20 NS

Ho 2.13 rejected — Ho 2.17 not rejected

Sum of ranks for direct filmed experiments

6	12	10	8

X_r^2 = 5.99 **significant at 0.02 — X_r^2 = 0.67 NS

Ho 2.14 rejected — Ho 2.18 not rejected

Sum of ranks for indirect filmed technique experiments

16	20	18	18

X_r^2 = 1.36 NS — X_r^2 = 0.02 NS

Ho 2.15 not rejected — Ho 2.19 not rejected

Sum of ranks for non-filmed technique experiments

3	3	3	3

X_r^2 = 0.00 NS — X_r^2 = 0.00

Ho 2.16 not rejected — Ho 2.20 not rejected

TABLE XXXVI

SUMMARY OF RESULTS OF ANALYSIS OF TIME SPENT

Null Hypothesis	Criteria	Degrees of Freedom	X_r^2	Probability
Ho 2.01	All experiments by subsection (class)	6	59.37	** 0.001
Ho 2.02	Direct filmed techniques by subsection	6	27.36	** 0.001
Ho 2.03	Indirect filmed techniques by subsection	6	31.94	** 0.001
Ho 2.04	Nonfilmed techniques by subsection	6	7.69	NS
Ho 2.05	All experiments by teacher	3	36.24	** 0.001
Ho 2.06	Direct filmed techniques by teacher	3	10.80	** 0.02
Ho 2.07	Indirect film techniques by teacher	3	20.90	** 0.001
Ho 2.08	Nonfilmed techniques by teacher	3	5.40	NS
Ho 2.09	All experiments by section (time-of-day)	2	1.90	NS
Ho 2.10	Direct filmed techniques by section	2	3.01	NS
Ho 2.11	Indirect filmed techniques by section	2	1.40	NS
Ho 2.12	Nonfilmed techniques by section	2	1.0	NS
Ho 2.13	All experiments by treatment (all experiments vs. all control)	1	5.0	** 0.05
Ho 2.14	Direct filmed techniques by treatment	1	5.99	** 0.02
Ho 2.15	Indirect filmed techniques by treatment	1	1.36	NS
Ho 2.16	Nonfilmed techniques by treatment	1	0.00	NS
Ho 2.17	All experiments by treatment (Groups 100+200+300 vs. 400+500+600)	1	0.2	NS
Ho 2.18	Direct filmed techniques by treatment	1	0.67	NS
Ho 2.19	Indirect filmed techniques by treatment	1	0.02	NS
Ho 2.20	Nonfilmed techniques by treatment	1	0.00	NS

The summary as shown in Table XXXVI indicates that in all cases for the non filmed technique experiments there is no significant difference between the groups by class (subsection), teacher, time of day or treatment. There appears to be more difference attributed to the teacher rather than to the treatment. For example, hypothesis 2.01 through 2.03 indicate significant differences between classes, however this can be attributed to teacher difference because the Friedman analysis only shows that a difference exists but does not indicate the direction.

One may explore further by utilizing a chi square analysis of the following null hypotheses.

Ho 2.21 There will be no significant difference in the overall mean time spent by students in the experimental and control classes for a given teacher.

Ho 2.22 There will be no significant difference in the overall mean time spent on direct filmed technique experiments by the students in the experimental and control classes for a given teacher.

Ho 2.23 There will be no significant difference in the overall mean time spent on the indirect filmed technique experiments by the students in the experimental and control classes for a given teacher.

Ho 2.24 There will be no significant difference in the overall mean time spent on the non filmed technique experiments by the students in the experimental and control groups for a given teacher.

Thus all four null hypotheses are found tenable and cannot be rejected. This confirmed the observation that the overall time difference lies between the teachers rather than between methods.

TABLE XXXVII

CHI SQUARE ANALYSIS OF TIME BY TEACHER AND TREATMENT FOR ALL EXPERIMENTS

	Teacher #A	Teacher #B	Teacher #C	Totals
Observed Experimental (expected)	151.54 (151.80)	126.33 (128.42)	148.59 (146.24)	426.46
Observed Control (expected)	151.79 (151.53)	130.29 (128.20)	143.64 (145.99)	425.72
Totals	303.33	256.62	292.23	852.18

$X^2 = 0.1445$ (df = 2) NS Ho 2.21 Not rejected

TABLE XXXVIII

CHI SQUARE ANALYSIS OF TIME BY TEACHER AND TREATMENT FOR DIRECT FILMED TECHNIQUE EXPERIMENTS

	Teacher #A	Teacher #B	Teacher #C	Totals
Observed Experimental (expected)	152.23 (152.68)	120.75 (124.51)	141.99 (137.78)	414.97
Observed Control (expected)	150.17 (149.72)	125.86 (122.10)	130.91 (135.12)	406.94
Totals	302.40	246.61	272.90	821.91

$X^2 = 0.4918$ (df = 2) NS Ho 2.22 Not rejected

TABLE XXXIX

CHI SQUARE ANALYSIS OF TIME BY TEACHER AND TREATMENT FOR INDIRECT FILMED TECHNIQUE EXPERIMENTS

	Teacher #A	Teacher #B	Teacher #C	Totals
Observed Experimental (expected)	156.50 (157.03)	133.95 (135.63)	156.62 (154.40)	447.07
Observed Control (expected)	157.85 (157.32)	137.56 (135.88)	152.46 (154.68)	447.87
Totals	314.35	271.51	309.08	894.94

$X^2 = 0.1090$ (df = 2) NS Ho 2.23 Not rejected

TABLE XL

CHI SQUARE ANALYSIS OF TIME BY TEACHER AND TREATMENT FOR NON FILMED TECHNIQUE EXPERIMENTS

	Teacher #A	Teacher #B	Teacher #C	Totals
Observed Experimental (expected)	119.66 (117.89	97.36 (100.35)	120.23 (122.42)	337.25
Observed Control (expected)	120.27 (122.04)	99.93 (100.68)	128.93 (126.74)	349.13
Totals	239.93	197.29	249.16	686.38

$X^2 = 0.2240$ (df = 2) NS Ho 2.24 Not rejected

The next logical step was to compare the mean times for each experiment between each teacher separately. This was accomplished by the Wilcoxon Matched Pairs Signed Rank Test. The following null hypotheses were tested.

Ho 2.25 There will be no significant difference in the time required for all of the experiments between the experimental group and the control group for a given teacher.

Ho 2.26 There will be no significant difference in the time required for the direct filmed technique experiments between the experimental and the control group for a given teacher.

Ho 2.27 There will be no significant difference in the time required for the indirect filmed technique experiments between the experimental and the control groups for a given teacher.

Ho 2.28 There will be no significant difference in the time required for the non filmed technique experiments between the experimental and the control group for a given teacher.

Table XLI shows the results. Thus it is found that although some experimental groups (those of Teachers A and B) have more faster times in the twenty experiments there is no overall significant difference in time spent between the experimental and control groups for a given teacher. Therefore it can be concluded that the use of single concept loop films does not result in any lengthening of the experimental time even though the students gain their setup directions and manipulative hints during the experiment from viewing the film.

TABLE XLI

MEAN TIME DIFFERENCES BETWEEN EXPERIMENTAL AND CONTROL CLASSES FOR EACH TEACHER AND THE SIGNED RANKS FOR EACH CATEGORY AND ANALYSIS BY WILCOXON MATCHED PAIRS SIGNED RANKS TEST

	Teacher A			Teacher B			Teacher C		
	Time	Ranking		Time	Ranking		Time	Ranking	
Experiment	diff	all	other	diff	all	other	diff	all	other
1*	- 0.86	- 5	- 2*	- 2.38	-14.5	6*	1.09	7	3*
2*	16.74	48	16*	2.08	12	4*	5.59	26	9*
3*	- 2.29	-13	- 5*	- 5.84	-27	-10*	- 0.63	- 3	- 1*
4*	10.20	41	14*	-12.40	-44	-15*	7.38	33	12*
5*	- 4.70	-22	- 8*	- 3.88	-18	- 7*	20.00	50	17*
6#	-22.74	-52	- 5#	6.38	29	1#	- 9.29	-39	- 3#
13*	- 6.78	-30	-11*	- 8.28	-37	-13*	32.99	59	18*
11	27.39	55	32	7.77	34	21	29.83	57	34
MeSal	-18.48	-49	-29	8.95	38	23	30.91	58	35
Ethanol	- 3.92	-19	-12	10.65	42	25	0.04	1	1
16#	21.01	51	6#	-11.52	-43	- 4#	- 8.11	-35	- 2#
MEK	13.60	46	27	-12.96	-45	-26	- 1.08	- 6	- 4
17	9.65	40	24	- 4.82	-23	-15	- 2.80	-17	-11
20	- 1.39	- 8	- 5	- 7.13	-32	-20	1.61	11	8
26	2.38	14.5	9	4.87	24	16	- 4.00	-21	-14
30	- 5.00	-25	-17	- 8.25	-36	-22	- 6.33	-28	-18
35	6.83	31	19	- 1.42	- 9	- 6	- 0.52	- 2	- 2
B&O	-29.35	-56	-33	- 1.46	-10	- 7	2.58	16	10
MDNB	- 3.96	-20	-13	0.67	4	3	24.25	53	30
29	-13.93	-47	-28	40.17	60	36	-24.60	-54	-31
No. Expts in which Exptl Group was faster		12			12			9	

All Experiments:

T = 939.5 Z = 0.1804 Prob. = 0.4286 NS

Ho 2.25 not rejected

TABLE XLI (Continued)

Experiment	Teacher A Time diff	Teacher A Ranking all	Teacher A Ranking other	Teacher B Time diff	Teacher B Ranking all	Teacher B Ranking other	Teacher C Time diff	Teacher C Ranking all	Teacher C Ranking other
Direct filmed technique experiments(*)									
	T = 90			Z = 0.1960			Prob. = 0.4207 NS Ho 2.26 not rejected		
Indirect filmed technique experiments									
	T = 321			Z = 0.1885			Prob. = 0.4247 NS Ho 2.27 not rejected		
Non-filmed technique experiments (#)									
	T = 7			Z = 0.6831			Prob. = 0.2483 NS Ho 2.28 not rejected		

Breakage

The comparison of breakage and the resulting costs is difficult to compare directly. Considering the number of items broken, which is more serious breaking several test tubes at seven cents each, two beakers at approximately fifty cents each, or only one 500ml three-neck flask at approximately ten dollars. Certainly breaking many items, although inexpensive is serious and can be attributed to carelessness, the breakage of costly items is another factor which should be considered. Organic chemistry laboratories now utilize standard taper glassware which avoids cork stoppers and rubber tubing connectors and the contamination and inconvenience which results. Does the use of single concept films lower the amount of these expensive pieces of standard taper glassware broken? To allow for these various factors, the following criteria were compared between the experimental and control groups.

1. The number of students having at least one incident of breakage.

2. The cost of items broken.

3. The total number of items broken.

4. The average cost per item broken.

5. Comparison of the above criteria for all experiments, the direct filmed technique experiments, indirect filmed technique experiments, and the non filmed technique experiments. The cost factors will also be compared for the breakage of standard taper glassware.

These statements generate the following null hypotheses.

Ho 3.01 There will be no significant difference in the proportion of students having at least one incident of breakage between the experimental and control groups.

Ho 3.02 There will be no significant difference in the cost of breakage per student attending class between the experimental group and control group for all experiments.

Ho 3.03 There will be no significant difference in the cost of breakage per student attending class between the experimental group and the control group for the direct filmed technique experiments.

Ho 3.04 There will be no significant difference in the cost of breakage per student attending class between the experimental and control group for the indirect filmed technique experiments.

Ho 3.05 There will be no significant difference in the cost of breakage per student attending class between the experimental group and control group for the non filmed technique experiments.

Ho 3.06 There will be no significant difference in the cost of breakage per student attending class between the experimental group and the control group for standard taper glassware.

Ho 3.07 There will be no significant difference in the number of incidents of breakage per student attending class between the experimental group and the control group for all experiments.

Ho 3.08 There will be no significant difference in the number of incidents of breakage per student attending class between the experimental group and the control group for the direct filmed technique experiments.

Ho 3.09 There will be no significant difference in the number of incidents of breakage per student attending class between the experimental group and the control group for the indirect filmed technique experiments.

Ho 3.10 There will be no significant difference in the number of incidents of breakage per student attending class between the experimental group and the control group for the non filmed technique experiments.

Ho 3.11 There will be no significant difference in the number of incidents of breakage per student attending class between the experimental group and the control group for standard taper glassware.

Ho 3.12 There will be no significant difference in the cost of breakage incident per student attending class between the experimental and control groups for all experiments.

Ho 3.13 There will be no significant difference in the cost per breakage incident per student attending class between the experimental group and control group for the direct filmed technique experiments.

Ho 3.14 There will be no significant difference in the cost per breakage incident per student attending class between the experimental group and the control group for the indirect filmed technique experiments.

Ho 3.15 There will be no significant difference in the cost per breakage incident per student attending class between the experimental group and the control group for the non filmed technique experiments.

Ho 3.16 There will be no significant difference in the cost per breakage incident per student attending class between the experimental group and the control group for the standard taper glassware.

Ho 3.17 There will be no significant difference in the mean cost per item broken between the experimental group and the control group for all experiments.

Ho 3.18 There will be no significant difference in the mean cost per item broken between the experimental group and the control group for the direct filmed technique experiments.

Ho 3.19 There will be no significant difference in the mean cost per item broken between the experimental group and the control group for the indirect filmed technique experiments.

Ho 3.20 There will be no significant difference in the mean cost per item broken between the experimental group and the control group for the non filmed technique experiments.

Ho 3.21 There will be no significant difference in the mean cost per item broken between the experimental group and the control group for the standard taper glassware.

The data is taken from Appendix D and compiled into the various categories in Tables XLII through XLVIII with the results summarized in Table XLIX.

TABLE XLII

NUMBER OF INCIDENTS OF EQUIPMENT BREAKAGE BY EACH STUDENT

Student Number	100	200	300	400	500	600	700
1	X	XXXX	X	XXX	XX	XXX	X
2	XX	XX	XXX	0	XX	XXX	X
3	X	X	0	XXX	XX	0	X
4	X	XX	XXX	X	0	0	X
5	0	XX	XXX	XXX	0	XXXXXX	X
6	0	Z	XX	XX	XX	0	XX
7	0	XXX	X	X	0	XX	X
8	X	0	0	XX	X	XXX	X
9	XXX	XX	XX	X	0	0	XX
10	0	0	XXXX	0	X	X	XX
11	X	X	0	0	X	X	0
12	XX	XX	XXXXX	XX	X	XXX	0
13	X	0	XX	X	X	XXX	XX
14	X	0	XX	XX	X	X	X
15	XXX	XX	X	X	X	XX	XX
16	XXX	0	XXXX	0	XXX	XX	XX
17	XXX	XXXX	0	XXXX	X	XXX	0
18	XX	0	XX	XXXX	X	XXXX	0
19	X	XX	XXXX	X	X	XXXX	XX
20	X	0	X	0	–	X	XX
21	0	0	0	0	–	0	X
22	0	X	X	X	–	–	0
23	XX	XX	–	0	–	–	XXXXX
24	XXXX	X	–	X	–	–	0
25	–	–	–	–	–	–	–
Incidents:	18	16	17	18	15	16	18
Nr Students:	24	25	24	23	19	21	24
% of Class having breakage	75.00	64.00	70.83	78.26	78.95	84.21	75.00

X = incidents of breakage; 0 = individuals without breakage;
– = no student with that number

TABLE XLIII

NUMBER OF INDIVIDUALS REPORTING AT LEAST ONE INCIDENT OF EQUIPMENT BREAKAGE

Group	Experimental			Control			
	100	200	300	400	500	600	700
Individuals w/Breakage	18	16	17	18	15	16	18
Nr Students	24	25	24	23	19	21	24
Percent of Class Reporting Breakage	75.00	64.00	70.83	78.26	78.95	84.21	75.00
Rank	4.5	6	7	3	2	1	4.5

$n_e = 3$, $R_e = 17.5$ $n_c = 4$, $R_c = 10.5$

$u = 0.5$ $z = 1.9623$ $p = 0.0250$ **Significant beyond 0.05 level

Ho 3.01 rejected

TABLE XLIV

COMPARISON OF COST OF BREAKAGE, QUANTITY OF ITEMS BROKEN, AND NUMBER OF STUDENTS FOR EACH SUBSECTION FOR ALL EXPERIMENTS

Group	Cost $	Number Items	Number Students	Cost Per Student	Breakage Per Student	Cost Per Break Per Student	Cost Per Item Broken
100	$46.45	33	444	$0.1046	0.0743	0.00317	$1.408
(rank)				(4)	(4)	(4)	(3)
200	34.08	31	470	0.0725	0.0660	0.00233	1.099
(rank)				(7)	(6)	(7)	(7)
300	49.36	43	440	0.1121	0.0977	0.00261	1.148
(rank)				(3)	(1)	(6)	(6)
Expt Group:	129.89	107	1354	0.0959	0.0790	0.000897	1.214
				(14)	(11)	(17)	(16)
400	45.15	35	451	0.1001	0.0776	0.00286	1.290
(rank)				(5)	(3)	(5)	(4)
500	30.13	25	356	0.0846	0.0702	0.00339	1.205
(rank)				(6)	(4)	(3)	(5)
600	114.31	40	402	0.2844	0.0995	0.00711	2.857
(rank)				(1)	(2)	(1)	(1)
700	52.08	25	451	0.1155	0.0554	0.00462	2.083
(rank)				(2)	(7)	(2)	(2)
Control Group:	241.67	125	1660	0.1456	0.0753	0.001165	1.9333
				(14)	(16)	(11)	(12)
Total	371.56	232	3014	0.12328	0.07694	0.0005314	1.6015

TABLE XLV

COMPARISON OF COST OF BREAKAGE, QUANTITY OF ITEMS BROKEN, AND NUMBER OF STUDENTS FOR EACH SUBSECTION FOR THE DIRECT FILMED TECHNIQUE EXPERIMENTS

Group	Cost $	Number Items	Number Students	Cost Per Student	Breakage Per Student	Cost Per Break Per Student	Cost Per item Broken
100	$15.65	16	141	0.1110	0.1135	0.00694	0.9781
(rank)				(6)	(3)	(6)	(6)
200	14.72	18	146	0.1009	0.1233	0.00560	0.8178
(rank)				(7)	(2)	(7)	(7)
300	24.88	15	135	0.1843	0.1111	0.01229	1.8178
(rank)				(3)	(4)	(3)	(3)
Experimental Group	55.25	49	135	0.1309	0.1161	0.00267	1.1276
(sum of ranks)				(16)	(9)	(16)	(16)
400	15.96	15	138	0.1157	0.1087	0.00771	1.0640
(rank)				(5)	(5)	(5)	(3)
500	17.55	15	112	0.1567	0.1339	0.01045	1.1700
(rank)				(4)	(1)	(4)	(4)
600	29.26	9	124	0.2360	0.0725	0.02622	3.2511
(rank)				(1)	(7)	(1)	(1)
700	31.26	11	139	0.2249	0.0791	0.02044	2.8418
(rank)				(2)	(6)	(2)	(2)
Control Group	94.03	50	315	0.1833	0.0975	0.00367	1.8806
(sum of ranks)				(20)	(19)	(12)	(12)
Total	149.28	99	935	0.15966	0.1059	0.00161	1.5079

TABLE XLVI

COMPARISON OF COST OF BREAKAGE, QUANTITY OF ITEMS BROKEN, AND THE NUMBER OF STUDENTS FOR EACH SUBSECTION FOR THE INDIRECT FILMED TECHNIQUE EXPERIMENTS

Group	Cost $	Number Items	Number Students	Cost Per Students	Breakage Per Student	Cost Per Break Per Student	Cost Per Item Broken
100	$30.31	16	263	0.11525	0.06084	0.00720	1.894
(rank)				(2)	(3)	(5)	(4)
200	19.36	13	276	0.07015	0.04711	0.00540	1.489
(rank)				(6)	(5)	(6)	(6)
300	21.48	17	261	0.08229	0.06513	0.00484	1.264
(rank)				(4)	(2)	(1)	(7)
Experimental Group	71.15	46	800	0.08894	0.05750	0.00193	1.263
(sum of ranks)				(12)	(10)	(12)	(17)
400	23.85	14	266	0.08966	0.05263	0.00640	1.703
(rank)				(3)	(4)	(4)	(3)
500	12.30	6	208	0.05913	0.02885	0.00986	2.050
(rank)				(7)	(7)	(2)	(3)
600	83.13	25	236	0.35225	0.10593	0.01409	3.325
(rank)				(1)	(1)	(1)	(1)
700	20.29	9	266	0.07627	0.03383	0.00848	2.544
(rank)				(5)	(6)	(6)	(2)
Control Group	139.57	54	976	0.14300	0.05533	0.00265	2.5846
(sum of ranks)				(16)	(8)	(16)	(11)
Total	210.72	100	1776	0.11865	0.056036	0.00119	2.1072

TABLE XLVII

COMPARISON OF COST OF BREAKAGE, QUANTITY OF ITEMS BROKEN, AND THE NUMBER OF STUDENTS FOR EACH SUBSECTION FOR THE NON-FILMED TECHNIQUE EXPERIMENTS

Group	Cost $	Number Items	Number Students	Cost Per Students	Breakage Per Student	Cost Per Break Per Student	Cost Per Item Broken
100	0.49	1	40	0.0122	0.0250	0.01225	0.4900
(rank)				(4)	(6)	(1)	(2)
200	0.00	0	48	0.0	0.0	0.0	0.0
(rank)				(7)	(7)	(7)	(7)
300	3.00	11	44	0.0681	0.2500	0.00619	0.2727
(rank)				(2)	(1)	(4)	(4)
Experimental Group	3.49	12	132	0.0264	0.0909	0.0022	0.2908
(sum of ranks)				(13)	(14)	(12)	(13)
400	5.34	6	47	0.1136	0.1277	0.01330	0.8900
(rank)				(1)	(3)	(2)	(1)
500	0.28	4	36	0.0077	0.1111	0.00194	0.0700
(rank)				(6)	(4)	(6)	(6)
600	1.92	6	42	0.0457	0.1428	0.00761	0.3200
(rank)				(3)	(2)	(3)	(3)
700	0.53	5	46	0.0115	0.1089	0.00230	0.1060
(rank)				(5)	(5)	(5)	(5)
Control Group	8.07	21	171	0.04719	0.12281	0.002247	0.38485
(sum of ranks)				(15)	(14)	(16)	(15)
Total	11.56	33	303	0.038152	0.1089108	0.00156	0.350303

TABLE XLVIII

COMPARISON OF COST OF BREAKAGE, QUANTITY OF ITEMS BROKEN AND THE NUMBER OF STUDENTS FOR EACH SUBSECTION FOR THE ITEMS OF STANDARD TAPER GLASSWARE WHICH WAS BROKEN THROUGHOUT THE SEMESTER

Group	Cost $	Number Items	Number Students	Cost Per Students	Breakage Per Student	Cost Per Break Per Student	Cost Per Item Broken
100	21.72	4	444	0.0489	0.0090	0.0122	5.4300
(rank)				(4)	(6)	(2)	(1)
200	13.91	3	470	0.0296	0.0064	0.0099	4.6367
(rank)				(7)	(7)	(4)	(4)
300	17.73	6	440	0.0403	0.0136	0.0067	2.9550
(rank)				(5)	(4)	(7)	(6)
Experimental Group	53.36	13	1354	0.0394	0.0096	0.0030	4.1046
(sum of ranks)				(16)	(17)	(13)	(11)
400	28.17	7	451	0.0625	0.0155	0.0089	4.0243
(rank)				(3)	(3)	(5)	(5)
500	11.48	4	356	0.0322	0.0112	0.0081	2.8700
(rank)				(6)	(5)	(6)	(7)
600	91.89	18	402	0.2286	0.0448	0.0127	5.1050
(rank)				(1)	(1)	(1)	(2)
700	37.49	8	451	0.0831	0.0177	0.0104	4.6863
(rank)				(2)	(2)	(3)	(3)
Control Group	169.03	37	1660	0.2287	0.0223	0.0028	4.5684
(sum of ranks)				(12)	(11)	(15)	(17)
Total	222.39	50	3014	0.0738	0.01659	0.001476	4.4478

TABLE XLIX

SUMMARY OF RESULTS OF BREAKAGE AND COST COMPARISONS

Hypothesis	Comparison	Sum of ranks Expt'l	Sum of ranks Cont'l	U	Z	Probability	Significance
Ho 3.01	Incidents of breakage	17.5	10.5	0.5	-1.9623	0.025	**0.05
Ho 3.02	Breakage cost per student						
Ho 3.02	all experiments	14	14	4	-0.7071	0.2389	NS
Ho 3.03	direct filmed technique	16	12	2	-1.4142	0.0793	**0.10
Ho 3.04	indirect filmed technique	12	16	6	0.0000	0.5000	NS
Ho 3.04	Non-filmed technique	13	15	5	-0.3536	0.3632	NS
Ho 3.06	Standard Taper Glass	16	12	2	-1.4142	0.0793	**0.05
	Breakage incidents per student						
Ho 3.07	all experiments	11	17	(5)	+0.3536	0.6368	NS
Ho 3.08	direct filmed technique	9	19	(3)	+1.0607	0.8554	NS
Ho 3.08	indirect filmed technique	10	18	(4)	+0.7071	0.7511	NS
Ho 3.10	Non-filmed technique	14	14	4	-0.7071	0.2389	NS
Ho 3.11	Standard Taper Glass	17	11	1	-1.7497	0.0401	**0.05
	Cost per item per student						
Ho 3.12	all experiments	17	11	1	-1.7497	0.0401	**0.05
Ho 3.13	direct filmed technique	16	12	2	-1.4142	0.0793	**0.10
Ho 3.14	indirect filmed technique	18	10	0	-2.1213	0.0170	**0.02
Ho 3.15	Non-filmed technique	12	16	6	0.0000	0.5000	NS
Ho 3.16	Standard Taper Glass	13	15	5	-0.3536	0.3632	NS
	Cost per item broken						
Ho 3.17	all experiments	16	12	2	-1.4142	0.0793	**0.10
Ho 3.18	direct filmed technique	16	12	2	-1.4142	0.0793	**0.10
Ho 3.19	indirect filmed technique	17	11	1	-1.7497	0.0401	**0.05
Ho 3.20	Non-filmed technique	13	15	5	-0.3536	0.3632	NS
Ho 3.21	Standard Taper Glass	11	17	(5)	+0.3536	0.6368	NS

\+ indicates Z in favor of control group

\- indicates Z in favor of experimental group

These hypotheses were tested using the Mann Whitney U test. Table XLIX summarizes the results of these tests. It was found that each of the criteria tested for the non-filmed technique experiments resulted in no significant difference. This was expected from groups which were randomly divided. The mean breakage per student for all experiments as well as the direct and indirect filmed technique experiments also resulted in no significant difference. However the mean number of items of standard taper glassware was significantly lower for the experimental group. Comparison of the average cost per item broken per student attending class and the overall mean cost per item broken resulting in a significant difference in favor of the control group.

The question of lack of randomness of the female students required that it be determined if any differences in breakage may be attributed to the female students. The following hypotheses were considered.

Ho 3.22 There will be no significant differences in the mean cost of equipment broken by female students between the experimental and control groups.

Ho 3.23 There will be no significant differences in the mean number of items of equipment broken per female attending class between the experimental and control group.

Ho 3.24 There will be no significant difference in the cost per item broken per female attending class between the experimental and control groups.

Ho 3.25 There will be no significant difference in the cost of breakage per female attending class between the experimental and control groups.

TABLE L

EQUIPMENT BREAKAGE BY FEMALE STUDENTS

	100	200	300	400	500	600	700
Cost of Breakage	$14.38	4.04	4.86	0.82	---	11.28	5.09
Number of items broken	5	9	4	2	---	2	1
Number of females per group	2	7	6	2	0	4	2
Cost per item broken (rank)	$2.876 (2)	0.4489 (5)	1.210 (4)	0.410 (6)	---	2.820 (3)	5.090 (1)
Number of items broken per female attending class (rank)	2.5 (1)	1.2857 (2)	0.667 (4)	1.00 (3)	---	0.50 (5.5)	0.50 (5.5)
Cost per item broken per female (rank)	1.438 (2)	0.0641 (6)	0.2025 (5)	0.2050 (4)	---	1.410 (3)	2.545 (1)
Cost of breakage per female attending class (rank)	7.190 (1)	0.5771 (5)	0.8100 (4)	0.4100 (6)	---	2.820 (2)	2.540 (3)

TABLE LI

SUMMARY OF STATISTICAL ANALYSIS OF BREAKAGE BY FEMALE STUDENTS

	Sum of Exptl	ranks Contl	U	Z	prob.	Signif.
Cost per item broken by females	11	10	4	-0.2182	0.4129	NS
Ho 3.22 not rejected						
Number of items broken per female attending class	7	14	(1)	+1.5276	0.0630	**
Ho 3.23 rejected in favor of control group						
Cost per item broken per female attending class	13	8	2	1.0911	0.1379	NS
Ho 3.24 not rejected						
Cost of breakage per female attending class	10	11	(4)	+0.2182	0.4129	NS
Ho 3.25 not rejected						

Thus it can be seen that there is no significant difference between the breakage of females in three out of four measures. Only the number of items broken per female resulted in significance, however, it is in favor of the control group. This means that those differences which were found in favor of the experimental group may be attributed to the treatments and not to the slight imbalance of females in the experimental group.

The overall results of the breakage study indicate that a smaller percentage of students who have access to the single concept films have indicents of breakage. Those students who have access to the films break fewer items of standard taper glassware and incur less breakage as the course progresses. The use of the films when a technique is first encountered lessens the amount of breakage when the technique is used at a later time in the course.

Accidents

Safe procedures need to be stressed in all laboratories but more especially in the undergraduate teaching laboratories because the students are more unaware of the many potentially hazardous situations. It is not unvommon for at least one student to be spashed or sprayed with sulfuric acid or perhaps showered with glass particles during every semester. In the organic laboratories safety must be stressed because of the many extremely toxic and explosive chemicals which are routinely handled. Goggles were mandatory in the organic laboratories whereas any kind of spectacles were allowed in the general laboratories. (This was changed at the beginning of the Fall 1969 semester when safety goggles became mandatory for all undergraduate laboratories.) It is a departmental policy that any student having any injury or accident must report it to his instructor. However, it is suspected that a great many minor cuts and acid burns go unreported. Students were asked to indicate on the data cards any accidents which they incurred during the experiment and to include a brief description. Surprisingly no serious accidents occurred in any of the classes used for this study. Thus, if one considers that all of the accidents which did occur (such as minor cuts, heat and acid burns, spilled sulfuric acid, minor fires)

TABLE LII

TABULATION OF NUMBER AND KIND OF ACCIDENTS REPORTED BY THE EXPERIMENTAL AND CONTROL GROUP CLASSES

Experiment Number	Group 100	Group 200	Group 300	Group 400	Group 500	Group 600	Group 700
2						608 cut 612 burned finger	
5	123 burned finger			405 Na expl. 421 Na expl.		611 burned finger	
6			307 burned thumb 317 burned thumb				707 burned thumb
13							703 burned finger 704 cut thumb
11		203 burned finger 206 burned finger 215 spilled sulfuric					
MEK					501 splashed acid 517 spilled sulfuric	617 burned finger	
17			314 burned finger				
20						601 burned finger 616 cut finger	
MDNB	112 small fire						
29			308 H_2O in $ClSO_3OH$				
Total number of accidents per group:	2	3	4	2	2	6	3
Number of students per group: (total number in attendance)	444	470	440	431	339	384	429
Number of students attending per accident occurring:	222	156.67	110.0	215.5	169.5	64.0	143.0

TABLE LII (Continued)

Experiment Number	Group 100	Group 200	Group 300	Group 400	Group 500	Group 600	Group 700
Rank	1	4	6	2	3	7	5
Sum of ranks:			11		17		

U = 5, Z = -0.3536, probability = 0.3632 (not significant) Ho 4.01 not rejected then the following hypotheses can be tested.

Ho. 4.01 There will be no significant difference in the number of accidents occurring between the experimental group and the control group.

TABLE LIII

CHI SQUARE ANALYSIS OF STUDENTS ATTENDING CLASS PER ACCIDENT BY TEACHER AND TREATMENT

	Teacher A	Teacher B	Teacher C	Totals
Experimental				
observed	222.0	156.7	110.0	488.7
(expected)	(228.0)	(170.0)	(90.7)	
Control				
observed	215.5	169.5	64.0	449.0
(expected)	(209.5)	(156.2)	(83.3)	
Totals	437.5	326.2	174.0	937.7

X^2 = 11.0812 (df = 2) *significant at 0.01 level Ho 4.02 rejected

Thus it is found that there is no significant difference in the number of accidents occurring between the experimental and control groups. However, the rank of the students per accident for an experimental class is superior to the control class for a given teacher in two out of three instances. It was suspected that the teacher has an effect upon the number of accidents occurring. This question generated the following null hypothesis.

Ho 4.02 There will be no significant difference in the number of students per accident occurring between the experimental and control groups for a given teacher.

Ho 4.02 was found to be untenable and was rejected. Thus the number of accidents occurring among the teachers is not random. It may be seen from Table LIII that in two out of three cases the observed number of students attending class per accident is less than the expected value for the experimental group. While this does not conclusively indicate that less accidents occur in the experimental group it indicates a definite tendency in that direction.

Laboratory Skill Survey

The laboratory skill survey profile was administered upon commencing and concluding the semester. It was determined whether students accurately indicate their skill in laboratory procedures or do those who possess a high degree of competancy tend to estimate their skill conservatively and those who possess a meagre degree of competency tend to be more liberal in their rating. Using the JH_2S examination scores as a measure of the laboratory skills because it covered some of the same techniques as a measure of the laboratory skills involved, the following hypotheses were tested.

Ho 5.01 There will be no significant difference in correlation between the JH_2S scores and the Entry skills for each of the classes.

Ho 5.02 There will be no significant difference in the correlation between the JH_2S scores and the Exit skills for each of the classes.

TABLE LIV

TABULATION OF RANKS OF SCORES AND RANK DIFFERENCES BETWEEN THE JH_2S EXAMINATION AND THE RESULTS OF THE LABORATORY SKILL PROFILE FOR GROUP 100

Group 100 Student Nr.	Rank on JH_2S	Entry Skills Rank	Rank Diff	Exit Skills Rank	Rank Diff	Net Skill Change Rank	Rank Diff
1	16	16	0	20	- 4	17	- 1
2	14	2	12	13	1	19	- 5
3	-	-	-	-	-	-	-
4	13	4	11	1	12	2	11
5	16	19	4	14	2	6	10
6	11	7	4	10	1	12	- 1
7	-	-	-	-	-	-	-
8	-	-	-	-	-	-	-
9	4	11	- 7	2	2	1	3
10	20	18	2	15	5	11	9
11	6	13	- 7	5	1	7	- 1
12	-	-	-	-	-	-	-
13	18	1	17	18	0	20	- 2
14	19	17	2	7	12	4	15
15	1	20	-19	11	-10	13	-12
16	6	16	-10	19	-13	16	-13
17	6	5	1	16	-13	18	-12
18	2.5	8	- 5.5	12	9.5	14	-11.5
19	16	10	6	9	6	10	4
20	2.5	6	- 3.5	6	- 3.5	9	6.5
21	12	12	0	4	8	3	9
22	8.5	14	- 5.5	17	8.5	15	- 6.5
23	8.5	3	5.5	3	4.5	5	3.5
24	12	9	3	8	4	8	4

Sum of squares of rank differences:	1295	1089	1367
Spearman rank correlations:	r_s = 0.0263	0.1812	-0.0278

TABLE LV

TABULATION OF RANKS OF SCORES AND RANK DIFFERENCES BETWEEN THE JH_2S EXAMINATION AND THE RESULTS FROM THE LABORATORY SKILL PROFILE FOR GROUP 200

Group 200 Student Nr.	Rank on JH_2S	Entry Skills Rank	Rank Diff	Exit Skills Rank	Rank Diff	Net Skill Change Rank	Rank Diff
1	3.5	7	- 3.5	13	- 9.5	12	- 8.5
2	21	21	0	18	3	18	3
3	22	11	11	15.5	6.5	17	5
4	10	19.5	- 9.5	19	- 9	20	-10
5	-	-	-	-	-	-	-
6	14	15	5	1	13	1	13
7	6.5	22	-15.5	21	14.5	19	12.5
8	-	-	-	-	-	-	-
9	14	14	0	11	3	8	6
10	-	-	-	-	-	-	-
11	6.5	5	1.5	9	2.5	9	2.5
12	20	1	19	2	18	14	6
13	6.5	4	2.5	8	1.5	10	3
14	3.5	19.5	-16	17	-13.5	16	12
15	2	18	-16	14	-12	7	5
16	16.5	3	13.5	3	13.5	5	10.5
17	14	16.5	- 2.5	15.5	- 1.5	13	1
18	10	9.5	0.5	12	- 2	11	- 1
19	18.5	14	4.5	5	13.5	3	15.5
20	12	16.5	- 4.5	10	2	6	6
21	6.5	6	0.5	7	1.5	4	2.5
22	18.5	8	10	4	14.5	2	16.5
23	1	2	- 1	6	- 5	15	-14
24	10	17	- 7	22	12	22	-12
25	16.5	9.5	11	20	3.5	21	4.5
Sum of squares of rank differences:			1870.75		2038		1815
Spearman rank correlations:			r_s = -0.0563		-0.1508		-0.0248

TABLE LVI

TABULATION OF RANKS OF SCORES AND RANK DIFFERENCES BETWEEN THE JH_2S EXAMINATION AND THE RESULTS FROM THE LABORATORY SKILL PROFILE FOR GROUP 300

Group 300 Student Nr.	Rank on JH_2S	Entry Skills Rank	Rank Diff	Exit Skills Rank	Rank Diff	Net Skill Change Rank	Rank Diff
1	5	3	2	13	- 8	16	-11
2	14.5	1	13.5	9	5.5	20	- 5.5
3	14.5	7	6.5	2	12.5	3	11.5
4	-	-	-	-	-	-	-
5	7.5	19	-11.5	19	11.5	14	6.5
6	3.5	4	- 0.5	17	13.5	18	14.5
7	-	-	-	-	-	-	-
8	7.5	10	- 2.5	14	- 6.5	13	- 5.5
9	7.5	8	- 0.5	8	- 0.5	9	- 1.5
10	20	6	14	18	2	19	1
11	14.5	20	- 5.5	1	13.5	1	13.5
12	7.5	11	- 3.5	5	2.5	5	2.5
13	14.5	5	9.5	6	8.5	10	5.5
14	11.5	15.5	- 4	10	1.5	6	5.5
15	17	18	- 1	7	10	4	13
16	2	12	-10	16	-14	15	-13
17	11.5	9	2.5	11	0.5	11	0.5
18	-	-	-	-	-	-	-
19	1	13	-12	15	-14	12	-11
20	10	14	4	3	7	2	8
21	3.5	15.5	-12	20	-16.5	17	13.5
22	19	17	2	12	7	7.5	11.5
23	18	2	16	4	14	7.5	10.5
24	-	-	-	-	-	-	-

Sum of squares of rank differences:	1397.2	1933	1766.5
Spearman rank correlation:	r_s = -0.0508	-0.4534	-0.3282

TABLE LVII

TABULATION OF RANKS OF SCORES AND RANK DIFFERENCES BETWEEN THE JH_2S EXAMINATION AND THE RESULTS FROM THE LABORATORY SKILL PROFILE FOR GROUP 400

Group 400 Student Nr.	Rank on JH_2S	Entry Skills Rank	Rank Diff	Exit Skills Rank	Rank Diff	Net Skill Change Rank	Rank Diff
1	7	19	-12	19	-12	19	-12
2	18	9.5	8.5	1	17	1	17
3	-	-	-	-	-	-	-
4	4.5	3	1.5	3.5	1	10	- 5.5
5	3	14	-11	18	-15	18	-15
6	2	17	-15	10	- 8	6	- 4
7	-	-	-	-	-	-	-
8	14.5	6	9.5	16	- 1.5	16	- 1.5
9	4.5	9.5	5	12	- 7.5	9	- 4.5
10	11.5	12	- 0.5	15	- 3.5	14	- 2.5
11	18	4	14	3.5	14.5	4	14
12	1	16	-15	9	- 8	3	- 2
13	15.4	15	- 0.5	2	12.5	12	2.5
14	-	-	-	-	-	-	-
15	7	5	2	13	- 6	11	4
16	11.5	13	- 1.5	11	0.5	8	3.5
17	18	18	0	14	4	7	11
18	7	8	- 1	8	- 1	5	2
19	16	7	11	5	11	2	14
20	11.5	1.5	10	6.5	5	13	- 1.5
21	-	-	-	-	-	-	-
22	9	1.5	7.5	6.5	2.5	15	6
23	11.5	11	0.5	17	5.5	17	- 5.5
24	-	-	-	-	-	-	-
Sum of squares of rank differences:			1368		1460		1357
Spearman rank correlation:			$r_s = -0.2000$		-0.2809		-0.1904

TABLE LVIII

TABLULATION OF RANKS OF SCORES AND RANK DIFFERENCES BETWEEN THE JH_2S EXAMINATION AND THE RESULTS FROM THE LABORATORY SKILL PROFILE FOR GROUP 500

Group 500 Student Nr.	Rank on JH_2S	Entry Skills Rank	Rank Diff	Exit Skills Rank	Rank Diff	Net Skill Change Rank	Rank Diff
1	4.5	7	- 2.5	6	- 1.5	8	- 3.5
2	8	1	7	4.5	3.5	11	- 3
3	11	4	7	2	9	4	7
4	8	2.5	5.5	7.5	0.5	9.5	- 1.5
5	8	2.5	5.5	7.5	0.5	9.5	- 1.5
6	-	-	-	-	-	-	-
7	2	11	- 9	11	- 9	7	5
8	-	-	-	-	-	-	-
9	-	-	-	-	-	-	-
10	3	10	- 7	4.5	- 1.5	2	1
11	13	8	5	9	4	6	7
12	-	-	-	-	-	-	-
13	8	5	3	12	4	13	5
14	4.5	13	- 8.5	10	5.5	5	1.5
15	13	6	7	3	10	3	10
16	-	-	-	-	-	-	-
17	13	14	- 1	14.5	- 0.5	12	1
18	8	9	- 1	1	7	1	7
19	-	-	-	-	-	-	-
20	1	12	-11	13.5	-12.5	14	-13
21	-	-	-	-	-	-	-
22	-	-	-	-	-	-	-
23	-	-	-	-	-	-	-
24	-	-	-	-	-	-	-
Sum of squares of rank differences:			573		547		496
Spearman rank correlation:			r_s = -0.2593		-0.2022		-0.0901

TABLE LVIX

TABULATION OF RANKS AND SCORES AND RANK DIFFERENCES BETWEEN THE JH_2S EXAMINATION AND THE RESULTS FROM THE LABORATORY SKILL PROFILE FOR GROUP 600

Group 600 Student Nr.	Rank on JH_2S	Entry Skills Rank	Rank Diff	Exit Skills Rank	Rank Diff	Net Skills Change Rank	Rank Diff
1	3.5	13	- 9.5	14.5	-11	15	-11.5
2	12.5	17.5	- 5	13	- 0.5	11	1.5
3	3.5	2	1.5	19	-15.5	19	15.5
4	15.5	17.5	- 2	17	- 1.5	15	1.5
5	14	4	10	5	9	6	8
6	7	16	- 9	6	1	3	4
7	7	11.5	- 4.5	16	- 9	16	- 9
8	3.5	6	- 2.5	1	2.5	4	- 0.5
9	-	-	-	-	-	-	-
10	3.5	3	0.5	18	-14.5	18	-14.5
11	19	14	5	10	9	8	11
12	15.5	11.5	4	12	3.5	12.5	3
13	17	10	7	9	8	9	8
14	10.5	1	9.5	3	7.5	10	0.5
15	18	19	1	4	14	1	17
16	1	8	- 7	11	-10	12.5	-11.5
17	9	5	4	7	2	7	2
18	10.5	8	2.5	2	8.5	2	8.5
19	-	-	-	-	-	-	-
20	12.5	15	2.5	8	2.5	5	7.5
21	7	15	2.5	8	2.5	5	7.5
Sum of squares of rank differences:			589		1421.5		1596.5
Spearman rank correlation:			r_s = +0.4833		-0.2469		-0.4004

TABLE LX

TABULATION OF RANKS AND SCORES AND RANK DIFFERENCES BETWEEN THE JH_2S EXAMINATION AND THE RESULTS FROM THE LABORATORY SKILL PROFILE FOR GROUP 700

Group 700 Student Nr.	Rank on JH_2S	Entry Skills Rank	Rank Diff	Exit Skills Rank	Rank Diff	Net Skills Change Rank	Rank Diff
1	3.5	18	-14.5	5	- 1.5	3	0.5
2	15.5	15.5	0	18	- 2.5	16	- 0.5
3	-	-	-	-	-	-	-
4	6	12	- 6	6	0	4	2
5	15.5	13	2.5	3	12.5	2	13.5
6	18.5	3	15.5	8	10.5	6.5	12
7	10	15.5	- 5.5	16	- 6	14	- 4
8	6	19	-13	1	5	1	5
9	3.5	15.5	-12	14	-10.5	8.5	- 5
10	10	2	8	7	3	12	- 2
11	-	-	-	-	-	-	-
12	-	-	-	-	-	-	-
13	15.5	1	14.5	4	11.5	13	2.5
14	12.5	15.5	- 3	10	2.5	5	7.5
15	20	20	0	2	18	18	2
16	8	4	4	15	- 7	15	- 7
17	10	10.5	- 0.5	19	- 9	19	- 9
18	1	10.5	- 9.5	13	-12	10.5	- 9.5
19	15.5	8	7.5	20	- 4.5	20	- 4.5
20	18.5	8	7.5	17	1.5	17	1.5
21	6	8	- 2	12	- 6	10.5	- 4.5
22	2	5	- 3	9	- 7	6.5	- 4.5
23	12.5	6	6.5	11	0.5	8.5	4
Sum of squares of rank differences:			1393.5		1299.5		766.5
Spearman rank correlation:		r_s = -0.0477			+0.0229		+0.4237

TABLE LXI

SUMMARY OF RESULTS FROM SPEARMAN RANK CORRELATIONS BETWEEN JH_2S EXAMINATION AND LABORATORY SKILLS PROFILE

Hypothesis Descriptions			Ho 4.01 Entry Skills		Ho 4.02 Exit Skills		Ho 4.03 Net Change in Skills	
Group	N	df	r_s	t	r_s	t	r_s	t
100	20	18	+0.0263	+0.1116 NS	+0.1812	+0.7817 NS	-0.0278	-0.1180 NS
200	22	20	-0.0563	-0.2522 NS	0.1508	-0.6822 NS	-0.0248	-0.1109 NS
300	20	18	-0.0508	-0.2158 NS	-0.4534	-2.1582 **sig at 0.05	-0.3282	-1.474 NS
400	19	17	-0.2000	-0.8416 NS	-0.2807	-1.2058 NS	-0.1904	-0.7997 NS
500	14	12	-0.2593	-0.9300 NS	-0.2022	-0.7152 NS	-0.0901	-0.3134 NS
600	19	17	+0.4833	+2.2762 **sig at 0.05	-0.2469	-1.0505 NS	-0.4004	-1.8016 **sig at 0.10
700	20	18	-0.0477	-0.2026 NS	+0.0229	+0.0972 NS	+0.4237	+1.9845 **sig at 0.10

Ho 5.03 There will be no significant difference in the correlation between the JH_2S scores and the net skill change for each of the classes.

Tables LIV through LX and the results summarized in Table LXI indicate the ranks, and rank difference of the scores as taken from the data in Appendix B.

Thus it was observed that the majority (16 out of 21) of the correlations are negative (whether significant or not) and that in the four cases which are significant at the 0.10 level two are positive and two negative. Thus while the three null hypotheses are tenable, the suspicion that the students do not accurately access their degree of laboratory proficiency is confirmed.

Attitude

The attitude or the feeling of like or dislike with which the student felt toward the experiments was tested by selecting ten of the experiments, five of which involved direct filmed techniques (2,3,4,5, and 13). Of the other five, one involved no filmed techniques (16) and the other four (11,17,26,35) involved indirect filmed techniques. These were chosen rather than some of the others because all ten of these experiments were in Coleman, Wawzonek, and Buckles (22) the laboratory manual for the course. Some of the other experiments such as the preparation of meta-dinitro benzene and methyl ethyl ketone were mimeographed by the department and were written in a different style. The change of style and format for these experiments would provide a confounding variable.

The attitude scale utilized nine categories and a Likert-type scale response for each. The identical scale was used for all of the ten selected experiments. See Appendix E for a copy of the attitude scale questionnaire. A compliation of frequencies of the responses for each category was made for each subsection. This information is compiled in Appendix F. From these data the median ($S_{.50}$) was calculated according to Edwards (25). In order to estimate the reliability of the instrument, the interquartile range (Q) was also determined. Thorndike (25) has reported that a large Q value is related either to the ambiguity of the question or to misinterpretation by the responder. Thus, those factors which yield a high Q value may be eliminated. Appendix E contains the frequency of responses for each item on each experiment by subsection. The data also includes the computation of $S_{.50}$ and Q for each item as well as the total and mean values of $S_{.50}$ for each experiment. Because the scale ranged from zero for a high or positive response to ten for a low or negative response, it was felt that these results could be easily misinterpreted. The S values used in the body of the paper for all computations was determined by subtracting the calculated $S_{.50}$ value from ten to yield a quantity which would be higher for a positive attitude.

When the experimental framework for this study is considered, the following questions pertaining to the attitude of the students become important. The differences in the overall attitude toward the experiments between the experimental and control groups. The influence of the teacher upon the attitude of the students toward the experiments (not the course). The influence of the time of day upon the attitude of the students toward the experiments. The difference in attitude, if any, between those experiments in which laboratory techniques are initially encountered and explained by demonstration or SCLF (i.e., direct filmed technique experiments) and those later experiments in which the students are expected that they will be able to use these same techniques without further explanation (i.e., indirect filmed technique experiments). The difference, if any, between the attitude of the students in the experimental and control groups for the direct filmed technique experiments and for the indirect filmed technique experiments.

These may be directed toward any or all of the parameters of the attitude scale. Specifically this study is concerned with laboratory techniques consequently the attitude of the students toward techniques and their difficulty was of prime interest. The difficulty level of the techniques corresponds to items E, F, G, and H on the attitude scale.

These problems generated the following set of null hypotheses.

Ho 6.01 There will be no significant difference in the attitude of the students toward the selected experiments among the teachers, type of experiment, and by treatment.

Ho 6.02 There will be no significant difference in the attitude of the students toward the selected experiments between the teachers.

Ho 6.03 There will be no significant difference in the attitude of the students toward the selected experiments between the experimental and control groups.

Ho 6.04 There will be no significant difference in the attitude of the students toward the selected experiments between the direct filmed technique experiments and the indirect filmed technique experiments.

Ho 6.05 There will be no significant difference in the attitude of the students toward the selected experiments between the sections (time of day for the experiment).

Ho 6.06 There will be no significant difference in the attitude of the students toward the selected experiments between the teacher and treatment (each group).

Ho 6.07 There will be no significant difference in the attitude of the students toward the selected experiments between the experiment type and treatment.

These hypotheses were tested utilizing the Kruskal-Wallis One Way Analysis of Variance. Table LXII contains a compilation of the data from Appendix F and Table LXIII contains a summary of the analysis of the hypotheses.

These results show that there was no significant difference in the attitude toward the experiments between the students of the experimental group and the control group. This resulted from the distribution of the students between treatment groups as well as the Hawthorne effect being equalized or nonexistent. There is no significant difference in the attitude of the students between the four teachers or the section times. However significant differences were found between the type of experiment (0.01 level in favor of the direct filmed technique experiments) and also among the factors between experimental, control, direct filmed technique and indirect filmed technique.

The analysis by the Kruskal-Wallis test does not indicate the direction or location of the significance but only the existence and level of significance. Consequently it was necessary to analyze the data further. The following null hypotheses were considered.

Ho 6.08 There will be no significant difference in the attitude of the students toward the selected experiments between the direct and indirect experiments of the experimental group and the direct and

TABLE LXII

MEAN OF $S_{.50}$ VALUES AND RANK ORDER FOR OVERALL ATTITUDE OF STUDENTS TOWARD THE SELECTED EXPERIMENTS

	#2	#3	#4	#5	#13	
100	6.0963 (29)	6.1134 (31)	6.3655 (53)	5.7063 (14)	5.8940 (21)	148
200	6.6996 (63)	6.3650 (51)	6.1925 (38)	6.1524 (34)	6.2833 (46)	232
300	6.5397 (59)	6.3824 (54)	6.1739 (37)	6.1697 (36)	6.7055 (64)	250
sub-total for experimental group and direct filmed technique						630
400	6.5470 (60)	6.3652 (52)	6.5698 (61)	5.7823 (17)	6.0353 (27)	217
500	6.2444 (43)	6.1296 (32)	6.0981 (30)	5.5325 (4)	5.8129 (18)	127
600	6.8459 (67)	6.9074 (69)	6.9166 (70)	6.3000 (49)	6.1932 (39)	294
700	6.7924 (66)	6.1637 (35)	6.8899 (68)	5.4995 (2)	6.3378 (50)	221
sub total for control group and direct filmed technique experiments						859
total for all groups and direct filmed technique experiments						1489
	#11	#16	#17	#26	#35	
100	5.5521 (6)	5.8495 (19)	6.2972 (48)	5.8909 (20)	6.7296 (45)	138
200	5.6688 (12)	6.4912 (57)	5.5026 (3)	5.9225 (22)	6.2181 (41)	135
300	5.6283 (9)	6.6405 (62)	5.6558 (11)	5.9378 (24)	6.2592 (44)	150
sub-total for experimental group and indirect filmed technique						423
400	5.7681 (16)	6.1438 (33)	5.9883 (25)	6.0371 (28)	6.1979 (40)	142
500	5.2796 (1)	5.5426 (5)	5.6032 (7)	5.7483 (15)	6.2926 (47)	75
600	5.9701 (26)	6.4000 (55)	5.9289 (23)	6.6333 (10)	6.5122 (58)	172
700	6.4604 (56)	5.7562 (65)	5.6987 (13)	6.6260 (8)	6.2307 (42)	184
Sub-total for control group and indirect filmed technique experiments						573
total for all groups and indirect filmed technique experiments						996
Grand total for all rankings						2485

( ) indicates rank order

TABLE LXIII

ANALYSIS OF ATTITUDES TOWARD SELECTED EXPERIMENTS BY KRUSKAL-WALLIS ONE WAY ANALYSIS OF VARIANCE

Teacher, Treatment, Type:							
Group:	100	200	300	400	500	600	700
Sum of ranks							
Direct:	148	232	250	217	127	294	221
Nr items ranked:	5	5	5	5	5	5	5
Indirect:	138	135	150	142	75	172	184
Nr items ranked:	5	5	5	5	5	5	5

H = 20.1461 df = 13 ** significant at 0.10 level
Ho 6.01 rejected

Teacher:	A	B	C	D
Sum of ranks:	645	569	866	405
Nr items ranked	20	20	20	10

H = 5.1350 df = 3 NS
Ho 6.02 not rejected

Treatment:	Experimental	Control
Sum of ranks:	1053	1432
Nr items ranked:	30	40

H = -1.2578 df = 1 NS
Ho 6.03 not rejected

Experiment type:	Direct	Indirect
Sum of ranks:	1489	996
Nr items ranked:	35	35

H = 7.0551 df = 1 ** significant at 0.01 level
Ho 6.04 rejected

Time of Day (Sections)	1:MW 1:30	2:TuThu11:30	3:TuThu 2:30
Sum or ranks:	954	726	805
Nr items ranked:	30	20	20

H = 0.8214 df = 2 NS
Ho 6.05 not rejected

Class (Teacher and Treatment)							
	100	200	300	400	500	600	700
Sum of ranks:	286	376	400	359	202	466	405
Nr items ranked:	10	10	10	10	10	10	10

H = 9.5642 df = 6 NS
Ho 6.06 not rejected

Type and Treatment	Experimental		Control	
	Direct	Indirect	Direct	Indirect
Sum of ranks:	630	423	895	573
Nr items ranked	15	15	20	20

H = 7.0778 df = 3 ** significant at 0.10 level
Ho 6.07 rejected

TABLE LXIV

RANK ORDER OF ATTITUDES TOWARD THE SELECTED EXPERIMENTS BY EXPERIMENT TYPE

	Direct Filmed Technique						Indirect Filmed Technique					
Group:	2	3	4	5	13		11	16	17	26	35	
100	8	10	24	3	6	51	4	14	29	15	27	89
200	29	22	16	12	19	98	10	32	2	16	24	84
300	26	25	15	24	30	110	7	34	9	18	26	94
Experimental Total						(259)						(267)
400	27	23	28	4	7	89	13	22	19	21	23	98
500	18	11	9	2	5	45	1	3	5	12	28	49
600	32	34	35	20	17	138	20	30	17	8	33	108
700	31	13	33	1	21	99	31	35	11	6	25	108
Control Total						(371)						(363)

TABLE LXV

ANALYSIS OF ATTITUDE TOWARD THE SELECTED EXPERIMENTS BETWEEN EXPERIMENTAL AND CONTROL GROUPS AND BY EXPERIMENT TYPE BY MANN-WHITNEY U TEST

Group	Type	Overall Rank Sum	Rank Sums Direct Only	Indirect Only
100	Direct	148	51	
100	Indirect	138		89
200	Direct	232	98	
200	Indirect	135		84
300	Direct	250	110	
300	Indirect	150		94
400	Direct	217	89	
400	Indirect	142		98
500	Direct	127	45	
500	Indirect	75		49
600	Direct	294	138	
600	Indirect	172		108
700	Direct	221	99	
700	Indirect	194		108

Rank Sum: Experimental: 1053
Control: 1432
U = 588
Z = 0.1424
P = 0.4443 NS
Ho 6.08 not rejected

Rank Sum: Direct: 1272
Indirect: 996
U = 583
Z = 0.3465
P = 0.3669 NS
Ho 6.09 not rejected

Rank Sum Direct Only: Experimental: 259
Control: 371
U = 139
Z = 0.3667
P = 0.3557 NS
Ho 6.10 not rejected

Rank Order Indirect Only: Experimental: 267
Control: 363
U = 147
Z = 0.1000
P = 0.4602 NS
Ho 6.11 not rejected

indirect experiments of the control group.

Ho 6.09 There will be no significant difference in the attitude of the students toward the selected experiments between the direct experiments of the experimental and control group and the indirect experiments of the experimental group and the control group.

Ho 6.10 There will be no significant difference in the attitude of the students toward the selected direct filmed technique experiments between the experimental and control group.

Ho 6.11 There will be no significant difference in the attitude of the students toward the selected indirect filmed technique experiments between the experimental and the control group.

These hypotheses were tested by means of the Mann-Whitney U test upon data taken from Tables LXII and LXIV. The analysis and results are summarized in Table LXV.

The results from these analyses confirmed the previous hypotheses in that there indeed is no significant difference between the treatment groups in over all attitude toward the difficulty level. The result that there is a significant difference in attitude in favor of the direct filmed technique experiments both toward the experiments as a whole and toward the difficulty level was confirmed. However, it should be noted that neither treatment group significantly favored the direct filmed technique experiments nor did either treatment group favor the indirect filmed technique experiments.

The next step was to consider the attitude of the students toward the techniques involved in the experiments as well as their respective difficulty. Consequentally the following hypotheses correspond to those previously considered with respect to the overall attitude toward the experiments.

Ho 6.12 There will be no significant difference in the attitude of the students toward the laboratory techniques and their difficulty with respect to the selected experiments among the teachers, experiment type, and treatments.

Ho 6.13 There will be no significant difference in the attitude of the students toward the laboratory techniques and their difficulty with respect to the selected experiments among the teachers.

Ho 6.14 There will be no significant difference in the attitude of the students toward the laboratory techniques and their difficulty with respect to the selected experiments between the experimental and control groups.

Ho 6.15 There will be no significant difference in the attitude of the students toward the laboratory techniques and their difficulty with respect to the selected experiments between the direct filmed technique experiments and the indirect filmed technique experiments.

Ho 6.16 There will be no significant difference in the attitude of the students toward the laboratory techniques and their difficulty with respect to the selected experiments between the sections (time of day for the experiment).

Ho 6.17 There will be no significant difference in the attitude of the students toward the laboratory techniques and their difficulty with respect to the selected experiments between the subsections (teacher and treatment groups).

Ho 6.18 There will be no significant difference in the attitude of the students toward the laboratory techniques and their difficulty with respect to the selected experiments between the experiment type and the treatment.

These hypotheses were also tested utilizing the Kruskal-Wallis One Way Analysis of Variance. Table LXVI contains a compilation of the data from Appendix F and Table LXVII contains a summary of the analysis of the hypotheses.

These results also show that there was no significant difference in the attitude of the student between the experimental and control groups. There was also no significant difference found between the teachers, or the time of day for the experiment. However again a difference was found between the attitude toward the first experiments encountered (direct filmed technique experiments) and the later experiments (indirect filmed technique experiments).

In order to determine the direction and degree to which these differences lie, the following null hypotheses were considered.

Ho 6.19 There will be no significant difference in the attitude of the students toward the laboratory techniques and their difficulty with respect to the selected experiments between the direct and indirect experiments of the experimental group and the direct and indirect experiments of the control group.

Ho 6.20 There will be no significant difference in the attitude of the students toward the laboratory techniques and their difficulty with respect to the selected experiments between the direct filmed technique experiments of the experimental and control groups and the indirect filmed technique experiments of the experimental and control groups.

TABLE LXVI

MEAN OF $S_{.50}$ VALUES AND RANK ORDER OF ATTITUDE TOWARD THE DIFFICULTY OF THE LABORATORY TECHNIQUES FOR THE SELECTED EXPERIMENTS

	#2	#3	#4	#5	#13	
100	5.4607 (28)	5.6686 (54)	5.4391 (35)	5.2364 (17)	5.3612 (29)	163
200	6.5918 (50)	5.7550 (60)	5.6458 (53)	5.5583 (47)	5.4479 (36)	246
300	6.3502 (38)	5.7372 (58)	5.7827 (61)	5.5297 (44)	5.1815 (13)	214
	sub-total for experimental group and direct filmed technique					633
400	6.5418 (46)	5.6419 (52)	5.7186 (57)	5.3208 (25)	5.2349 (16)	196
500	5.9584 (65)	5.8334 (62)	5.5166 (42)	5.1043 (9)	5.0707 (7)	185
600	6.7102 (69)	6.4166 (68)	5.9048 (64)	5.8750 (63)	5.2433 (20)	284
700	7.0000 (70)	6.2529 (67)	5.9732 (66)	5.1418 (12)	5.4972 (41)	256
	sub-total for control group and direct filmed techniques					923
total for both groups and direct filmed technique experiments						1556
	#11	#16	#17	#26	#35	
100	5.0024 (5)	5.3903 (30)	5.7499 (59)	5.4941 (40)	5.4048 (31)	165
200	5.3157 (24)	5.4885 (39)	5.7172 (56)	5.5251 (43)	5.2738 (22)	184
300	5.4118 (33)	5.7160 (55)	5.2448 (21)	5.5595 (48)	5.3402 (27)	184
	sub-total for control g r oup and indirect filmed techniques					533
400	5.0750 (8)	5.2871 (23)	5.3331 (26)	5.4286 (34)	5.6389 (51)	142
500	5.1292 (11)	4.8875 (2)	5.2184 (15)	5.2418 (19)	5.0335 (6)	53
600	4.9687 (3)	5.4625 (37)	5.5311 (45)	5.0000 (4)	5.2082 (14)	103
700	5.1167 (10)	5.5896 (49)	5.4076 (32)	4.8419 (1)	5.2370 (18)	110
	Sub-total for control group and indirect filmed techniques					408
Total for both groups and indirect filmed technique experiments						941
Grand Total for all rankings						2485

( ) indicates rank order

TABLE LXVII

ANALYSIS OF ATTITUDES TOWARD THE DIFFICULTY OF THE LABORATORY TECHNIQUES INVOLVED IN THE SELECTED EXPERIMENTS BY KRUSKAL-WALLIS ONE WAY ANALYSIS OF VARIANCE

Teacher, Treatment Type:							
Group:	100	200	300	400	500	600	700
Sum of ranks							
Direct:	163	246	214	196	185	284	256
Nr items ranked:	5	5	5	5	5	5	5
Indirect:	165	184	184	142	53	103	110
Nr items ranked:	5	5	5	5	5	5	5

H = 23.3198 df = 13 ** significant at 0.05 level
Ho 6.12 rejected

Teacher:	A	B	C	D
Sum or ranks:	666	668	785	366
Nr items ranked:	20	20	20	10

H = -0.1300 df = 3 NS
Ho 6.13 not rejected

Treatment:	Experimental	Control
Sum of ranks:	1156	1329
Nr items ranked:	30	40

H = -0.1187 df = 1 NS
Ho 6.14 not rejected

Experiment Type	Direct	Indirect
Sum of ranks:	1544	941
Nr items ranked:	35	35

H = 11.1886 df = 1 ** significant beyond 0.001 level

Time of day (Sections)	(1)MW 1:30	(2)TuThu11:30	(3)TuThu 2:30
Sum of ranks:	953	768	764
Nr items ranked:	30	20	20

H = 0.4791 df = 2 NS
Ho 6.01 rejected

Subsection (Teacher and Treatment)	100	200	300	400	500	600	700
Sum or ranks:	328	430	398	338	238	387	366
Nr items ranked:	10	10	10	10	10	10	10

H = 4.3202 df = 6 NS
Ho 6.17 not rejected

Type and Treatment	Experimental		Control	
	Direct	Indirect	Direct	Indirect
Sum or ranks:	623	533	921	408
Nr items ranked:	15	15	20	20

H = 16.3195 df = 3 ** significant beyond 0.001 level
Ho 6.18 rejected

Ho 6.21 There will be no significant difference in the attitude of the students toward the laboratory techniques and their difficulty with respect to the selected direct filmed technique experiments between the experimental and control groups.

Ho 6.22 There will be no significant difference in the attitude of the students toward the laboratory techniques and their difficulty with respect tot the selected indirect filmed technique experiments between the experimental and control groups.

These hypotheses were tested utilizing the Mann-Whitney U test. The data is taken from Tables LXVI and LXVIII and Table LXIX contains a summary of the analyses.

It should be noted that again there was no significant difference between the experimental and control groups for the attitude of the students toward the laboratory techniques involved in the experiments. There was also no significant difference in the attitude between the experimental and control groups for the direct filmed technique experiments. However a significant difference was found in favor of the experimental group when one compares the attitude of the students toward the techniques involved in the indirect filmed technique experiments. Thus neither treatment group favored the direct filmed technique experiments but the experimental group significantly (0.005 level) favored the indirect filmed technique experiments. This is indeed an important point. These experiments involve laboratory techniques in which the students were previously instructed (i.e., the direct filmed technique experiments) and are expected to routinely perform those techniques. It is apparent that the students in the control group found these later experiments more difficult than those students in the

TABLE LXVIII

RANK ORDER OF ATTITUDES TOWARD DIFFICULTY OF THE LABORATORY TECHNIQUES OF THE SELECTED EXPERIMENTS BY EXPERIMENT TYPE

	Direct Filmed Technique Experiments						Indirect Filmed Technique Experiments					
Group	2	3	4	5	13		11	16	17	26	35	
100	13	22	11	6	10	62	5	20	35	27	21	108
200	19	25	21	18	12	95	17	26	34	28	15	120
300	9	24	26	16	4	79	23	33	14	30	19	119
Experimental Total						(236)						(347)
400	17	20	23	8	5	73	7	16	18	24	32	97
500	30	27	15	2	1	75	9	2	11	13	6	41
600	34	33	29	28	7	131	3	25	29	4	10	71
700	35	32	31	3	14	115	8	31	22	1	12	74
Control Total						(394)						(283)

TABLE LXIX

ANALYSIS OF ATTITUDE TOWARD THE DIFFICULTY OF THE LABORATORY TECHNIQUES INVOLVED WITH THE SELECTED EXPERIMENTS BETWEEN THE EXPERIMENTAL AND CONTROL GROUPS AND BY EXPERIMENT TYPE BY MANN-WHITNEY U TEST

			Rank Sums	
Group	Type	Overall Rank Sum	Direct Only	Indirect Only
100	Direct	163	62	
100	Indirect	165		108
200	Direct	246	95	
200	Indirect	184		120
300	Direct	214	79	
300	Indirect	184		119
400	Direct	196	73	
400	Indirect	142		97
500	Direct	185	75	
500	Indirect	53		41
600	Direct	284	131	
600	Indirect	103		71
700	Direct	256	115	
700	Indirect	110		74

Rank Sum: Experimental: 1156
Control: 1329
U = 509
Z = 1.0800
P = 0.1401 NS
Ho 6.19 not rejected

Rank Sum: Direct: 1556
Indirect: 941
U = 299
Z = 3.6824
P = 0.0002 ** significant
Ho 6.20 rejected

Rank Sum, Direct Only: Experimental: 236
Control: 394
U = 116
Z = 1.1333
P = 0.1292 NS
Ho 6.21 not rejected

Rank Sum, Indirect Only: Experimental: 347
Control: 283
U = 73
Z = 2.5667
P = 0.0051 ** significant
Ho 6.22 rejected

experimental group who had access to the single concept loop films.

In summary the students attitude toward the experiments (not the course as a whole) does not differ for the different teachers, the time of day, or the treatment groups. Overall the students prefer the earlier experiments over the later experiments in which they are supposed to rely upon what they have learned. The major difference found is that those students who had access to the single concept loop films felt that these later experiments were less difficult than those students in the control group who did not have access to the films.

Laboratory Proficiency

The proof of laboratory proficiency should be a combination of correct set-up, high purity of yield, optimum percent yield, and positive results on unknown analyses. These data were reported, when applicable, on the data cards. However, their interpretation would require the wisdom of Solomon and the patience of Job. If melting point becomes the criteria for purity (gas chromatography, TLC, infrared, and NMR were not available for the Chem 3015 students) it is difficult to evaluate which of the following would represent the better result: a single value such as 89.9°C for the melting point of m-dinitrobenzene or a range 89.4°-89.9°C reported by a careful student. Upon questioning, the former would reply that the sample had a sharp melting point. This would be the proper "textbook" answer, however, this experiment will yield a sample which is not sufficinetly pure to produce that sharp a melting point. Percentage yields can be accurately computed, but usually the higher percentages are damp or otherwise contaminated. The unknowns were direct and straightforward with no tricks, thus the majority of the students submit a correct analysis.

Until precise methods are agreed upon and the correlation between purity and percentage yield is also established for comparison purposes, it is quite difficult to compare the results of these experiments with a more than pass-fail, or good-fair-bad categories.

The major purpose of this study was to determine the effects of the single concept loop films and determine if they were effective in enabling the student to properly set up and use his equipment. For this reason the JH_2S examination was administered to ascertain whether differences would be found between those students who watched the films and those who did not. The overall results of the JH_2S examination may be seen in Table LXX. It would be expected that students in the experimental group should score higher than those in the control group. The following null hypotheses were considered.

Ho 7.01 There will be no significant difference in the means of the JH_2S Exam scores between the experimental and control groups.

Ho 7.02 There will be no significant difference in the means of the JH_2S Exam scores between the experimental and control groups of each teacher.

It was shown that the slight imbalance of females in the experimental group did not effect the overall differences in laboratory breakage. One might wonder what effect the female students would have on the JH_2S Examination scores. This question generated the following null hypotheses.

Ho 7.03 There will be no significant difference in the means of the JH_2S examination scores of the female students between the experimental and control groups.

TABLE LXX

RESULTS FROM JH_2S EXAMINATION BY SUBSECTION

Group	N	$\bar{X}$	ΣX^2	ΣX	Σx^2	s^2
100	22	20.1819	9258	444	297.2728	14.1558
200	22	21.1364	10071	465	242.5909	11.5519
300	22	25.4545	14600	560	345.4546	16.4502
Experimental Group	66	22.2576	33929	1469	1232.6212	18.9634
400	19	20.7895	8523	395	311.1579	17.2865
500	15	20.4667	6357	307	73.7334	4.2666
600	19	23.0000	10255	437	204.0000	11.3333
700	21	19.5714	8273	411	229.1429	11.4571
Control Group	74	20.9459	33408	1550	941.7838	12.9011
Total	140	21.5643	67337	3019	2234.4214	16.0750

Kuder-Richardson Formula 21, r = 0.7328

TABLE LXXI

SUMMARY OF RESULTS FROM ANALYSIS OF RESULTS OF JH_2S EXAM

Criteria	N	$\bar{X}$	s^2	t	
Experimental	66	22.2576	18.9634	1.9508	**significant at .05
Control	74	20.9459	12.9011		Ho 7.01 rejected
100 400	22 19	20.1819 20.7895	14.1558 17.2865	-0.4912	NS
200 500	22 15	12.1364 20.4667	11.5519 5.2666	0.6559	NS
300 600	22 19	25.4545 23.0000	16.4502 11.3333	2.0879	**significant at 0.025

TABLE LXXII

SUMMARY OF RESULTS OF JH_2S EXAMINATION SCORES BY SEX

Comparison	N	$\bar{X}$	s^2	t	probability
Experimental group females only	14	20.8572	19.5165	0.9106	NS
Control group females only	8	19.2500	9.0714		
				Ho 7.03 not rejected	
Experimental group males only	52	22.6346	18.5109	1.9876	** 0.05
Control group males only	66	21.2727	7.4937		
				Ho 7.04 rejected	
Males only					
100	20	20.3500	15.2921	-0.4723	NS
200	17	21.0588	18.6838		
200	15	22.2667	8.6381	1.8692	** 0.05
500	15	20.4667	5.2667		
300	17	25.6471	16.9931	1.6109	** 0.01
600	15	23.5333	10.6952		
				Ho 7.05 rejected	

Ho 7.04 There will be no significant difference in the means of the JH_2S examination of the male students between the experimental and control groups.

Ho 7.05 There will be no significant difference in the means of the JH_2S examination scores of the male students between the experimental and control group classes of each teacher.

It is found that Ho 7.08 was tenable, thus there was no difference between the female students. However, eliminating the female students increased the value of t for the overall group, thus leaving the females in each group had a conservative effect upon the results consequently strengthening the case for single concept films.

One would expect to find a difference in the JH_2S examination scores with respect to the amount of film viewing. This question generates the following null hypothesis.

Ho 7.06 There will be no significant difference in the means of the JH_2S Examination scores among those students watching a greater number of films (13 or more), those watching a moderate number (7 to 12), those watching few (0 to 6) and those in the control group watching none.

This analysis may be accomplished by a single classification analysis of variance. Fifteen scores were selected at random for each group. It can be seen from the results in Table LXXIII that the mean score increases rapidly with increased viewing.

Therefore the null hypothesis was untenable. Thus the difference in the JH_2S Examination score was dependent upon viewing the single concept loop films. These results were from a random sample of scores. Perhaps there is also a difference which can be attributed to the

TABLE LXXIII

ANALYSIS OF JH_2S SCORES BY FILM VIEWING. RANDOM SAMPLES OF FIFTEEN SCORES FOR EACH VIEWING CATEGORY

	13 or more	7 to 12	0 to 6	none (control)	Totals
ΣX^2	9749	7480	6707	5791	29727
ΣX	377	326	313	293	1309
$\bar{X}$	24.1333	21.7333	20.8667	19.5333	21.8167

	df	SS	$\bar{S}$	F
Between	3	256.8501	85.6167	5.256**
Within	56	912.1332	16.2881	
Total	59	1168.9833		

**significant beyond 0.01 level   Ho 7.06 rejected teacher. The following null hypotheses were considered.

Ho 7.07 There will be no significant difference between the mean JH_2S examination scors between those who watched more (13 or more) films, those who watched less (12 or less) and those in the control group who watched none.

Ho 7.08 There will be no significant difference between the means of the JH_2S Examination scores between the teachers who taught both experimental and control groups.

Ho 7.09 There will be no interaction between the teachers and the film viewing.

In order to utilize a two way analysis of variance, equal cell frequencies are necessary, five examination scores were selected for each category at random. The results are shown in Table LXXIV.

Thus the null hypotheses were untenable and it was concluded that both the teacher and the viewing habits contributed to success on the examination.

Another interesting aspect to consider is the examination itself. Table LXXV indicates the particular laboratory technique tested with each question on the examination. The list also includes the relevant films and whether the technique is covered specifically in the particular film. Table LXXVI and LXXVII show the number and percentage of students answering each question correctly and whether or not they watched the relevant films. We would expect a higher percentage of those students who watched the relevant films to answer a particular question correctly. This led to the following null hypothesis.

Ho 7.10 There will be no significant difference in the percentage of students answering questions on the JH_2S Examination correctly among those who watched the relevant films and those who did not both in the control and in the experimental groups.

Table LXXVIII shows the tabulation of percentage of students answering each question correctly in the three categories. Friedman Two Way Analysis of Variance was used. The hypothesis is untenable and was rejected. Thus confirming the belief that watching the relevant films had a positive effect upon answering the particular questions correctly.

TABLE LXXIV

ANALYSIS OF JH_2S SCORES BY FILM VIEWING AND TEACHER. RANDOM SAMPLES OF FIVE SCORES FOR EACH CATEGORY

	Viewed 13 or more	7 to 12	6 or less	Viewed None
Teacher	2720	2018	2038	6776
A	116	100	100	316
	23.20	20.00	20.00	21.07
Teacher	2184	1874	1848	5906
B	104	96	96	296
	20.80	19.20	1920	19.73
Teacher	4240	3047	1989	9276
C	144	123	99	366
	28.80	24.6	19.80	24.40
ΣX^2	9144	6939	5875	21958
ΣX	364	319	295	978
$\bar{X}$	24.27	21.27	19.67	21.73
	df	SS	$\overline{SS}$	F
Film Viewing	2	163.60	81.80	10.367 **
Teacher	2	173.33	86.67	10.985 **
Interaction	4	81.87	20.47	2.594 NS
Within	36	284.00	7.89	
Total	44			

** significant beyond 0.01 level Ho 7.07 rejected
Ho 7.08 rejected
Ho 7.09 not rejected

TABLE LXXV

TEST QUESTIONS KEYED TO EXPERIMENTS AND FILMS

Question	Technique	Covered specifically in film	Film Number
1	Methods of heating (high bp & flammable)	No	7
2	Methods of heating (low bp & non-flammable)	No	7
3	Methods of heating (warming)	No	7
4	Filling distilling flask	Yes	13
5	Addition of boiling chips	Yes	6
6	Methods of collecting (flammable)	Indirectly	13
7	Methods of collecting	Indirectly	13
8	Methods of collecting (whats wrong)	Indirectly	13
9	Thermometer placement	Yes	13,15
10	Steam distillation	Yes	18
11	Thermometer placement	Yes	13
12	Thermometer placement	Yes	13
13	Thermometer placement	Yes	13
14	Thermometer placement	Yes	13
15	Melting point	Yes	9,10
16	Melting point	Yes	9,10
17	Melting point	Yes	9,10
18	Rapid filtration	Yes	4
19	Rapid filtration	Yes	4
20	Rapid filtration	Yes	4
21	Distillation heating methods	Yes	7,12,13
22	Distillation heating methods	Yes	7,12,13
23	Methods of collecting	Yes	13
24	Methods of collecting	Yes	13
25	Methods of collecting	Yes	13
26	Methods of collecting	Yes	13
27	Concentrating on aqueous solution	No	7
28	Heating a flammable solvent	Indirect	7
29	Ether removal from ether extract	Yes	23
30	Drilling a cork	Yes	11
31	Placement of tubing on a condenser	Yes	11
32	Clamps in distillation	Yes	12
33	Set up in distillation	Yes	12
34	Filling a distillation flask	Yes	13
35	Methods of separating	Implied,	1,12,13,18,
36	Methods of separating	requires inductive	19,20,21,
37	Methods of separating	reasoning from	23,22
38	Methods of separating	films	
39	Removal of decolorizing carbon	Yes	1,3
40	Removal of $CaCl_2$ from ether solution	Yes	22(19-23 series)

TABLE LXXV (Continued)

Question	Technique	Covered specifically in film	Film Number
41	Rapid filtering	Yes	4
42	Diaxotization (methods of addition)	Yes	25 or 26
43	Determination of acidity or basicity	Yes	17A,17B,17C
44	Sodium removal	No	
45	Nitrogen test in Na fusion	Yes	17A
46	Esterification	Implied	(5)
47	Diazotication reaction	Implied	(25 or 26)
48	Solvent heating	Implied	(7)
49	Saponification	Implied	(4)
50	Waste removal	No	

TABLE LXXVI

NUMBER OF INDIVIDUALS GIVING CORRECT AND INCORRECT ANSWERS TO QUESTIONS ON EXAMINATION WITH RESPECT TO WHETHER THEY WATCHED OR DID NOT WATCH THE RELEVANT FILMS

		Group 100				Group 200				Group 300				Totals					
Question	Film	Watched		Did not		Watched		Did not		Watched		Did not		Watched			Did not		
Nr	Nr.	OK	X	OK	X	OK	X	OK	X	OK	X	OK	X	OK	X	%	OK	X	%
1.	7	4	7	0	8	0	7	1	8	2	5	4	10	6	19	24.00	5	26	16.13
2.	7	1	10	1	7	1	6	1	8	1	6	4	10	3	22	12.00	6	25	19.35
3.	7	7	4	4	4	2	5	7	2	7	0	12	2	16	9	64.00	23	6	79.31
4.	13	0	11	0	8	0	7	1	8	0	17	0	4	0	35	00.00	1	20	04.76
5.	6	10	2	3	4	3	4	5	4	10	5	6	0	23	11	67.65	14	12	53.85
6.	13	2	9	1	7	1	6	1	8	1	16	0	4	4	31	11.43	2	19	09.52
7.	13	6	5	1	7	4	3	4	5	8	9	2	2	18	17	51.43	7	14	33.33
8.	13	5	6	4	4	3	4	6	3	12	5	2	2	20	15	57.14	12	9	57.14
9	13 or 15	3	10	3	3	0	7	2	7	9	8	0	4	12	25	32.43	5	14	26.32
10.	18	2	3	2	12	0	3	5	8	5	11	0	5	7	17	29.17	7	25	22.58
11.	13	7	4	8	0	7	0	9	1	16	1	3	1	30	5	85.71	19	2	90.48
12.	13	4	7	6	2	6	1	6	3	13	4	4	0	23	12	65.71	16	5	76.19
13.	13	7	4	6	2	5	2	7	2	16	1	4	0	28	7	80.00	17	4	80.95
14.	13	10	1	5	3	5	2	7	2	13	4	2	2	28	7	80.00	17	4	80.95
15.	9,10	5	11	0	3	4	5	6	1	9	8	2	2	18	34	34.62	8	6	57.14
16.	9,10	0	16	0	3	1	8	0	7	1	16	0	4	2	40	04.76	0	14	00.00
17.	9,10	6	10	0	3	5	4	4	3	8	9	2	2	19	23	45.24	6	8	42.86
18.	4	2	13	2	4	3	2	4	7	10	5	4	2	15	20	42.86	10	13	43.48
19.	4	8	5	2	4	3	2	7	4	13	2	4	2	24	9	72.73	13	10	36.52
20.	4	6	9	3	4	2	3	3	8	5	10	2	4	13	22	37.14	8	16	33.33
21.	7,12,13	7	9	1	7	4	4	2	6	4	9	0	1	13	22	37.14	3	14	17.65
22.	7,12,13	2	9	0	8	2	6	1	7	1	12	1	0	5	27	15.63	2	15	11.76
23.	13	9	2	6	2	5	2	7	2	17	0	3	1	31	4	88.57	16	5	76.19
24.	13	7	4	6	2	4	3	5	4	9	8	0	4	20	15	57.14	11	10	52.38
25.	13	1	10	0	8	1	6	1	8	6	11	0	4	8	27	22.86	1	20	04.76
26.	13	6	5	0	8	3	4	6	3	6	11	4	0	15	20	42.86	10	11	47.62
27.	7	4	7	3	5	1	6	5	4	4	3	6	8	9	16	36.00	14	17	45.16

TABLE LXXVI (Continued)

Question	Film	Group 100				Group 200				Group 300				Totals					
		Watched		Did not		Watched		Did not		Watched		Did not		Watched			Did not		
Nr.	Nr.	OK	X	OK	X	OK	X	OK	X	OK	X	OK	X	OK	X	%	OK	X	%
28.	7	5	6	5	3	3	4	3	6	6	1	8	6	14	11	56.00	16	15	51.61
29.	23	1	0	7	11	2	2	5	7	8	14	7	0	11	16	40.74	19	18	51.35
30.	11	5	3	2	9	1	2	2	11	6	1	13	1	12	6	66.67	17	21	44.74
31.	5,12,15	9	8	2	1	5	6	3	2	14	7	0	0	28	21	57.14	5	3	62.50
32.	12	10	2	5	2	9	1	3	3	15	3	3	0	34	6	85.00	11	5	68.75
33.	12	1	12	1	5	2	5	3	6	4	15	1	2	7	32	17.95	5	13	27.78
34.	13	6	5	3	5	1	6	1	8	9	8	4	0	16	19	45.71	8	13	38.10
35.		8	5	5	1	7	1	3	5	17	4	0	0	32	10	76.19	8	6	57.14
36.		6	7	2	4	3	5	1	7	11	10	0	0	20	22	47.62	3	11	21.43
37.		5	8	3	3	6	2	1	7	10	11	0	0	21	21	50.00	4	10	28.57
38.		5	8	0	6	0	8	1	7	5	17	0	0	10	32	23.81	1	13	07.14
39.	1,3	3	12	0	4	0	7	1	3	2	6	0	13	5	30	14.29	1	19	05.00
40.	22	1	4	0	14	2	4	8	8	2	5	2	12	5	13	27.78	10	34	22.73
41.	4	14	1	4	0	4	1	10	1	15	0	4	2	33	2	94.29	18	3	85.71
42.	25,26	0	0	3	16	0	0	0	16	1	0	7	13	1	0	10.00	10	45	18.18
43.	A,B,C	6	2	4	7	2	4	5	5	7	4	5	5	15	10	60.00	14	17	45.16
44.	17			(17	2)			(9	7)			(13	8)				(39	17)	69.64
45.	17A	1	7	0	11	0	6	0	10	1	10	1	9	2	23	08.00	1	30	03.23
46.	(5)	2	16	0	1	2	8	2	4	9	12	0	1	13	36	26.53	2	6	25.00
47.	(7)	2	9	4	4	1	6	3	6	2	5	8	6	5	20	20.00	15	16	48.39
48.	(7)	3	15	0	1	2	8	2	4	7	15	0	1	12	38	24.00	2	6	25.00
49.	(4)	7	11	0	1	7	3	3	3	12	9	1	0	26	23	53.06	4	4	50.00
50.	none			(17	2)			(15	1)			(19	2)				(51	5)	91.07

TABLE LXXVII

NUMBER OF INDIVIDUALS IN THE CONTROL GROUPS GIVING CORRECT AND INCORRECT ANSWERS TO QUESTIONS ON JH_2S EXAMINATION

	Group 400		Group 500		Group 600		Group 700		Totals		
Question	OK	X	OK	X	OK	X	OK	X	OK	X	% Correct
1.	3	16	4	11	8	11	3	18	18	56	24.32
2.	2	17	0	15	4	15	3	18	9	65	12.16
3.	13	6	14	1	16	3	15	6	58	16	78.38
4.	1	19	1	14	0	19	0	21	2	72	2.70
5.	12	7	8	7	11	8	14	7	45	29	60.81
6.	3	16	1	14	3	16	1	20	8	66	10.81
7.	7	12	7	8	15	4	10	11	49	35	66.22
8.	12	7	7	8	12	7	15	6	46	28	62.16
9.	6	13	1	14	11	8	5	16	23	51	31.08
10.	4	15	3	12	6	13	4	17	17	57	22.97
11.	16	3	15	0	17	2	16	5	64	10	86.49
12.	14	5	13	2	12	7	18	3	57	17	77.03
13.	16	3	13	2	15	4	17	4	61	13	82.43
14.	10	9	4	11	10	9	17	4	41	33	55.41
15.	3	16	5	10	4	15	0	21	12	62	16.22
16.	0	19	1	14	0	19	1	20	2	72	2.70
17.	5	14	5	10	6	13	2	19	18	56	24.32
18.	13	6	7	8	11	8	11	10	42	32	56.76
19.	10	9	10	5	10	9	13	8	43	31	58.11
20.	3	16	7	8	4	15	4	17	18	56	24.32
21.	2	17	6	9	3	16	7	14	18	56	24.32
22.	0	19	0	15	3	16	1	20	4	70	5.41
23.	14	5	10	5	15	4	19	2	58	16	78.38
24.	9	11	6	9	7	12	13	8	34	40	45.95
25.	1	18	1	14	6	13	2	19	10	64	13.51
26.	8	11	10	5	11	8	7	14	36	38	48.65
27.	4	15	3	12	5	14	4	17	16	58	21.62

TABLE LXXVII (Continued)

Question	Group 400		Group 500		Group 600		Group 700		Totals		
	OK	X	OK	X	OK	X	OK	X	OK	X	% Correct
28.	11	8	7	8	3	16	14	7	35	39	47.30
29.	14	5	9	6	10	9	9	12	42	32	56.76
30.	4	15	2	13	17	2	1	20	24	50	32.43
31.	8	11	10	5	12	7	13	8	43	31	58.11
32.	12	7	9	6	17	2	10	11	48	26	64.86
33.	0	19	3	12	3	16	6	15	12	62	16.22
34.	7	12	5	10	3	16	4	17	19	55	25.68
35.	12	7	10	5	15	4	17	4	54	20	72.97
36.	12	7	6	9	5	14	9	12	32	42	43.24
37.	12	7	6	9	3	16	10	11	31	43	41.89
38.	6	13	1	14	5	14	4	17	16	58	21.62
39.	4	15	0	15	3	16	1	20	18	56	24.32
40.	2	17	1	14	1	18	2	19	6	68	8.11
41.	17	2	13	2	18	1	18	3	66	8	89.19
42.	4	15	2	13	6	13	2	19	14	60	18.92
43.	7	12	9	6	16	3	2	19	34	38	45.95
44.	15	4	8	7	10	9	9	12	42	32	56.76
45.	1	18	1	14	0	19	3	18	5	69	6.76
46.	5	14	5	10	11	8	6	15	22	52	29.73
47.	12	7	7	8	11	8	16	5	46	28	62.16
48.	5	14	3	12	3	16	5	16	16	58	21.62
49.	16	3	9	6	11	8	5	16	41	33	55.41
50.	17	2	12	3	18	1	19	2	66	8	89.19

TABLE LXXVIII

PERCENT OF STUDENTS ANSWERING EACH QUESTION CORRECTLY ON THE JH_2S EXAMINATION

Question Number	Watched Films		Did Not Watch		Control	
1	24.00%	(2)	16.13%	(3)	24.32%	(1)
2	12.00	(3)	19.35	(1)	12.16	(2)
3	64.00	(3)	79.31	(1)	78.38	(2)
4	0.00	(3)	4.76	(1)	2.70	(2)
5	67.65	(1)	53.85	(3)	60.81	(2)
6	11.43	(2)	9.52	(3)	10.81	(2)
7	51.43	(2)	33.33	(3)	66.22	(1)
8	57.14	(2.5)	57.14	(2.5)	62.16	(1)
9	32.43	(1)	26.32	(3)	31.08	(2)
10	29.17	(1)	22.58	(3)	22.97	(2)
11	85.71	(3)	90.48	(1)	86.49	(2)
12	65.71	(3)	76.19	(2)	77.03	(1)
13	80.00	(3)	80.95	(2)	82.43	(1)
14	80.00	(2)	80.95	(1)	55.41	(3)
15	34.62	(2)	57.14	(1)	16.22	(3)
16	4.76	(1)	0.00	(3)	2.70	(2)
17	45.25	(1)	42.86	(2)	24.32	(3)
18	42.86	(3)	43.48	(2)	56.76	(1)
19	72.72	(1)	56.52	(3)	58.11	(2)
20	37.14	(1)	33.33	(3)	24.32	(2)
21	37.14	(1)	17.65	(3)	24.32	(2)
22	15.63	(1)	11.76	(2)	5.41	(3)
23	88.57	(1)	76.19	(3)	78.38	(2)
24	57.14	(1)	52.38	(2)	49.95	(3)
25	22.86	(1)	4.76	(3)	13.51	(2)
26	42.86	(3)	47.62	(2)	48.65	(1)
27	36.00	(2)	45.16	(1)	21.62	(3)
28	56.00	(2)	51.61	(3)	47.30	(1)
29	40.74	(3)	51.35	(2)	56.76	(1)
30	66.67	(1)	44.74	(2)	32.43	(3)

TABLE LXXVIII (Continued)

Question Number	Watched Films		Did Not Watch		Control	
31	57.14	(3)	62.50	(1)	58.11	(2)
32	85.00	(1)	68.75	(2)	64.84	(3)
33	17.95	(2)	27.78	(1)	16.22	(3)
34	45.71	(1)	38.10	(2)	25.68	(3)
35	76.19	(1)	57.14	(3)	72.97	(2)
36	47.62	(1)	21.43	(3)	43.24	(2)
37	50.00	(1)	28.57	(3)	41.89	(2)
38	23.81	(1)	7.14	(3)	21.62	(2)
39	14.29	(2)	5.00	(3)	24.32	(1)
40	27.78	(1)	22.73	(2)	8.11	(3)
41	94.29	(1)	85.71	(3)	89.19	(2)
42	100.00	(1)	18.18	(3)	18.92	(2)
43	60.00	(1)	45.16	(3)	45.95	(2)
44	69.64	(1.5)	69.64	(1.5)	56.76	(3)
45	8.00	(1)	3.23	(3)	6.76	(2)
46	26.53	(2)	25.00	(3)	29.73	(1)
47	20.00	(3)	48.39	(2)	62.16	(1)
48	24.00	(2)	25.00	(1)	21.62	(3)
49	53.06	(2)	50.00	(3)	55.41	(1)
50	91.07	(1.5)	91.07	(1.5)	89.19	(3)
Sum of ranks:		(85.5)		(113.5)		(101)

X_r^2 = 7.87 ** (df = 2)

**significant at 0.02 level

Ho 7.07 rejected

CHAPTER V

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Summary

The purpose of this study was to determine the effects of the use of single concept loop films on pre-laboratory instruction in introductory organic chemistry. A series of twenty-six single concept loop films were produced by the author to depict techniques determined by his observations of a similar introductory organic chemistry laboratory section. Those techniques in which the students had difficulties as well as all of the laboratory setups requiring the use of standard taper glassware formed the basis for the objectives in the films. The films were produced on super 8 mm color film and placed in Technicolor Magi-Cartridges after editing.

The evaluation of the films was accomplished under actual classroom conditions and use. Three Technicolor 810 projectors were available for the students to use in their laboratory. One subsection during each laboratory period was used for the experimental class and the remaining subsections served as a control. The Hawthorne effect was equalized in each class by collecting data cards from all students. Each was told that this was part of a project designed to improve the course. In fact, students in the author's control class seemed eager to help. They dutifully wrote down their time spent, the equipment which they broke, and the other pertinent data. During the following semester, moreover, students from this particular control class were asking how the project came out. In the experimental classes, the purpose of the films and their operation was explained without subsequent elaboration or reinforcement. The strategy was to use a low key approach. The evaluation of the films was made through analyses of the actual time necessary to perform the experiments, the breakage of laboratory equipment, the accidents, attitude, self-appraisal of laboratory techniques, and the JH_2S Laboratory Technique Examination.

The results from the statistical analyses of the group showed that the group was randomly distributed with respect to classification, college of major, high school chemistry background, semester hours of college chemistry, semester hours of chemistry laboratory credit, chemistry grade point average, and overall grade point average. Only sex was found to be nonrandomly distributed. There were slightly more women in the experimental group. However, it was discovered that the women scored slightly lower on the JH_2S Examination than the men causing a conservative effect upon the overall results. The laboratory breakage difference between the women in the experimental and control groups was not significant except the number of items broken per female attending class which was significant in favor of the control group. This would also have a conservative effect upon the results. One can, therefore accept the findings which are in favor of the experimental group.

It was discovered that more experimental time differences occurred among teachers than between treatments. However, it was found that there was no overall differences in the amount of time necessary to perform an experiment between those students who had the techniques explained to them prior to commencing the experimentation and those who were given the basic precautions and objectives but had to learn the techniques from viewing the films. It must be noted that not all of the students in the experimental classes watched the films. Some students watched the films. Others waited until the experiments were underway and tried to imitate the techniques of those who had watched the films. The experimental times reported did include the time spent in watching the films. However, most of the films were less than four minutes in length and would not add significantly to experimental times. In fact, students in the experimental classes did not require a longer time to perform the experiments, but appeared to proceed efficiently.

Fortunately no serious accidents occurred during the semester, although they are not uncommon in organic chemistry laboratories. All of the accidents which did occur were, however, minor. These consisted of minor surface burns, small cuts, splashed acid, a small acetone fire (although no ether fires), and only one incident of a flask of chlorosulfonic acid turning over in the ice bath. If one were to consider all of these accidents of equal magnitude, then there was no significant differences in the accidents between groups. A trend may be indicated by the fact that in two of three cases the students in the experimental class of a given teacher had less than the expected[1] number of accidents when compared to the corresponding control class which had more accidents than expected.

Significant differences did result in the amount and kind of

---

[1]Chi square analysis.

laboratory breakage. Table LXXIX summarizes the results from the breakage study. It should be noted that all criteria where differences did occur favored the experimental group. (Less breakage or lower cost is considered to be favorable.) There is no significant difference in any of the factors for the non-filmed technique experiments. This is to be expected: the groups were randomly distributed; they were as equal as one can expect for a random distribution. If all factors are equal and the experiment does not require that the techniques which were shown by the films, one would expect no differences in the amount or kind of breakage. One finds no significant difference in the overall number of items broken by student for the direct filmed technique experiments or the indirect filmed technique experiments. One finds significance, however, at the 0.04 level in the number of items per student of standard taper glassware broken. The cost-per-item-per-student (a factor that considers the cost of items broken in proportion to the number of students) shows significance in favor of the experimental group at the 0.04 level. In the direct filmed technique experiments which came at the first of the semester there is a significant difference only at the 0.08 level. For the indirect filmed technique experiments which follow later in the term, the level of significance has increased to 0.02, which indicates that the care of the students (their technique) was improving. This is borne out by the mean cost per item broken. There is significance at the 0.08 level overall as well as for the direct filmed technique experiments. In the experimental group, the indirect filmed technique experiments show even more favorable significance at the 0.04 level.

Thus one may summarize the effects of the single concept films upon the breakage of laboratory equipment by indicating that the number of items of standard taper glassware is significantly less and the impact of the films has a lasting effect: the cost-per-item-per-student factor decreases for the later experiments which require techniques and manipulations taught earlier by SCLF.

TABLE LXXIX

SUMMARY OF STATISTICAL SIGNIFICANCE OF BREAKAGE FACTORS

	Cost per student	number of items broken per student	cost per item broken per student	mean cost per item broken
All experiments	NS	NS	.04	.08
Direct filmed technique experiments	.08	NS	.08	.08
Indirect filmen technique experiments	NS	NS	0.02	.04
Non-filmed technique experiments	NS	NS	NS	NS
Standard Taper glassware	.08	.04	NS	NS

**All significance in favor of the use of single concept loop films.

The results from the self appraisal of laboratory techniques questionnaire yielded a nonsignificant negative correlation. This result indicated that the students who claim that they are proficient in a particular task frequently are not as proficient as they indicate, while those who actually are quite adept tend to be modest about their proficiency. The lack of significance in the results is a result that some of the students did, in fact, appriase their abilities accurately.

The attitude of the students did not differ significantly between the experimental and control groups neither did it vary much among the different teachers nor did it vary much among the times of day. The entire group liked the earlier experiments (direct filmed technique experiments) better than the later experiments (indirect filmed technique experiments). The attitude of the students specifically toward the difficulty of the laboratory techniques did not differ from their attitude toward the experiments as a whole. However those students in the experimental group felt that the techniques required for the later experiments were significantly less difficult. Only one factor was different. Specifically, those students in the experimental group found the techniques required in these later experiments were not as difficult as did the students in the control group. This result indicated another residual effect of the use of SCLF.

Results of the JH_2S Examination indicate that students viewing SCLF learn enough to enable them to cope with new situations. Some of the photographs used in the JH_2S Examination depicted incorrect or slightly unsafe equipment setups and procedures. (These setups did not appear in the SCLF.) Those students who watched more films scored significantly higher than other students in their group and higher than those in the control group who saw none of the films. The narrow range of scores on the examination makes it doubtful that the examination covered particular points treated only in the films but not in the control classes. The examination was constructed from the techniques needed for the course and not specifically from the objectives for the films.

Conclusions

1. Students given basic objectives of the experiment and allowed to learn their manipulative techniques by watching single concept loop films required no more time for actual experimentation than students who watched the technique performed as a demonstration. Despite the time and effort required by the instructor to assemble the equipment and demonstrate its use, SCLF's save the instructor this time and effort and require no additional time from the students.

2. The use of SCLF's reduced significantly the breakage of standard taper glassware.

3. The proportion of students having incidents of laboratory equipment breakage was significantly less for those students who had access to the single concept loop films.

4. The use of SCLF for the initial exposure to a set of laboratory techniques resulted later in an overall significant reduction in breakage when these same techniques were encountered again.

5. The attitude of the students toward the experiments did not differ between the experimental and control groups. The students preferred the experiments in which laboratory techniques were introduced (by either demonstration or SCLF) rather than those experiments in which the students had to rely upon techniques which they had previously been instructed.

6. The students in the control group found the techniques required in the later experiments significantly more difficult than the students who had access to the SCLF. It is apparent that the students in the experimental group had gained confidence in these techniques and could more readily put them into practice.

7. The residual effects of SCLF's upon laboratory techniques manifests itself in the reduction of equipment breakage and increase in confidence in the execution of laboratory techniques which were previously taught by the films.

8. The results of the JH_2S Examination indicate that students using SCLF are better enabled to detect unsafe or improper setups and select the optimum equipment or setup for a given task.

Recommendations for Further Study

This study explored one approach to teaching laboratory techniques. There are certain topics which demand further investigation.

1. Determination of the specific effects upon the quality of preparation through the use of highly detailed and specific SCLF. This will entail comparison of the actual purity and percentage yields of the products.

2. Specific comparisons of written laboratory examinations and the quality of laboratory preparations.

3. The use of coordinated sound directions on synchronized magnetic tape or sound film loops. When questioned, students felt that the question of narrated directions would increase the effectiveness of single concept loop films (Appendix H).

4. The effects of repetitive film loop viewing. McTavish (52)

has shown that learning factual material increases with viewing up to three times but diminishes slightly with four (forced) viewings. He did not, though, explore laboratory proficiency, breakage, accidents, experimentation time, and attitude.

5. The effects of parallel films. When a lack of understanding occurs, repetition of the exact same material may not help. The effects of a series of parallel films each utilizing the same behavioral objectives but approaching the problem from a slightly different point and with different details have not been studied.

6. The possible effects of goal, intelligence and aptitude upon learning manipulative skills with SCLF's. Differences in vocational goals, intellect, mechanical aptitude, arithmatic reasoning, verbal reasoning, intellectual set, and other psychological parameters may result in differences in the skills acquired through the use of single concept technique films.

Recommendations for Use of Single Concept Films

1. The results from this study may be applied to the use of any mode of projection. The differences between Technicolor loop film cartridge projection and Kodak Ektagraphic reel-to-reel systems are merely technological. Both systems are convenient for the student to operate and the projected images are identical.

2. It is recommended that in any utilization of single concept films for individual student use that a convenient viewing area be provided and that multiple copies as well as available replacement footage be available. If SCLF are used when an entire class will be needing the information at nearly the same time no more than ten or twelve

students per copy would be suggested. One of the important features of SCLF is that they are ready whenever the student needs the information. In a laboratory class the time is important and hould not be wasted by waiting.

3. The use of SCLF should prove effective in other chemistry courses such as physical chemistry, instrumental analysis, organic analysis, inorganic preparation and others where laboratory techniques, procedures, and equipment operation is vital to the success of the course. Courses, such as those mentioned, frequently involve one instrument of each type needed which are used in a varied sequence throughout the course. It is quite difficult for the instructor to make certain that he has shown the operational procedures to each individual. SCLF could allieviate this difficulty.

4. The use of SCLF in other laboratory courses, including individualized instruction and research projects which lead one into areas of unfamiliarity with equipment should prove effective. Radiation monitoring techniques, preparing samples for neutron activation analysis, operation of x-ray apparatus, preparation of samples for x-ray crystallography, operation and handling of x-ray cameras, electronics, are but a few examples from physics. In the biological sciences equipment such as microscopes and Warburg apparatus have been quite common. However there is an increasing array of equipment such as pH meters, burets, automatic titrometers, analytical balances, desk calculators, gas chromatographs, spectrometers, which were once only in the domain of the physical scientist. These and other devices need to be routinely and proficiently used by the student as well as the researcher whenever the task requires its use. The utilization of SCLF could

alleviate not only the problem of introduction into the operation of a particular instrument but could bridge the gap which exists in the operational characteristics between two models of a similar device.

SELECTED BIBLIOGRAPHY

(1) Abramson, Bernard, "A Comparison of Two Methods of Teaching Mechanics in High School," Science Education, 1952 36 96-106.

(2) Advisory Council on College Chemistry, Newsletter Nr. 12. (Serial Publication 33) Stanford, California, January 1968.

(3) Alpert, D. and Bitzer, D. L., "Advances in Computer Based Education," Science 1970 167 1582-1590.

(4) Anderson, J. L., "The Rebirth of Single Concept Films," Educational Screen and Audiovisual Guide, 1966 45 (2) 28-29.

(5) Anderson, Kenneth E., and Montgomery, Fred S., "An Evaluation of the Introductory Physics Course on Film," Science Education, 1959 43 386-94.

(6) Anderson, Kenneth E., Montgomery, Fred S., and Moore, Sid F., "An Evaluation of the Introductory Chemistry Course on Film," Science Education, 1961 45 254-69.

(7) Anderson, Kenneth E., Montgomery, Fred S., and Scannel, Dale P., "An Evaluation of the Introductory Chemistry Course on Film by Factorial Design and Covariance With Method and Sex as the Major Variables," Science Education 1961 45 269-274.

(8) __________, "An Evaluation of the Introductory Chemistry Course on Film by Factorial Design and Covariance With Method and Career Plans as the Main Variables," Science Education 1961 45 275-278.

(9) Babcock, Chester, "Evaluating Educational Innovation," Audio Visual Instruction, 1964 9 268-270.

(10) Barnard, W. Robert, "Teaching Aids - 8mm Projectors in the Modern Chemistry Classroom," Journal of Chemical Education, 1968 45 136-140.

(11) Barnard, W. Robert, et. al., "Modern Teaching Aids for College Chemistry," Advisory Council on College Chemistry Serial Publication 18, Stanford, California, December 1966, 46 pp.

(12) Barnard, W. Robert, Lagowski, J. J., and O'Connor, Rod, "Teaching Aids - The Modern Chemistry Classroom," Journal of Chemical Education, 1968 45 63-70.

(13) Barnard, W. Robert, and O'Connor, Rod, "Teaching Aids: Television for the Modern Chemistry Classroom, Part II," Journal of Chemical Education, 1968 45 745-749.

(14) Barnard, W. Robert, and Yingling, Richard T., "Prelaboratory Instruction Films," Unpublished mimeographed pamphlet, Ohio State University, Columbus, ca. 1968, 8pp.

(15) Bradley, Robert L., "Lecture Demonstration v. Individual Laboratory Work in a Natural Science Course at Michigan State University," Unpublished Ph.D. Dissertation, Michigan State University, East Lansing, Michigan, 1962, 68pp.

(16) Brandon, Julian, R., "Single Concept Film: A Pilot Study Based on CHEM Study Films," Journal of Research in Science Teaching, 1966 4 187-191.

(17) Broadwell, Martin M., "Successful Instructor Training in Industry," J. Eng. Educ., 1967 58(2) 132-134.

(18) Brown, Dean R., Michaels, Gene E., and Bledsoe, Joseph, C., "An Experiment In The Use of Film Slides In An Introductory Course in Microbiology," Journal of Research in Science Teaching, 1965 3 333-334.

(19) Brubacher, C. H. Jr., Schwendeman, R. H., and McQuarrie, D. A., "Live and Filmed Laboratories," Journal of Chemical Education, 1964 41 670-671.

(20) Camilla, Sister Mary, "Single Concept Film Loops," Catholic School Journal 1968 68 47ff.

(21) Castleberry, S., and Lagowski, J. J., "Individualized Instruction Using Computer Techniques," J. Chem. Educ., 1970 47 91-96.

(22) Coleman, George H., Wawzonek, Stanley, and Buckles, Robert E., "Laboratory Manual of Organic Chemistry," 2nd Edition, Prentice Hall, Englewood Cliffs, New Jersey, 1962, 218pp.

(23) Cowger, Richard W., "Retention of Film Content Under Conditions of Self Selection and Individual Viewing," Unpublished Ed.D. Dissertation, University of Oregon, Eugene, 1968.

(24) Dworkin, Solomon, and Holden, Alan, "An Experimental Evaluation of Sound Filmstrips v. Classroom Lectures," Audio Visual Communications Review, 1960 8 157.

(25) Edwards, Allen L., "Techniques of Attitude Scale Construction," Appleton-Century-Crofts, Inc., New York, 19__.

(26) Ellis, Henry C., Greenwood, Charles M. Lindberg, Howard P., and Moore, Richard K., "Effect of Repetition in Programmed Learning," I.E.E.E. Trans. on Educ. 1964 E-7 (1) 1-5.

(27) Foecke, H. A., "Effective Teaching and the Educational System," J. Eng. Educ., 1967 58(2) 117-21.

(28) Friedman, Milton, "A Comparison of Alternate Tests of Significance for the Problem of M Rankings," Ann. Math. Stat. 1940 11 86.

(29) Gausman, Chester H., and Vonnes, John, "The Single Concept Film-Tool for Individualized Instruction," American Vocational Journal 1969 44 14-17.

(30) Geller, Molly, "The Measurement of the Effectiveness of a Teaching Machine Program in the Organic Chemistry Area of First Year College Chemistry," Journal of Research in Science Teaching, 1963 1 154-161.

(31) Greenhill, Leslie P., "Electronic Aids to Learning," Electronics and Power 1965 11 54-56.

(32) Greenhill, Leslie P., and McNiven, Malcolm, "Relationship between Learning and the Perceived Usefulness of a Film," Audio Visual Communications Review 1956 4 255-267.

(33) Guilford, J. P., "Fundamental Statistics in Psychology and Education," 2nd Ed., McGraw-Hill Book Co., New York, New York, 1950, p. 495.

(34) Happe', L. B. K., "Development of the Educational Single Concept Film in Great Britain," J.S.M.P.T.E. 1963 72 679ff.

(35) Harby, S. F., "Evaluation of a Procedure for Using Daylight Projection of Film Loops in Teaching Skills," (Technical Report No. SDC 269-7-25 Instructional Film Research Program, Pennsylvania State College) AV Comm. Rev. 1953 1 291-2.

(36) Hart, Gardner L., "Navy Training Films Program," in Brock, Doris L., "New Tools for Instruction," Hinds, Haydn, and Eldridge, Inc., New York, 1948.

(37) Hart, Harold, and Schuetz, Robert D., "Organic Chemistry," 3rd Ed., Houghton Mifflin Co., Boston, 1966, 353 pp.

(38) Hendricks, B. Clifford, "Laboratory Performance Tests in Chemistry," Journal of Chemical Education, 1950 27 309f.

(39) Hermanson-Snickars, F., Jeppeson, B. I., and Wallmark, J. T., "Experiment with Pretesting of Programmed Texts," I.E.E.E. Trans. on Educ. 1968 E-11 (1) 37-41.

(40) Homman, Guy B., and Anderson, Kenneth E., "A Study of Several Factors and Their Relationship to Achievement in High School Chemistry By Use of Factorial Design and Covariance," Science Education 1962 46 269-282.

(41) Isbell, A. F., "Teaching Aids Program," Advisory Council on College Chemistry, Newsletter Nr. 10 (Serial Publication 28) Stanford, California, August 1967.

(42) Jeffery, Jack C., "Identification of Objectives of the Chemistry Laboratory and Development of Means for Measuring Student Achievement of Some of These Objectives," Unpublished Ph.D. Dissertation, University of Texas, Austin, 1967.

(43) Johnston, Raymond; Piel, Nicholas; Davis, Robert; and Hartsell, Horace, "Physiology 501 - Preparatory Laboratory, Michigan State University, Summer 1966," from N.D.E.A. Institute for Advanced Study in Educational Media, July 31-Sept. 1, 1967, Instructional Media Center, Michigan State University, East Lansing.

(44) Kanner, Joseph H., "The Instructional Effectiveness of Color in Television: A Review of the Evidence," (ERIC Clearinghouse on Educational Media and Technology,) AV Comm. Rev. 1968 16 333.

(45) Kemp, Jerrold E., and Szumski, Richard F., "8 Millimeter Film," Educational Screen & Audiovisual Guide, 1968 47 (7) 12-13.

(46) __________, "8 Millimeter Film II," Educational Screen & Audiovisual Guide, 1968 47 (10) 17ff.

(47) __________, "8 Millimeter Film, Part III," Educational Screen & Audiovisual Guide, 1968 47 (12) 19-20.

(48) Kennedy, Mannert, "BSCS Single Topic Films," American Biology Teacher, 1967 29 552-6.

(49) Knudsen, Steve, "Aspects and Applications of the Single Concept Film," J.S.M.P.T.E. 1963 72 295.

(50) Lewis, William C., "Technology for Education," J.S.M.P.T.E. 1968 77 1031-1033.

(51) Lumsdaine, A. A., "Audio-Visual Research in the U.S. Air Force," Audio Visual Communications Review, 1953 1 76-90.

(52) McTavish, Chester L., "Effect of Repetitive Film Showing on Learning," Technical Report SDC 269-712 Special Devices Center under contract with Pennsylvania State College, November, 1947.

(53) Matzkin, Myron A., "Can a $5.95 Splicer do a $299 Job?" Modern Photography, 1969 33 (72).

(54) May, Mark, and Lumsdaine, Arthur A., "Learning From Films," Yale University Press, New Haven, 1958, p. 18ff.

(55) Miller, Elwood E., "Single Concept Films: Criteria for Clipping," Audio Visual Instruction, 1967 12 36-38.

(56) Miller, Elwood, and Bollmann, Charles G., "The Case for the Short Film" J.S.M.P.T.E. 1968 77 1046-1048.

(57) Morrison, Robert T., and Boyd, Robert N., "Organic Chemistry," 2nd Ed., Allyn & Bacon, Inc., Boston, 1966, 1204pp.

(58) Myers, Nat C. Jr., "Automatic Cartridge 8mm Sound Film Loop Application in Education: A Progress Report," J.S.M.P.T.E. 1966 75 1132f.

(59) Nelson, Kenneth G., and Pella, Milton, O., "Evaluation of the Adapted Harvey White Physics Films in Turkey," Science Education 1961 45 284-293.

(60) Noall, Matthew F., and Wingert Lerue, "Staff Utilization Studies Help With Education: B The Physics Film Project," Bulletin of the National Association of Secondary School Principals, 1959 43 183-95.

(61) O'Connor, Rod, "Status of the AC_3 Film Program," Advisory Council on College Chemistry, Newsletter Nr. 17 (Serial Publication 30) Stanford, California, October 1967.

(62) O'Connor, Rod, and Slabaugh, Wendell, "Teacher-Produced Instructional Films in Chemistry," Advisory Council on College Chemistry, Serial Publication 31, Stanford, California, December, 1967, 33p.

(63) Popham, W. James, "Educational Statistics," Harper and Row, New York, 1967.

(64) Popham, W. James, and Sadnavitch, Joseph M., "Filmed Science Courses in the Public Schools, an Experimental Appraisal," Science Education 1961 45 327-335.

(65) Purdue Research Foundation, Preparation & Evaluation in Use of a Series of Brief Films of Selected Demonstrations From the Introductory Physics Course. Final Report to the U.S. Office of Education, August 31, 1961, p. 36.

(66) Requa, Lyle Keith, "An Analysis of Two Methods of Teaching Biological Sciences Laboratory," Unpublished Ed.D. Dissertation, Oklahoma State University, Stillwater, 1966.

(67) Ridgeway, David W., "The Success Story of CHEM Study," Educational Screen and Audiovisual Guide 1967 46 (10) 23-25.

(68) Rodewald, L. B., Culp, G. H., and Lagowski, J. J., "The Use of Computers in Organic Chemistry Instruction," J. Chem. Educ., 1970 47 (2) 134-136.

(69) Rogers, Carl R., "On Becoming a Person," Hogg Research Foundation For Mental Health, University of Texas, Austin, 1954.

(70) Rosenstein, Alvin J., and Kanner, Joseph H., "Television and Army Training: Color v. B&W," AV Comm. Rev. 1961 9 (1) 44-9.

(71) Sadnavitch, Joseph M., and Popham, W. James, "Measuring Attitudes Toward Filmed Courses," Audio Visual Communications Review 1960 8 286-288.

(72) Sadnavitch, Joseph M., Popham W. James, and Black, W. A., "Retention Value of Filmed Science Course," Science Education 1962 46 22-27.

(73) Scuorzo, Herbert E., "Big Boom in Loops," Grade Teacher, 1966 83 (2) 80f.

(74) __________, "Single Concept Film," Grade Teacher, 1964 81 (5) 15ff.

(75) Sharefkin, Jacob, "Perspectives in Organic Chemistry Instruction," Journal of Chemical Education, 1949 26 222-223.

(76) Siegel, Laurence, (ed) "Instruction - Some Contemporary Viewpoints," Chandler Publishing Co., San Francisco, 1967, 276pp.

(77) __________, "The Instructional Gestalt: A Conceptual Framework," Teachers College Record, 1960 62 202-213.

(78) Siegel, Laurence, Macomber, F. G., and Adams, James F., "The Effectiveness of Large Group Instruction at the University Level," Harvard Educational Review, 1959 29 216-26.

(79) Siegel, Laurence, and Siegel, Lila Corkland, "The Instructional Gestalt: A Conceptual Framework and Design for Educational Research," Audio Visual Communications Review, 1964 12 16-45.

(80) Siegel, Sidney, "Non Parametric Statistics," McGraw-Hill Book Co., New York, 1956.

(81) Sleeman, Phillip J., and Crosswhite, Vivian, "The 8mm Film Revolution," Audio Visual Instruction, 1968 13 880-2.

(82) Stein, Sarah C., "An Experimental Study of the Use of Motion Picture Film Loops in the Instruction of Beginning Typewriting," Unpublished Doctoral Dissertation, University of Southern California, Los Angeles, 1968.

(83) Steiner, Richard L., "Using Audiovisual Materials in Presenting Investigative Laboratory Projects," American Biology Teahcer, 1966 28 404-5.

(84) Strum, R. D. and Ward J., "Some Comments on Computer Assisted Instruction in Engineering Education," I.E.E.E. Trans. on Educ., 1967 E-10 (1) 1-3.

(85) Tabutt, Frederick, D., "Computers in Chemical Education," Chem and Eng. News, 1970 48(3).

(86) Trinklein, Lloyd A., "A Comparative Study of the Effectiveness of Using Full Film and Short Format Films to Teach Chemistry," Unpublished Ph.D. Dissertation, Michigan State University, East Lansing, 1966.

(87) Tukey, John W., "Conclusions Vs. Decisions," Technometrics 1960 2 423-433.

(88) Vander Meer, A. W., "Relative Effectiveness of Color and Black and White in Instructional Films," Audio Visual Communications Review 1960 8 156.

(89) Wendt, Paul R., and Butts, Gorden K., "Audio Visual Materials," Review of Educational Research, 1962 32 (2) 149-155.

(90) Wittich, W. A.; Pella, Milton, O.; and Wedemeyer, C. A., "The Wisconsin Physics Film Evaluation Project," Audio Visual Communications Review 1960 8 156.

(91) Woodruff, Asahel, D., "Basic Concepts of Teaching," Chandler Publishing Co., San Francisco, 1962.

(92) Yager, Robert E.; Engen, Harold B.; and Snider, Bill F. C., "Effects on Laboratory & Demonstration Methods Upon the Outcomes of Instruction in Secondary Biology," Journal of Research in Science Teaching 1969 6 76-86.

(93) Young, Alfred F., "A Comparative Study of Supplimentary Programmed and Conventional Methods of Instruction in Teaching Freshman Chemistry 1015 at Oklahoma State University," Unpublished Doctoral Dissertation, Oklahoma State University, Stillwater, 1970.

APPENDIX A

JH_2S EXAMINATION

JH_2S EXAMINATION

I N T R O D U C T O R Y   O R G A N I C   C H E M I S T R Y

L A B O R A T O R Y   T E C H N I Q U E S   E X A M I N A T I O N

Please do not open this test booklet until instructed to do so.

DO NOT MARK ON THE QUESTION BOOKLETS

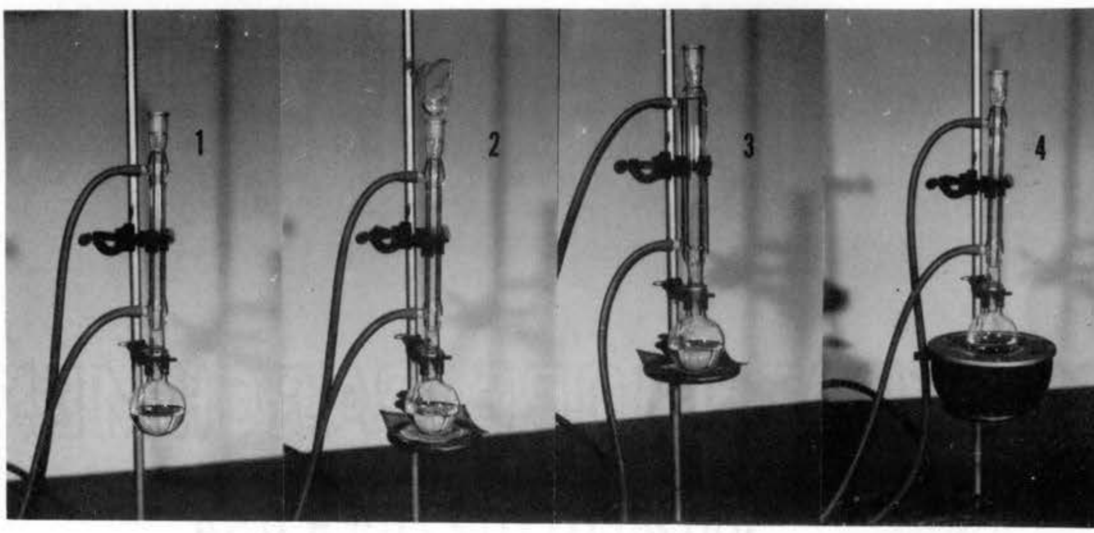
Select what you consider to be the BEST answer. DO NOT MARK MORE THAN ONE ANSWER.

Questions 1 through 3 refer to photographs 1, 2, 3, 4.

1. Which would be suitable for heating a solution whose boiling point is 123°C and whose vapors are rather flammable?
   A) 1; B) 2; C) 3; D) 4; E) Either 1 or 3.

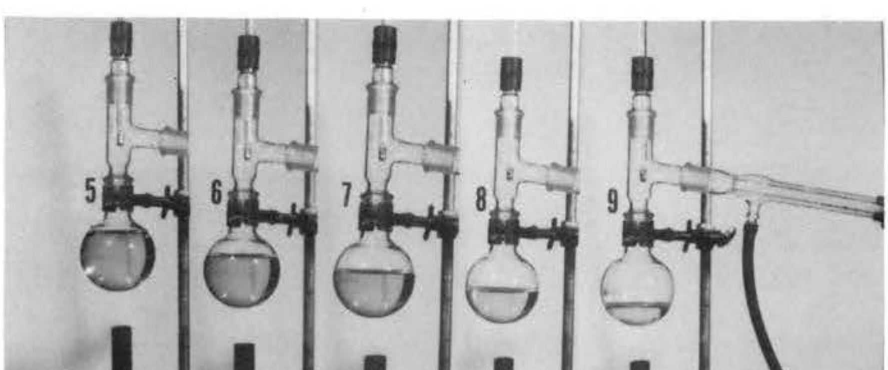
2. Which would be suitable for heating a solution whose boiling point is 60°C and whose vapors are not flammable?
   A) Any of them; B) 1, 2, or 3; C) Only 3; D) 1 or 3; E) 1 or 2.

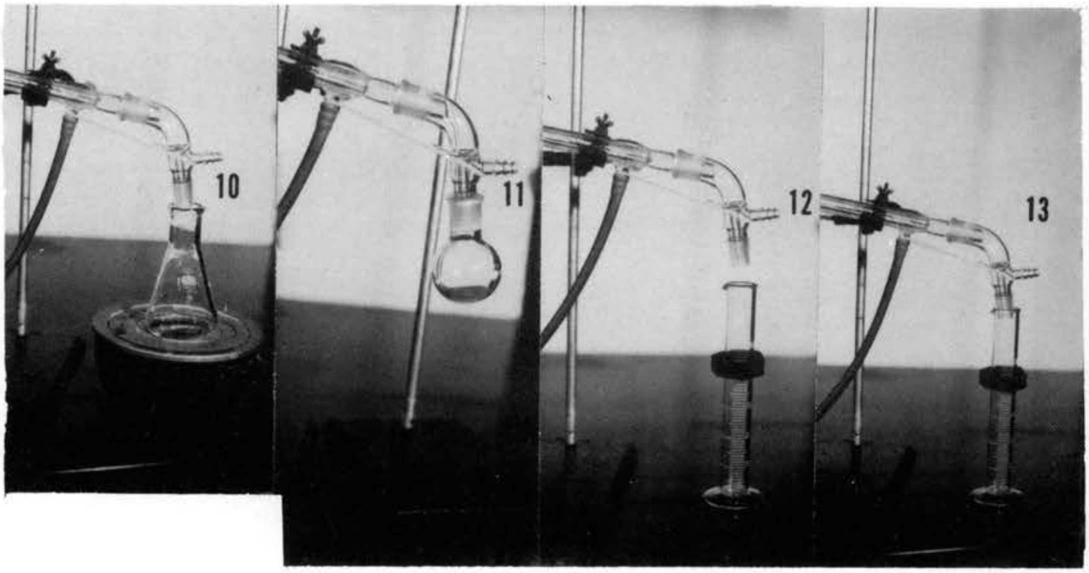
3. Which would be suitable for warming but not necessarily boiling a solution whose vapors are extremely flammable?
   A) 1; B) 2; C) 3; D) 4; E) None of them.



4. Refer to photographs 5 through 9. Which of them would be proper for commencing a distillation?
   A) Any of them; B) 6 through 9; C) 7 through 9; D) 6 through 8; E) 7 through 8.

5. You will notice that the boiling chips have been left out of the above flasks. When should the boiling chips be added?
   A) Before the liquid was added; B) After the liquid was added; C) After the liquid has been warmed; D) A or B; E) B or C.





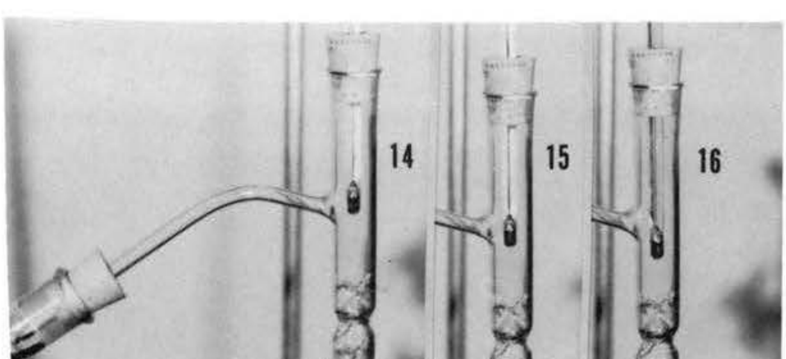
Questions 6 through 8 refer to photographs 10, 11, 12, 13.

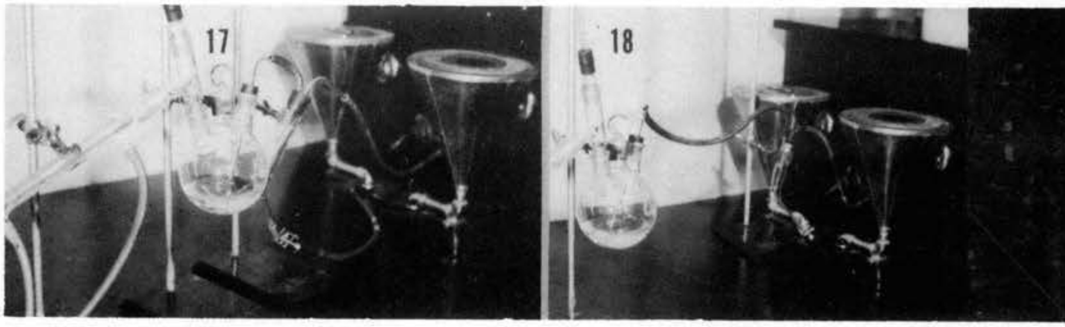
6. Which of the methods of receiving the distillate would be suitable to collect a distillate which was flammable?
A) 10; B) 11; C) 12; D) 13; E) None of them.

7. Which of the methods would be suitable to collect a distillate when one wished to measure the time and volume delivered?
A) 10; B) 11; C) 12; D) 13; E) Either none of them or both 12 and 13.

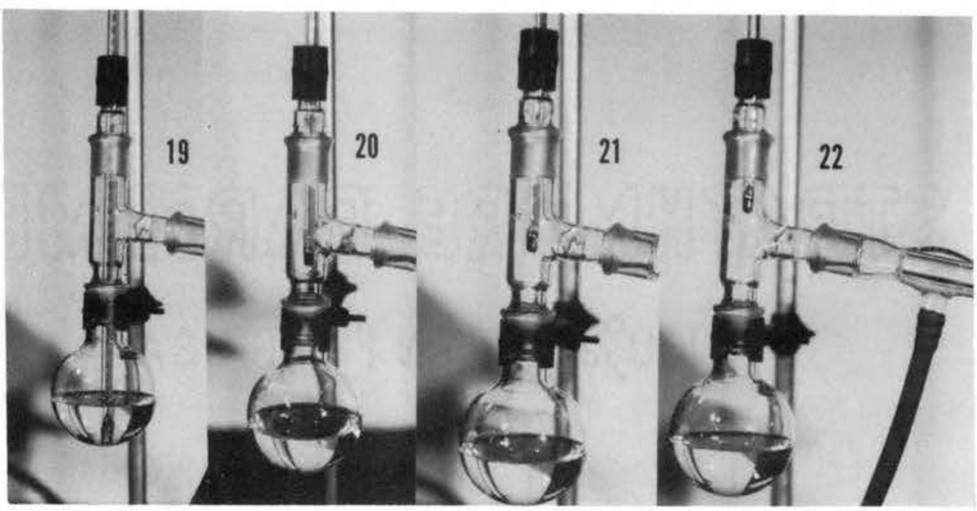
8. What is wrong with photograph #10?
A) Nothing--it is correct; B) Should use a round bottom flask; C) Neck of flask should be positioned higher; D) Flask should be clamped or should be resting on the table rather than sitting on a water bath; E) It is the wrong size flask.

9. Refer to photographs 14 through 16. Which of the thermometer positions will yield the correct temperature of the distilling vapors?
A) 14; B) 15; C) 16; D) Either 14 or 15; E) Actually there will be no significant difference in the temperature readings.





10. Refer to photographs 17 and 18. If it is necessary to move the steam distillation away from the source of steam, which would be preferable?
A) 17; B) 18; C) Either; D) Neither; E) Use a larger steam line.



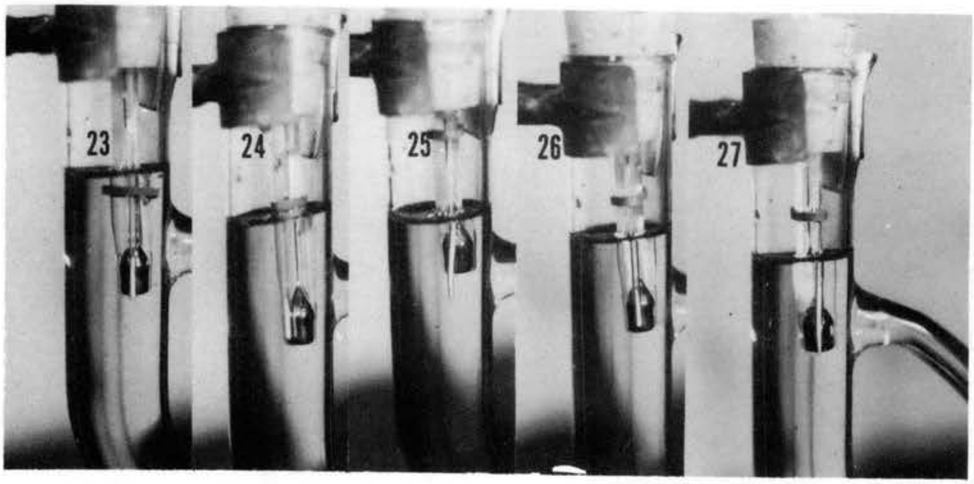
Questions 11 through 14 refer to photographs 19, 20, 21, 22.

11. Which of the thermometer positions will yield the temperature of the distilling vapors?
A) 19; B) 20; C) 21; D) 22; E) 20, 21, and 22.

12. Which of the thermometer positions will produce the highest reading?
A) 19; B) 20; C) 21; D) 22; E) They will all read the same.

13. Which of the thermometer positions will produce the lowest reading?
A) 19; B) 20; C) 21; D) 22; E) They will all read the same.

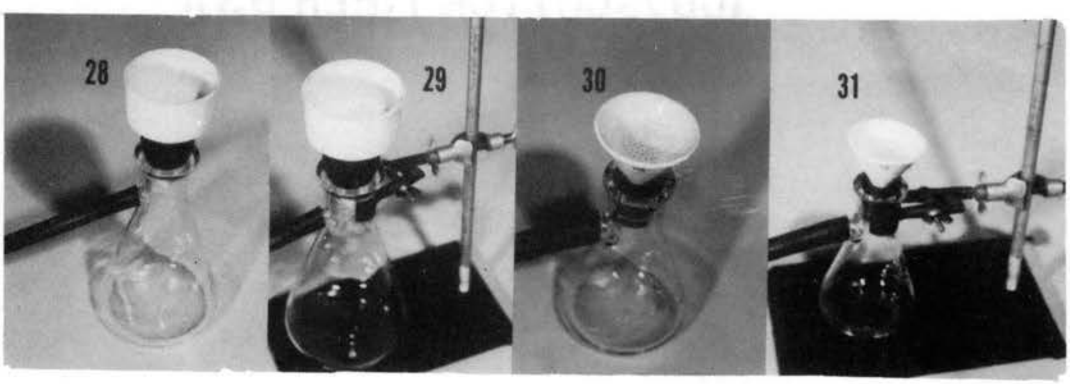
14. Which of the thermometer positions will indicate the temperature of the boiling liquid?
A) 19; B) 20; C) 21; D) 22; E) None of them.



15. **Which of the following will yield the most desirable melting point information?**
A) 23; B) 24; C) 25; D) 26; E) 27.

16. If you were not completely satisfied with the choices in the preceding question, what changes would you make?
A) None except 24, 26, and 27 are correct; B) Raise the thermometer bulb on 24 or 26; C) Lower the thermometer bulb on 26 or 27; D) Lower the thermometer bulb on 26; E) Properly fill the capillaries.

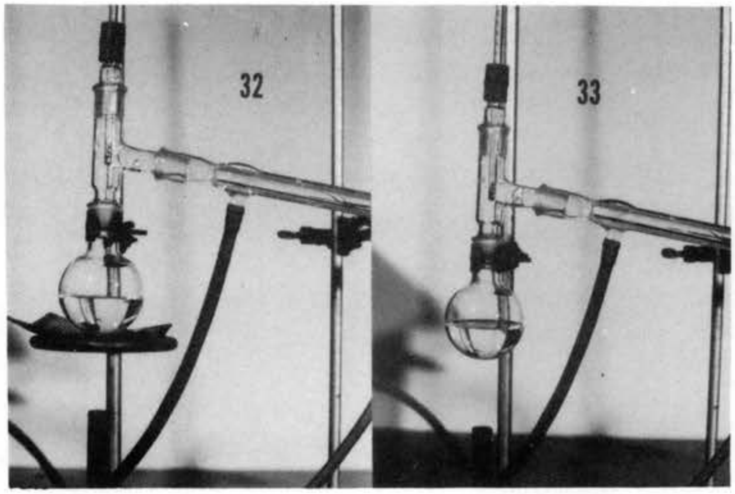
17. What is wrong in photograph 24?
A) Nothing (except the tube was not clamped in a vertical position);
B) The liquid will expand upon heating and push the cork out;
C) The liquid will expand upon heating and touch the rubber ring;
D) The thermometer bulb is low;
E) Capillary is improperly filled.



18. Which would be the proper set-up for filtering approximately 150 ml of a solution which contains about 10 grams of precipitate?
A) 28 or 29; B) 30 or 31; C) 28 or 30; D) 29 or 31; E) Only 29.

19. Which would be the proper set-up for filtering about ten ml of a solution which contains about a gram of precipitate?
A) 28; B) 29; C) 30; D) 31; E) More than one would be proper.

20. During a filtration if one notices that the filtering action slows down even though the paper is not clogged with precipitate, which of the following is most likely the reason?
A) Water pressure was turned down; B) Holes in the filter paper; C) Thin wall rubber tubing has collapsed; D) Filter paper was too fine a porosity; E) Not enough information given.



21. Which of these distillation set-ups would be suitable for the distillation of a flammable liquid?
A) 32; B) 33; C) Both;
D) Neither; E) 32 if there are no leaks.

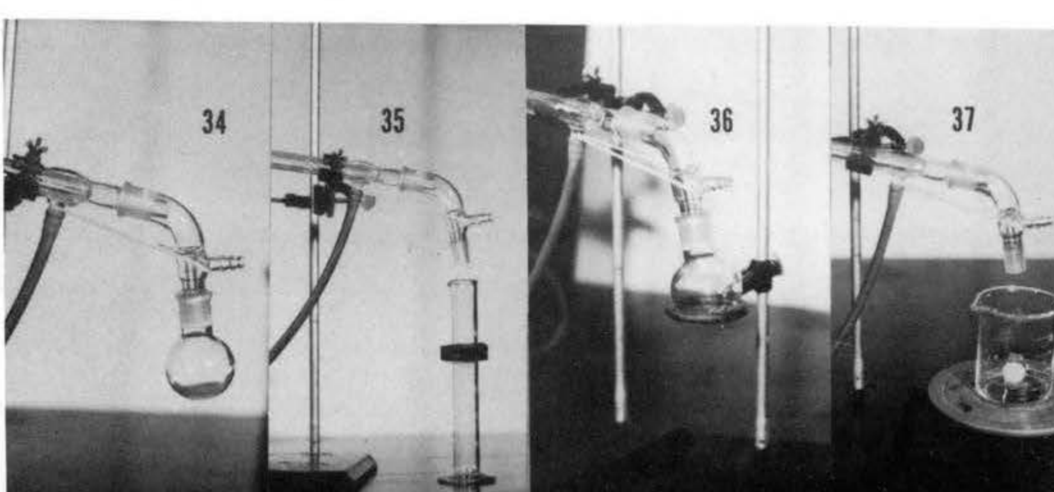
22. Which of these would be suitable for the distillation of a high boiling non-flammable liquid?
A) 32; B) 33; C) Both;
D) Neither; E) 32 if there are no leaks.

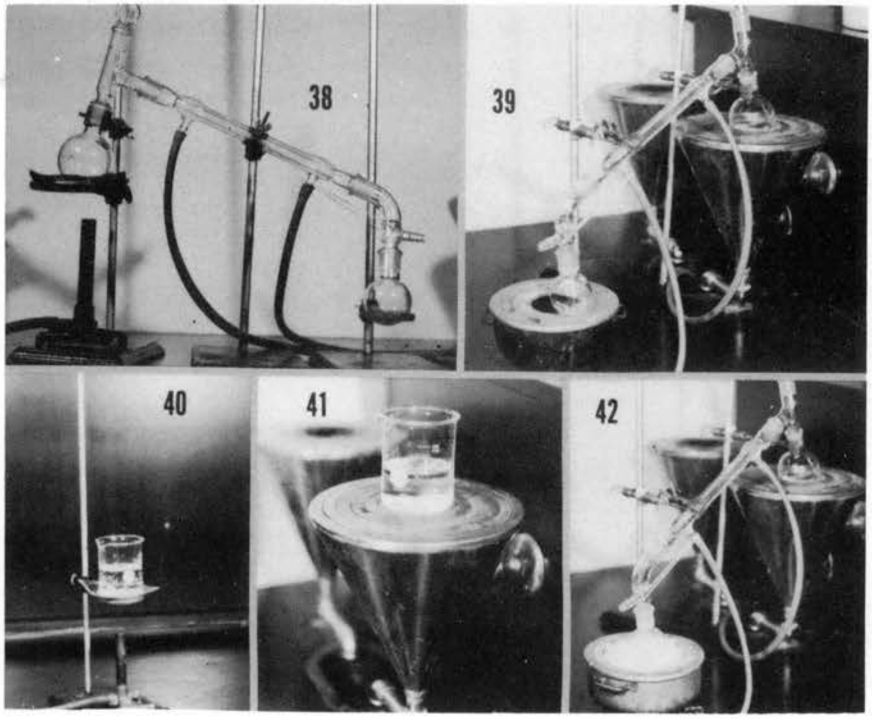
23. Which of the receivers would be suitable for a flammable distillate?
A) 34; B) 35; C) 36; D) 37; E) Either none or more than one.

24. Which of the methods is least desirable (least safe?)
A) 34; B) 35; C) 36; D) 37; E) 35 and 37.

25. Which of the methods would be suitable for collecting a distillate which will be discarded?
A) 34; B) 35; C) 36; D) 37; E) Any of them.

26. What is wrong with 36?
A) The flask should be clamped with a utility clamp rather than rest on an iron ring; B) The receiver should be positioned lower; C) The rubber band should extend down to the rim on the neck of the flask; D) It is the wrong size flask; E) Nothing: it is correct.





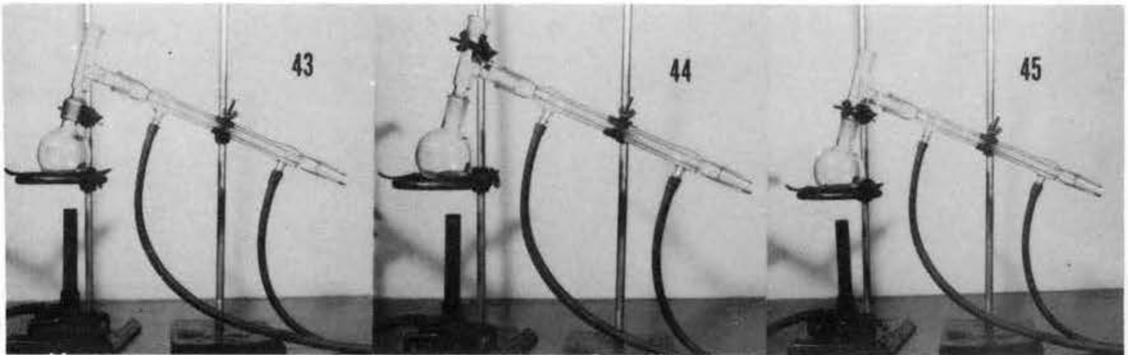
27. Which would be most suitaple for concentrating an aqueous solution?
A) 38; B) 39; C) 40; D) 41; E) 42.

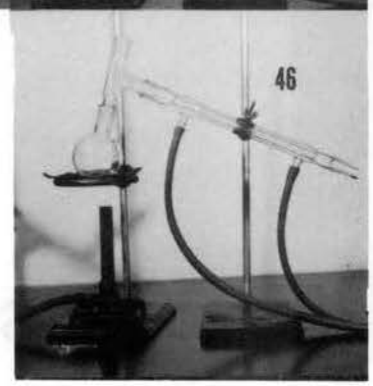
28. Which would be most suitable for heating a solvent such as methyl ethyl ketone?
A) 38; B) 39; C) 40; D) 41; E) 42.

29. Which would be most suitable for removing ether from an extraction?
A) 38; B) 39; C) 40; D) 41; E) 42.

30. The best method for drilling a hole in a cork is
A) from the small end; B) from the large end; C) from either end; D) from one end to about the middle then drill from the other; E) makes little difference if the cork borer is sharp.

31. What general rule is always followed in the placement of tubing on a water cooled condenser for reflux or distillation?
A) The end toward the boiling flask is the outlet (to the sink) and the other end is the water inlet.
B) The end toward the boiling flask is the water inlet and the other end is the outlet and goes in the sink.
C) The lower end is the water inlet and the upper end is the outlet.
D) The upper end is the water inlet and the lower end is the outlet.
E) None of the above because reflux goes one way and distillation goes just the opposite.

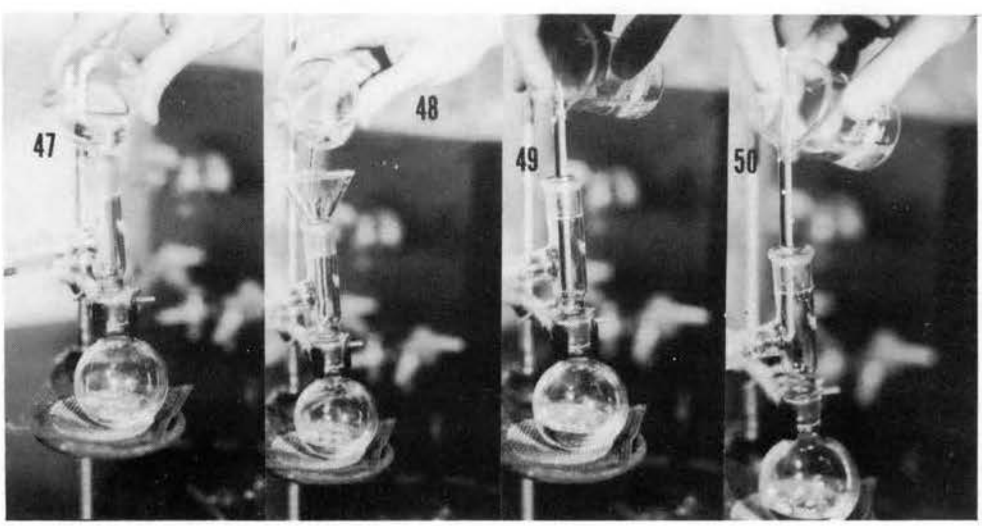


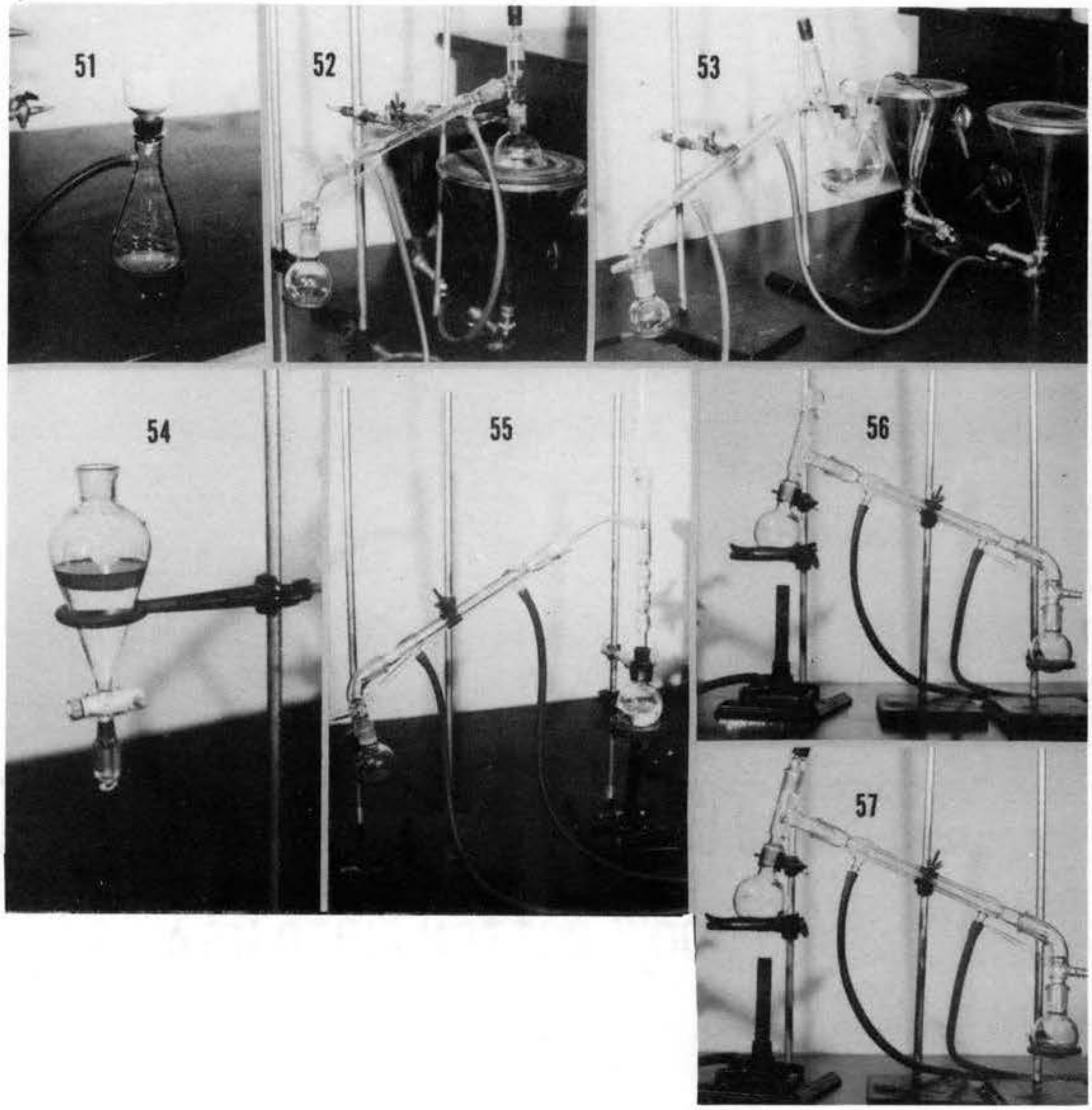


32. Which distillation set-up is properly clamped?
    A) 43; B) 44; C) 45; D) 46;
    E) Either none or more than one.

33. What would you add next to the system?
    A) receiver; B) receiver adapter;
    C) thermometer; D) water in the condenser; E) the liquid to be distilled.

34. Which is the proper method for filling the distilling flask?
    A) 47 or 48; B) 49 or 50; C) 48 or 49; D) 47 or 50; E) Only one.



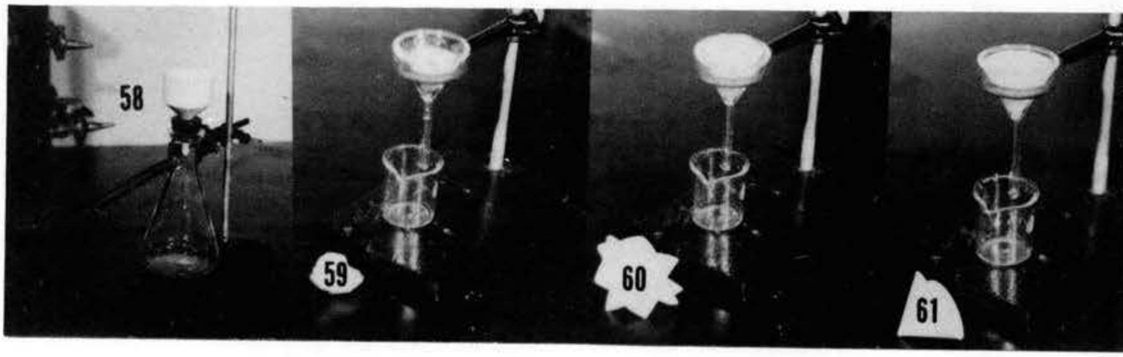


35. Which would be most suitable for separating a mixture of cyclohexanol and water?
A) 51; B) 53; C) 54; D) 55; E) Either 52, 56, or 57.

36. Which would be most suitable for separating a mixture of hydrocarbons?
A) 52; B) 53; C) 55; D) 56 or 57; E) 52 or 55.

37. Which would be most suitable for separating acetanalide from water?
A) 51; B) 52; C) 53; D) 54; E) 55.

38. Which would be most suitable for the separation of volatile water-insoluble components from non-volatile components?
A) 52; B) 53; C) 55; D) 56; E) 57.



39. Which would be most convenient for removing decolorizing carbon from a solution?
A) 58; B) 59; C) 60; D) 61; E) More than one is correct.

40. Which would be most convenient for removing calcium chloride from an ether solution?
A) 58; B) 59; C) 60; D) 61; E) More than one is correct.

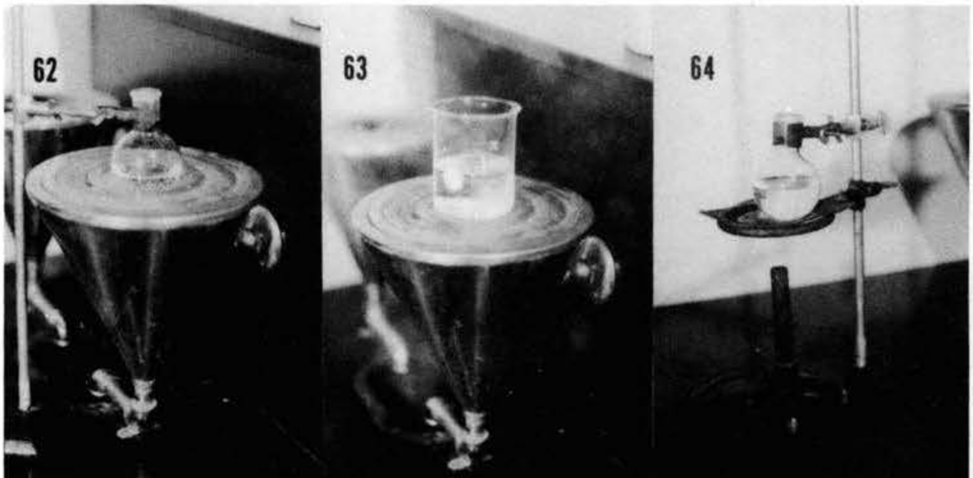
41. Which of the methods is most rapid?
A) 58; B) 59; C) 60; D) 61; E) More than one is correct.

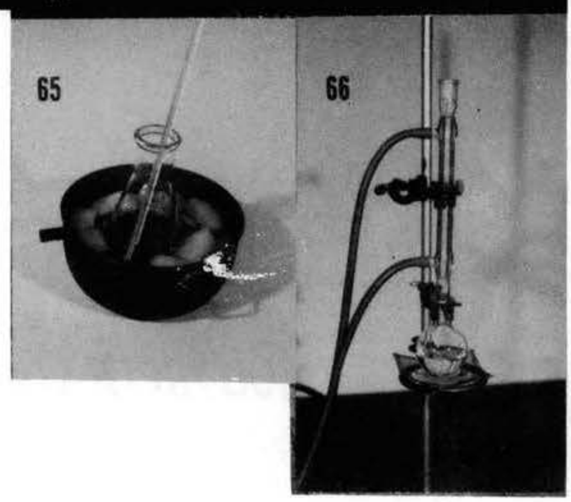
42. If during a diazotization reaction one needed to add 15 ml of a nitrite solution, which of the following would be best?
A) All of the 15 ml poured in rapidly with stirring.
B) Three portions of about 5 ml each with stirring.
C) Portions of about 1 ml each minute with stirring.
D) One drop every three or four seconds with stirring.
E) One drop every thirty seconds with stirring.

43. Which is the best method for determining whether a particular solution is acidic or basic?
A) Dip a piece of litmus paper in the solution.
B) Dip a piece of both red and blue litmus paper in the solution.
C) Dip a stirring rod in the solution and touch the wet rod to red and blue litmus.
D) Use a pH meter.
E) More than one of the above is correct.

44. The safest method for getting rid of excess dodium metal left over from a sodium fusion is to
A) place it carefully in a large beaker of water.
B) place it in a quantity of alcohol.
C) bury it in dry sand or earth.
D) cover it with powdered sulfur (flowers of sulfur.)
E) place it in the sink with plenty of running water.

45. If one suspects nitrogen in a sample and the test of the sodium fusion yields a barely discernable green, what should you do next?
A) Report 'no nitrogen present.'
B) Report 'nitrogen present.'
C) Filter the solution and look for traces of blue on the paper.
D) Repeat the sodium fusion and nitrogen test.
E) Repeat the nitrogen test on another portion of the fusion extract.





46. Which of the following would be most suitable for the reaction between ethanol and acetic acid?
A) 62; B) 63; C) 64; D) 65; E) 66.

47. Which would be most suitable for the diazotization of aniline?
A) 62; B) 63; C) 64; D) 65; E) 66.

48. Which would be most suitable to heat a solvent for recrystallization such as isopropyl alcohol?
A) 62; B) 63; C) 64; D) 66; E) Either 62 or 63.

49. Which would be most suitable for a saponification ıeaction?
A) 62; B) 63; C) 64; D) 65; E) 66.

50. What would be the best means of getting rid of excess benzen
A) Pour it down the sink (with plenty of water). B) React it with ethanol and then pour it down the sink; C) Pour it into the waste jar in the hood; D) Bury it in dry sand, earth, or vermiculite; E) Allow it to evaporate in the hood.

APPENDIX B

GROUP 100

Stud. NR	JH_2S	Chem Hrs	Lab Hrs	Chem GPA	GPA	Entry Skills	Exit Skills	Net Skills
101	17	8	4	2.500	2.900	95	232	137*
102	18	15	6	1.500	1.500	154	267	113*
103	-	10	4	2.500	2.590	153	-	-
104	19	8	4	2.000	2.100	144	373	229*
105	17	10	4	3.400	3.500	84	258	197
106	20	8	4	2.000	2.030	120	276	156
107	24	10	4	2.500	3.200	99	-	-
108	-	6	3	3.000	2.810	108	-	-
109	24	7	3	3.430	2.210	108	344	236*
110	13	8	4	3.500	2.800	85	247	162*
111	23	8	4	3.500	2.410	106	301	195
112	19	8	4	3.500	3.050	82*	-	-
113	15	10	4	2.500	2.500	158	240	88*
114	14	13	6	2.380	3.200	90	295	205*
115	26	8	4	2.500	2.300	125	275	150*
116	16	18	7	3.170	3.520	91	237	146
117	23	8	4	3.000	3.620	123	245	122
118	25	5	2	3.000	3.200	119	268	149*
119	17	10	4	2.000	2.650	112	278	166*
120	25	8	4	3.000	3.550	128	299	171
121	21	8	4	3.000	3.240	107	330	223*
122	22	10	4	3.000	3.030	97	245	148
123	22	10	4	2.500	2.200	145	343	198*
124	19	10	4	2.000	2.900	116	291	175*
Totals		208	94	59.880	61.610			
Mean		9.46	4.27	2.722	2.801			

GROUP 200

Stud. NR	JH_2S	Chem Hrs	Lab Hrs	Chem GPA	GPA	Entry Skills	Exit Skills	Net Skills
201	24	16	8	2.000	2.300	107	294	187
202	15	10	4	3.000	2.600	86	263	177
203	12	8	4	3.500	3.870	103	283	180
204	22	5	2	4.000	3.460	90	254	164
205	-	10	4	4.000	2.500	86	243	157
206	20	8	4	2.500	2.500	99	361	262
207	23	8	4	2.000	2.700	74	243	169
208	17	14	6	2.640	2.650	-	-	-
209	20	8	4	3.500	3.750	101	300	199
210	-	8	4	2.500	2.400	116	274	158
211	23	10	4	4.000	3.200	117	313	196
212	16	8	4	2.000	2.800	164	349	185
213	23	8	4	2.000	2.920	123	318	195
214	24	8	4	2.500	3.500	90	271	181
215	27	8	4	2.500	2.000	92	292	200
216	19	8	4	4.000	3.700	137	344	207
217	20	8	4	4.000	3.750	97	283	186
218	22	10	4	2.000	2.500	104	295	191
219	18	8	4	3.000	3.500	102	325	223
220	21	8	4	2.000	2.850	97	302	205
221	23	7	2	2.720	2.900	113	322	209
222	18	7	2	2.000	2.700	105	333	228
223	29	5	2	3.000	3.200	140	323	183
224	22	10	4	2.000	2.800	93	223	130
225	19	8	4	3.500	3.460	104	250	146
Totals		198	90	64.360	69.610			
Mean		8.60	3.91	2.798	3.026			

GROUP 300

Stud. NR	JH_2S	Chem Hrs	Lab Hrs	Chem GPA	GPA	Entry Skills	Exit Skills	Net Skills
301	28	20	5	2.500	2.680	133	276	143
302	24	8	4	3.000	3.000	178*	296	118
303	24	10	4	2.670	2,000	117	339	222
304	18	10	4	1.500	1,900	-	-	-
305	27	15	7	3.330	3.330	91	246	155
306	29	10	4	4.000	3.200	128	257	129
307	-	-	-	-	-	-	-	-
308	27	8	4	3.500	3.300	109	273	164
309	27	8	4	2.500	2.700	112	298	186
310	18	12	6	3.670	3,670	121	249	128
311	24	8	4	2.500	2.950	90	350	260
312	27	8	4	2,500	2.750	108	315	207
313	24	8	4	2.000	2.970	125	309	184
314	25	8	4	2.500	2.750	99	293	194
315	23	14	4	1.890	2.000	92	305	213
316	30	5	2	3.000	3.000	105	256	151
317	25	10	4	3.500	2.400	111	290	179
318	23	10	4	1.500	2.400	143	-	-
319	37	8	4	4.000	4.000	103	269	166
320	26	5	2	3.000	2.890	100	332	232
321	29	8	4	3.500	3.100	99	237	138
322	22	10	4	2.500	2.500	96	285	189
323	23	10	4	2.000	2.000	137	326	189
324	-	-	-	-	-	-	-	-
Totals		213	90	60.960	61.490			
Mean		9.68	4.09	2.770	2.795			

GROUP 400

Stud. NR	JH_2S	Chem Hrs	Lab Hrs	Chem GPA	GPA	Entry Skills	Exit Skills	Net Skills
401	22	8	4	2.000	2.790	77	141	74
402	16	8	4	4.000	3.500	104	400	296
403	-	10	4	3.000	2.600	116	0	0
404	24	38	15	2.900	2.500	177	355	178
405	25	8	4	4.000	3.570	94	220	126
406	28	13	7	2.540	2.500	83	306	223
407	-	10	4	2.000	2.400	143	336	193
408	18	8	4	3.000	2.600	113	252	139
409	24	8	4	3.500	3.000	104	293	189
410	19	8	4	3.500	3.860	97	260	163
411	16	8	4	2.500	3.230	125	355	230
412	31	8	4	4.000	3.790	89	321	232
413	18	8	4	2.000	3.100	92	357	165
414	-	10	4	2.500	2.500	119	349	230
415	22	8	4	3.000	3.450	117	285	168
416	19	10	4	2.000	2.000	95	295	200
417	16	8	4	2.500	2.420	77	280	203
418	22	16	7	3.180	3.300	109	336	227
419	17	8	4	4.000	3.350	110	344	234
420	19	10	4	3.000	2.800	180	339	159
421	-	18	4	1.500	2.000	119	-	-
422	20	10	4	2.500	3.100	111	310	199
423	19	9	4	1.000	1.570	98	228	130
424	-	-	-	-	-	-	-	-
Totals		202	93	55.120	56.430			
Mean		10.63	4.89	2.901	2.970			

GROUP 500

Stud. NR	JH_2S	Chem Hrs	Lab Hrs	Chem GPA	GPA	Entry Skills	Exit Skills	Net Skills
501	21	10	4	4.000	3.400	107	332	225
502	20	8	4	2.500	2.400	123	333	210
503	19	7	2	2.430	2.600	116	353	237
504	20	8	4	1.500	2.100	94	337	243
505	20	8	4	3.000	3.200	120	331	211
506	20	8	4	2.500	2.980	126	-	-
507	23	8	4	2.500	3.000	76	307	231
508	-	10	6	3.310	3.400	115	306	191
509	-	8	4	2.500	2.200	-	-	-
510	22	8	4	2.500	2.400	82	333	251
511	18	8	4	3.000	3.350	94	326	232
512	-	8	4	2.500	2.800	111	-	-
513	20	8	4	3.000	3.450	115	280	165
514	21	8	4	2.000	2.400	75	309	234
515	18	19	5	2.000	2.000	112	352	240
516	-	9	4	3.560	2.700	71	295	224
517	18	10	4	2,000	2.710	73	263	190
518	20	12	6	2.000	2.100	91	357	266
519	-	9	4	2.000	2.100	80	-	-
520	27	8	4	3.000	3.700	75	263	113
Totals		146	61	37.930	41.790			
Mean		9.12	3.81	2.370	2.611			

GROUP 600

Stud. NR	JH_2S	Chem Hrs	Lab Hrs	Chem GPA	GPA	Entry Skills	Exit Skills	Net Skills
601	26	5	4	3.000	3.000	107	300	193
602	22	12	6	3.330	3.600	95	305	210
603	26	7	4	1.290	2.200	148	277	129
604	20	8	4	2.500	3.130	95	294	199
605	21	10	4	2.000	2.200	130	357	227
606	25	9	4	2.560	3.300	102	354	252
607	25	8	4	2.000	2.400	108	298	150
608	26	8	4	2.000	2.100	126	374	248
609	17	10	4	-	-	140	181	41
610	26	8	4	3.500	3.600	133	282	149
611	11	8	4	3.500	3.500	104	327	223
612	20	10	4	3.500	3.200	108	309	201
613	18	10	4	3.000	2.600	111	330	219
614	23	10	4	2.000	2.03	154	367	213
615	17	8	4	3.500	3.400	82	358	276
616	28	8	4	2.500	2.500	112	313	201
617	24	7	2	2.430	2.350	128	353	225
618	23	18	6	2.890	3.540	112	371	259
619	-	4	4	1.500	2.600	152	-	-
620	22	9	4	2.000	2.600	103	331	228
621	25	9	4	3.000	3.000	112	300	188
Totals		182	82	50.500	54.250			
Mean		9.10	4.10	2.657	2.855			

GROUP 700

Stud. NR	JH_2S	Chem Hrs	Lab Hrs	Chem GPA	GPA	Entry Skills	Exit Skills	Net Skills
701	23	10	4	4.000	2.800	96	319	223
702	17	8	3	2.000	2.700	101	265	164
703	-	8	4	2.000	2.500	77	-	-
704	22	8	4	2.000	2.600	104	317	213
705	17	8	4	2.500	3.410	102	330	228
706	16	8	4	2.000	2.790	116	312	196
707	19	8	4	2.000	2.500	101	275	174
708	22	8	4	3.500	3.100	90	343	253
709	23	10	4	4.000	2.800	101	291	190
710	19	8	4	2.000	2.890	132	313	181
711	-	8	4	2.000	3.000	121	282	161
712	17	10	4	2.000	2.700	124	-	-
713	17	8	4	3.000	3.200	143	320	177
714	18	8	4	2.500	2.970	101	305	204
715	15	8	4	3.500	3.600	89	335	157
716	21	5	2	3.000	3.200	115	281	166
717	19	8	4	3.000	3.700	110	254	144
718	28	8	4	3.000	2.800	110	292	182
719	17	8	4	2.500	2.900	111	165	54
720	16	8	4	2.000	2.600	111	273	162
721	22	13	5	2.000	2.920	111	293	182
722	25	8	4	2.000	2.750	113	309	196
723	18	8	4	3.500	3.400	112	302	190
724	-	8	4	2.000	3.111	139	-	-
Total		176	82	56.000	62.330			
Mean		8.38	3.90	2.666	2.968			

APPENDIX C

EXPERIMENT #1 (Films 1, 2, 3, 4, 5, 6, 7) Crystallization

Student Number	100	200	300	400	500	600	700
1	150	105	110	150	105	-	150
2	150	120	140	165	140	120	115
3	150	120	135	155	100	120	120
4	150	110	125	165	135	135	120
5	165	120	125	120	140	125	110
6	160	110	125	155	95	-	110
7	150	120	125	165	105	115	95
8	150	70	120	165	105	140	120
9	150	120	140	150	-	140	110
10	150	120	150	130	120	135	120
11	150	130	120	150	90	130	90
12	140	130	120	150	95	120	-
13	150	120	125	150	120	140	90
14	150	120	135	155	150	140	135
15	150	120	130	130	110	135	120
16	150	120	135	120	120	130	170
17	150	120	130	165	140	115	150
18	150	115	125	165	130	140	120
19	165	120	140	150	-	130	120
20	165	120	135	150	-	120	150
21	150	120	135	160	120	140	120
22	115	110	140	150	-	-	120
23	135	90	120	150	-	-	120
24	150	120	-	-	-	-	150
25	-	115	-	-	-	-	-
Total	3595	2885	3015	3465	2120	2470	2825
NR	24	25	23	23	18	19	23
Mean	149.79	115.40	131.59	150.65	117.78	130.00	122.83

EXPERIMENT #2 (Films 8, 9, 10) Melting Points

Student Number	100	200	300	400	500	600	700
1	165	75	140	120	60	-	105
2	135	120	160	140	60	135	165
3	150	105	135	140	70	120	90
4	165	130	165	120	120	140	100
5	165	145	150	135	90	120	110
6	165	110	135	120	105	120	75
7	160	90	120	100	120	120	140
8	-	135	135	120	90	120	85
9	150	90	135	165	110	130	120
10	165	120	120	160	155	125	90
11	165	113	135	140	130	150	105
12	140	120	150	140	145	110	100
13	150	115	85	165	150	125	135
14	150	120	120	150	120	150	120
15	150	120	120	90	120	120	90
16	150	120	145	150	130	120	105
17	150	120	150	175	140	120	120
18	150	120	90	130	60	140	75
19	165	105	110	120	135	105	90
20	160	105	135	120	75	120	60
21	150	120	130	135	-	130	120
22	120	120	120	150	-	120	100
23	135	75	135	150	-	-	120
24	165	105	-	-	-	-	90
25	-	105	-	-	-	-	-
Total	3520	2693	3020	3135	2315	2640	2510
NR	23	24	23	23	20	21	24
Mean	153.04	112.83	131.30	136.30	110.75	125.71	102.08

EXPERIMENT #3 (Films 12, 13, 14) Distillation

Student Number	100	200	300	400	500	600	700
1	150	105	125	90	70	120	80
2	90	-	120	90	105	105	80
3	150	90	120	120	70	120	60
4	150	90	100	120	90	120	60
5	130	80	125	120	90	120	80
6	135	65	120	135	65	120	80
7	120	80	105	90	90	105	75
8	120	90	90	90	90	105	70
9	120	90	90	150	120	105	105
10	120	90	90	150	65	105	105
11	120	90	90	150	75	105	75
12	120	120	105	150	75	105	85
13	120	120	95	150	135	80	60
14	120	90	120	165	135	90	60
15	135	90	105	150	135	75	90
16	120	105	120	165	135	75	90
17	150	90	120	120	135	100	60
18	120	90	70	120	135	105	60
19	165	105	85	120	-	100	105
20	150	120	110	120	105	120	55
21	90	90	110	130	-	120	60
22	90	120	90	120	-	-	60
23	90	95	90	150	-	-	60
24	150	105	-	120	-	-	-
25	-	75	-	-	-	-	-
Total	3030	2285	2395	3085	1920	2200	1715
NR	24	24	23	24	19	21	23
Mean	126.25	95.21	104.13	128.54	101.05	104.76	74.57

EXPERIMENT #4 (Films 11, 15) Fractional Distillation

Student Number	100	200	300	400	500	600	700
1	150	90	95	60	70	90	75
2	105	90	90	60	120	130	-
3	120	90	90	150	70	90	80
4	120	90	90	90	90	120	80
5	120	105	95	75	90	120	75
6	120	105	90	120	105	90	75
7	120	95	80	75	105	60	75
8	120	75	110	90	105	60	-
9	120	110	110	120	120	70	90
10	130	105	105	130	75	75	90
11	105	105	105	130	90	85	90
12	150	90	90	130	90	85	90
13	120	90	90	120	80	120	90
14	105	60	90	105	80	120	120
15	150	60	90	120	150	105	90
16	150	110	120	105	150	105	90
17	120	90	120	100	120	110	105
18	90	90	100	90	130	130	100
19	120	90	120	100	130	105	90
20	150	90	145	120	90	90	90
21	60	75	150	120	-	90	90
22	105	90	120	120	-	-	90
23	60	75	120	120	-	-	75
24	150	100	-	75	-	-	75
25	-	105	-	-	-	-	-
Total	2860	2275	2415	2615	2060	2050	1925
NR	24	25	23	24	20	21	22
Mean	119.17	90.60	105.00	108.95	103.00	97.62	87.50

EXPERIMENT #5 (Films 16, 17A, 17B, 17C) Qualitative Analysis

Student Number	100	200	300	400	500	600	700
1	150	90	150	165	70	150	165
2	150	120	120	150	135	120	165
3	130	120	140	150	120	120	110
4	165	90	135	120	110	150	110
5	150	-	100	130	120	135	150
6	135	120	135	150	105	135	150
7	120	90	105	120	135	120	120
8	150	90	150	-	105	150	110
9	120	120	105	-	-	135	165
10	165	120	135	170	105	130	95
11	120	150	150	150	75	105	165
12	150	60	75	150	90	130	120
13	150	120	150	165	150	160	145
14	120	120	160	-	90	135	120
15	150	120	135	120	110	135	150
16	150	120	150	165	120	135	120
17	150	120	115	135	120	95	165
18	150	90	150	150	130	120	125
19	155	120	150	135	-	105	90
20	150	120	105	120	120	120	75
21	120	90	150	150	-	90	105
22	120	120	150	150	-	-	105
23	135	90	-	150	-	-	140
24	130	120	-	165	-	-	135
25	-	100	-	-	-	-	-
Total	3385	2600	2915	3060	2010	2695	3100
NR	24	24	22	21	18	21	24
Mean	141.04	107.83	131.67	145.71	111.67	128.33	129.17

EXPERIMENT #6 Hydrocarbons

Student Number	100	200	300	400	500	600	700
1	150	120	120	150	90	135	105
2	90	90	120	150	90	120	105
3	-	-	120	120	75	135	110
4	120	90	135	120	90	150	110
5	135	80	125	140	80	150	90
6	135	80	120	150	90	135	90
7	120	90	130	135	90	120	105
8	-	90	120	135	90	120	120
9	120	95	120	150	105	125	90
10	-	90	130	150	90	120	90
11	140	120	130	150	90	140	90
12	140	120	120	150	90	130	90
13	120	90	120	150	120	130	105
14	120	120	130	140	90	120	105
15	120	90	160	150	90	120	90
16	120	90	120	150	90	120	90
17	-	90	120	150	90	130	90
18	-	120	125	120	120	120	90
19	135	120	140	140	90	130	120
20	130	90	120	120	90	135	90
21	90	90	120	150	-	135	120
22	90	90	120	150	-	-	120
23	90	90	-	150	-	-	105
24	120	90	-	150	-	-	-
25	-	90	-	-	-	-	-
Total	2285	2325	2645	3420	1850	2720	2320
NR	19	24	22	24	20	21	23
Mean	120.26	96.88	120.23	142.50	92.50	129.52	100.87

M-Dinitrobenzene

Student Number	100	200	300	400	500	600	700
1	-	90	160	120	105	180	-
2	120	90	210	120	135	135	-
3	-	150	160	120	105	180	135
4	-	150	160	120	120	180	135
5	150	150	160	150	120	180	90
6	150	150	190	180	110	165	90
7	150	150	-	150	105	120	120
8	150	120	150	150	105	120	-
9	-	150	150	150	-	140	80
10	-	120	165	150	120	140	80
11	180	-	165	150	120	150	150
12	180	120	240	150	-	150	120
13	180	120	240	160	-	165	90
14	180	120	220	165	150	315	90
15	120	150	220	120	150	165	180
16	120	120	180	180	150	150	90
17	180	120	180	170	-	160	90
18	180	120	165	170	135	135	90
19	150	120	165	165	-	180	135
20	150	120	230	165	135	165	85
21	120	90	230	180	-	-	90
22	120	120	210	180	-	-	90
23	-	120	-	180	-	-	90
24	120	120	-	150	-	-	90
25	-	120	-	-	-	-	-
Total	2700	3000	3950	3695	1865	3275	2210
NR	18	24	21	24	15	20	21
Mean	150.00	125.00	188.10	153.96	124.33	163.75	105.24

EXPERIMENT #13 Cyclohexanol Films 18, 19, 20, 21, 22, 23 Total Time

Student Number	100	200	300	400	500	600	700
1	150	210	215	210	195	180	210
2	230	210	275	210	200	195	210
3	150	180	230	210	195	180	250
4	150	240	210	210	210	210	250
5	285	180	215	240	210	210	205
6	285	180	265	240	210	210	205
7	240	210	210	240	210	240	270
8	-	210	210	240	210	240	240
9	300	210	210	240	200	180	205
10	300	240	270	240	210	180	-
11	130	240	270	285	210	220	205
12	130	180	240	285	210	220	250
13	240	180	240	285	195	270	210
14	290	180	255	-	-	270	210
15	330	205	240	285	240	245	180
16	300	180	235	240	240	245	180
17	330	180	235	210	240	210	225
18	240	210	270	210	-	195	225
19	240	210	270	240	-	210	285
20	240	210	285	240	200	240	225
21	230	210	300	240	-	180	270
22	230	210	300	240	-	-	270
23	-	180	270	240	-	-	240
24	150	210	-	240	-	-	240
25	-	210	-	-	-	-	-
Total	4930	5065	5720	5310	3585	4530	5260
NR	22	25	23	23	17	21	23
Mean	224.09	202.60	248.70	230.87	210.88	215.71	228.70

EXPERIMENT #11 n-butylbromide Two Day Total Time

Student Number	100	200	300	400	500	600	700
1	195	210	230	180	180	225	180
2	195	210	260	180	240	275	180
3	210	190	260	180	180	220	230
4	210	210	250	180	240	185	210
5	255	210	230	195	240	185	180
6	255	245	260	195	180	225	180
7	240	175	250	200	210	170	180
8	240	245	250	195	210	170	180
9	255	225	250	220	180	205	210
10	255	225	235	220	180	205	210
11	245	180	235	210	-	185	180
12	245	180	235	210	210	185	180
13	240	210	250	215	200	185	180
14	-	210	225	210	-	185	180
15	210	220	225	215	200	295	180
16	210	205	220	210	200	295	180
17	225	205	220	210	180	180	225
18	225	210	170	210	-	275	225
19	225	175	170	180	-	180	210
20	225	210	225	180	180	180	180
21	225	210	235	190	-	180	210
22	225	210	235	190	-	-	210
23	195	220	255	195	-	-	210
24	195	210	255	-	-	-	210
25	-	210	-	-	-	-	-
Total	5200	5210	5630	4570	3210	4095	4700
NR	23	25	24	23	16	20	24
Mean	226.09	208.40	234.58	198.70	200.63	204.75	195.83

Methyl Salicyate

Student Number	100	200	300	400	500	600	700
1	210	210	230	240	180	275	250
2	210	210	270	240	225	180	-
3	210	180	225	240	180	275	210
4	210	180	225	240	185	210	200
5	215	210	235	240	185	195	210
6	215	210	270	335	180	275	210
7	215	210	-	240	225	180	270
8	-	185	255	240	225	180	270
9	315	210	255	240	240	160	210
10	315	215	270	255	215	160	200
11	250	-	270	300	195	185	250
12	250	210	215	300	195	185	250
13	250	210	215	190	220	215	240
14	250	215	215	190	215	215	240
15	265	215	215	190	215	220	240
16	265	240	245	180	240	220	210
17	180	210	250	210	185	200	210
18	180	270	235	210	185	180	210
19	240	270	235	190	-	200	195
20	255	225	220	190	225	200	195
21	255	175	220	300	-	195	180
22	210	150	240	335	-	-	200
23	210	225	180	300	-	-	210
24	210	180	-	-	-	-	210
25	-	165	-	-	-	-	-
Total	5170	5160	5190	5595	3915	4305	5070
NR	23	24	22	23	19	21	23
Mean	224.78	215.00	235.91	243.26	206.05	205.00	220.43

Ethanol

Student Number	100	200	300	400	500	600	700
1	165	120	145	210	90	155	120
2	150	120	135	210	90	145	-
3	150	90	120	120	90	140	80
4	150	90	130	120	-	125	80
5	115	90	175	180	90	125	90
6	115	90	135	165	90	150	90
7	120	90	125	120	90	130	120
8	180	105	125	120	90	110	120
9	195	105	195	155	-	135	75
10	195	-	195	155	90	135	75
11	125	130	105	120	-	155	90
12	165	150	105	120	120	155	90
13	125	150	180	125	90	145	60
14	125	90	180	180	-	145	60
15	150	90	150	150	90	185	90
16	150	90	150	180	90	185	90
17	180	120	115	150	-	150	120
18	180	135	115	150	150	145	120
19	150	135	155	180	-	150	100
20	150	100	155	180	90	130	75
21	135	105	155	150	-	130	105
22	150	100	125	150	-	-	105
23	135	80	-	155	-	-	105
24	150	90	-	-	-	-	105
25	-	105	-	-	-	-	-
Total	3605	2570	3170	3545	1350	3025	2285
NR	24	24	22	23	14	21	24
Mean	150.21	107.08	144.10	154.13	96.43	144.05	95.21

EXPERIMENT #16 Carbon Compounds

Student Number	100	200	300	400	500	600	700
1	110	105	155	150	90	130	90
2	110	120	140	90	105	130	120
3	120	75	125	90	80	135	-
4	-	85	140	90	90	120	110
5	90	85	130	90	110	110	75
6	95	120	125	75	120	150	75
7	-	150	-	75	75	90	135
8	-	-	125	90	-	100	90
9	160	90	125	90	-	105	90
10	160	90	120	95	150	135	90
11	120	90	125	95	120	125	90
12	155	90	90	95	120	145	120
13	150	150	90	110	135	130	80
14	120	90	120	100	120	175	120
15	120	90	125	120	120	125	105
16	120	90	140	90	90	145	120
17	120	90	120	90	120	120	120
18	90	90	100	90	120	120	80
19	130	70	120	90	-	120	120
20	125	100	105	120	60	120	90
21	105	90	105	105	-	165	80
22	110	100	130	110	-	-	100
23	80	55	90	105	-	-	120
24	110	90	-	-	-	-	120
25	-	95	-	-	-	-	-
Total	2500	2300	2645	2255	1825	2695	2350
NR	21	24	22	23	17	21	23
Mean	119.05	95.83	120.23	98.04	107.35	128.33	102.17

Methyl Ethyl Ketone

Student Number	100	200	300	400	500	600	700
1	180	145	210	150	165	185	240
2	180	145	205	150	150	190	240
3	145	-	205	120	165	185	130
4	145	145	210	120	150	180	130
5	145	145	200	150	150	200	130
6	145	160	205	240	180	195	130
7	140	160	-	160	180	140	130
8	140	160	205	160	180	140	190
9	180	190	205	120	180	195	215
10	180	-	165	120	180	195	215
11	210	160	165	120	180	210	150
12	210	150	185	120	195	210	185
13	200	150	185	195	190	215	215
14	210	120	225	150	180	215	215
15	240	120	170	120	190	230	210
16	240	180	170	150	135	230	185
17	210	180	180	165	135	215	150
18	190	140	180	165	-	190	210
19	180	150	240	240	-	215	210
20	180	150	240	240	150	220	135
21	180	190	210	240	-	220	180
22	180	150	210	240	-	-	180
23	180	150	180	240	-	-	185
24	180	150	-	-	-	-	185
25	-	190	-	-	-	-	-
Total	4345	4370	3580	4350	3875	3035	4175
NR	24	23	22	23	18	21	24
Mean	182.08	155.65	197.73	168.48	168.61	198.81	181.04

EXPERIMENT #17 Acids

Student Number	100	200	300	400	500	600	700
1	120	80	125	90	75	130	105
2	120	120	115	90	-	120	105
3	120	85	105	90	75	130	105
4	120	75	105	120	95	105	105
5	95	85	125	90	95	105	90
6	95	85	115	125	120	130	90
7	120	120	-	90	90	120	90
8	120	85	120	90	90	120	90
9	120	120	120	120	-	105	100
10	120	-	100	130	120	105	100
11	150	110	100	100	-	105	-
12	150	85	75	100	120	105	105
13	120	85	75	-	-	110	75
14	-	90	120	120	85	120	75
15	90	90	-	90	140	120	85
16	120	90	125	120	140	115	105
17	150	90	150	-	90	105	90
18	155	130	105	120	-	120	90
19	125	130	125	150	-	-	90
20	125	85	105	90	80	-	90
21	90	85	105	120	-	105	110
22	120	90	125	120	-	-	110
23	90	120	105	125	-	-	105
24	95	85	-	-	-	-	105
25	-	90	-	-	-	-	-
Total	2730	2310	2345	2290	1415	2175	2215
NR	23	24	21	21	14	19	23
Mean	118.70	96.25	111.67	109.05	101.07	114.47	96.30

EXPERIMENT #20 Isoamylacetate

Student Number	100	200	300	400	500	600	700
1	150	115	135	150	120	136	144
2	-	115	135	150	125	125	-
3	150	100	125	130	125	135	115
4	150	100	125	130	110	115	115
5	-	110	135	150	110	115	120
6	145	110	135	150	150	135	120
7	150	105	-	135	120	125	100
8	150	135	125	150	120	125	100
9	120	110	125	120	-	135	105
10	120	105	140	120	150	135	105
11	135	110	140	135	90	125	120
12	135	110	120	135	90	125	120
13	120	110	120	145	115	-	120
14	120	110	140	120	115	150	120
15	135	110	140	155	120	135	90
16	135	120	130	120	120	195	120
17	130	110	130	120	200	125	120
18	130	120	130	150	120	125	120
19	130	120	130	120	-	125	120
20	130	135	155	120	120	125	105
21	-	135	155	135	-	125	100
22	-	135	135	135	-	-	100
23	150	120	130	185	-	-	120
24	135	120	-	-	-	-	70
25	-	135	-	-	-	-	-
Total	2720	2905	2935	3160	2220	2636	2569
NR	20	25	22	23	18	20	23
Mean	136.00	116.20	133.41	137.39	123.33	131.80	111.70

EXPERIMENT #26 Amines

Student Number	100	200	300	400	500	600	700
1	120	70	90	120	80	90	150
2	100	90	90	120	120	100	105
3	150	90	90	120	75	105	105
4	150	80	90	120	90	-	105
5	110	-	80	150	90	-	75
6	105	80	85	120	120	85	75
7	-	120	-	-	90	125	80
8	90	105	77	150	75	-	80
9	180	80	70	120	120	120	100
10	180	-	80	125	120	130	105
11	180	-	80	120	130	110	90
12	180	150	75	120	90	110	120
13	120	120	65	105	120	100	90
14	-	120	120	100	100	105	90
15	135	120	120	120	90	100	90
16	140	90	130	90	90	125	120
17	120	-	125	-	75	80	-
18	115	105	110	150	120	115	75
19	-	120	110	150	-	85	90
20	130	100	150	120	60	105	90
21	75	100	150	150	-	100	90
22	120	100	130	135	-	-	90
23	75	-	105	120	-	-	90
24	100	110	-	-	-	-	-
25	-	100	-	-	-	-	-
Total	2675	2050	2222	2625	1855	1890	2105
NR	21	20	22	21	19	18	22
Mean	127.38	102.50	101.00	125.00	97.63	105.00	95.68

EXPERIMENT #30 Diazo Compounds

Student Number	100	200	300	400	500	600	700
1	120	60	70	75	60	75	150
2	65	90	85	75	90	-	-
3	85	60	75	70	60	85	65
4	85	60	75	60	75	65	65
5	85	60	70	90	75	65	60
6	85	60	85	90	60	70	60
7	85	60	-	-	90	-	90
8	90	-	60	60	-	95	90
9	90	70	60	90	60	75	80
10	90	75	60	90	90	75	105
11	60	-	70	-	90	70	120
12	60	-	50	-	90	70	120
13	-	-	50	95	-	80	60
14	-	90	70	90	80	90	60
15	-	90	70	90	60	65	75
16	85	75	80	90	60	80	-
17	100	75	90	90	60	70	90
18	75	50	65	150	60	80	90
19	-	50	65	75	-	80	75
20	125	45	75	75	90	-	90
21	45	-	75	90	-	-	90
22	65	45	65	90	-	80	90
23	45	-	-	90	-	-	90
24	85	60	-	-	-	-	-
25	-	-	-	-	-	-	-
Total	1625	1175	1465	1725	1250	1370	1815
NR	20	18	21	20	17	18	21
Mean	81.25	65.28	69.76	86.25	73.53	76.11	86.43

EXPERIMENT #35 Aspirin

Student Number	100	200	300	400	500	600	700
1	120	100	105	90	60	105	-
2	70	100	95	90	120	85	-
3	105	90	90	90	60	105	50
4	105	90	90	90	60	95	50
5	105	60	105	120	60	-	45
6	105	60	95	120	90	120	45
7	115	105	-	75	75	110	50
8	115	75	105	75	75	110	50
9	140	105	105	90	60	90	60
10	140	-	90	120	90	90	60
11	120	75	90	90	105	75	60
12	120	60	75	90	90	75	60
13	90	60	75	-	100	95	45
14	-	90	95	85	100	95	45
15	95	90	95	85	85	-	-
16	95	45	90	85	85	-	60
17	115	45	90	105	60	105	60
18	115	90	-	105	60	85	60
19	105	90	90	130	-	-	45
20	105	75	110	120	120	100	45
21	80	75	105	90	-	100	60
22	80	80	115	90	-	-	60
23	80	75	105	120	-	-	60
24	90	120	-	-	-	-	-
25	-	75	-	-	-	-	-
Total	2410	1930	2015	2155	1555	1640	1070
NR	23	24	21	22	19	17	20
Mean	104.78	180.42	95.95	97.96	81.84	96.47	53.50

Butter and Margarine Total (2 Days)

Student Number	100	200	300	400	500	600	700
1	150	120	150	240	150	185	210
2	195	120	155	240	165	160	-
3	150	150	140	180	150	185	150
4	-	150	140	180	135	165	150
5	180	150	155	240	135	165	180
6	180	150	155	210	150	185	180
7	150	150	-	240	150	170	140
8	150	150	280	240	150	170	140
9	-	150	280	180	180	180	150
10	180	195	130	180	150	180	150
11	120	-	130	180	150	125	210
12	120	150	155	180	210	125	210
13	120	180	155	-	195	165	210
14	-	180	150	195	195	165	180
15	195	180	150	180	150	145	180
16	195	150	145	195	150	145	180
17	300	150	145	180	-	180	180
18	255	190	225	180	195	160	180
19	190	190	225	240	-	180	210
20	190	165	135	240	165	145	210
21	195	150	135	210	-	145	150
22	195	165	155	210	-	-	150
23	160	190	155	-	-	-	150
24	160	190	-	-	-	-	-
25	150	150	-	-	-	-	-
Total	3880	3865	3645	4320	2925	3425	3850
NR	22	24	22	21	18	21	22
Mean	176.36	161.04	165.68	205.71	162.50	163.10	175.00

EXPERIMENT #29 Sulfanilamide

Student Number	100	200	300	400	500	600	700
1	255	210	215	210	240	250	210
2	240	210	195	210	240	195	-
3	180	165	190	180	240	255	140
4	210	165	190	210	195	230	140
5	270	180	215	210	195	205	-
6	270	180	225	240	210	235	210
7	185	180	-	210	240	190	210
8	185	210	215	210	240	170	210
9	120	180	205	210	250	205	140
10	120	-	215	230	210	205	-
11	120	120	240	180	195	200	-
12	120	120	220	180	195	200	180
13	120	120	220	185	250	215	180
14	120	190	190	210	250	245	180
15	290	190	190	165	180	245	-
16	290	180	195	210	210	245	180
17	120	180	160	240	150	265	180
18	180	185	140	240	150	170	150
19	290	185	160	240	-	195	180
20	240	140	230	240	240	295	180
21	135	-	230	240	-	295	150
22	240	140	210	240	-	-	150
23	135	180	185	240	-	-	150
24	255	195	-	-	-	-	-
25	-	210	-	-	-	-	-
Total	4810	4015	4435	4930	4080	4750	
NR	24	23	22	23	19	21	18
Mean	200.42	174.57	201.59	214.35	214.74	226.19	171.11

APPENDIX D

SUMMARY OF LABORATORY BREAKAGE

LABORATORY BREAKAGE AND COST BY EXPERIMENT, BY CLASS, AND BY INDIVIDUAL FOR EXPERIMENTAL GROUP

Group 100		Group 200		Group 300		Totals	
EXPERIMENT #1							
102 - funnel	0.75*	205 - 125ml E Flask	0.58	306 - 50ml Grad Cyl	1.45*		
109 - funnel	0.75	215 - 125ml E Flask	0.58*	319 - funnel	0.75*		
109 - 125ml E Flask	0.58	217 - T-tube	0.07*				
116 - 100ml Beaker	0.53*	217 - T-tube	0.07*				
4 items cost:	2.61	4 items cost:	1.30	2 items cost:	2.20	10 items total cost:	6.11
(24 students)		(25 students)		(22 students)		(71 students)	
EXPERIMENT #2							
102 - Thiele	4.41*			305 - 50ml Beaker	0.49*		
				306 - Thiele	4.41*		
				309 - Therm	2.85*		
1 item cost:	4.41	0 items		3 items cost:	7.75	4 items total cost:	12.16
(23 students)		(24 students)		(23 students)		(70 students)	
EXPERIMENT #3							
104 - funnel	0.75	212 - 50ml Beaker	0.49	318 - West Condenser	7.36*		
1 item cost:	0.75	1 item cost:	0.49	1 item cost:	7.36	3 items total cost:	8.60
(24 students)		(24 students)		(23 students)		(71 students)	
EXPERIMENT #4							
108 - 50ml RB Flask	2.51	207 - T-tube	0.07	313 - 100ml RB Flask	2.41		
109 - 10ml Grad Cyl	1.15	212 - 50ml RB Flask	2.51				
118 - Therm	2.85*	217 - funnel	0.75*				
		224 - 50ml Grad Cyl	1.45				
3 items cost:	6.51	4 items cost:	4.78	1 item cost:	2.41	8 items total cost:	13.70
(24 students)		(25 students)		(23 students)		(72 students)	

Group 100		Group 200		Group 300		Totals	
EXPERIMENT #5							
103 - T-tube	0.07	201 - 100ml Beaker	0.53	302 - 100ml Beaker	0.53		
111 - 100ml Beaker	0.53	202 - T-tube	0.07	310 - funnel	0.75		
112 - T-tube	0.07	203 - T-tube	0.07	312 - 10ml Grad Cyl	1.15		
116 - 100ml Beaker	0.53	206 - T-tube	0.07	318 - 100ml Beaker	0153		
123 - Medicine dropper	0.05			320 - T-tube	0.07		
				321 - 250ml Beaker	0.49		
5 items cost:	1.25	4 items cost:	0.74	6 items cost:	3.52	15 items total cost:	5.51
(24 students)		(23 students)		(21 students)		(68 students)	
EXPERIMENT #6							
114 - 250ml Beaker	0.49			301 - T-tube	0.07		
				302 - T-tube	0.07		
				304 - Side arm tube	2.30		
				307 - T-tube	0.07		
				316 - T-tube	0.07		
				322 - T-tube	0.07		
1 item cost:	0.49	0 items		6 items cost:	2.65	7 items total cost:	3.14
(19 students)		(24 students)		(22 students)		(65 students)	
META DINITRO BENZENE							
		202 - 10ml Grad Cyl	1.15*	321 - Therm	2.85		
		209 - Hirsch funnel	1.85				
0 items		2 items cost:	3.00	1 item cost:	2.85	3 items total cost:	5.85
(18 students)		(24 students)		(21 students)		(63 students)	

Group 100		Group 200		Group 300		Totals	
EXPERIMENT #13							
112 - T-tube	0.07*	201 - T-tube	0.07	305 - Stopper	1.57*		
113 - Vial	0.05	201 - T-tube	0.07	305 - T-tube	0.07*		
		207 - Therm	2.85				
		223 - Therm	2.85				
		223 - Stopper	1.57				
2 items cost:	0.12	5 items cost:	7.41	2 items cost:	1.64	10 items total cost:	9.17
(22 students)		(25 students)		(23 students)		(70 students)	
EXPERIMENT #11							
116 - 10ml Grad Cyl	115*	209 - 250ml Beaker	0.49	310 - 50ml Grad Cyl	1.45*		
120 - Rod	0.08*						
2 items cost:	1.23	1 item cost:	0.49	1 item cost:	1.45	4 items total cost:	3.17
(23 students)		(25 students)		(23 students)		(71 students)	
METHYL SALICYLATE							
117 - 250ml Beaker	0.49			309 - Stopper	1.57*		
124 - T-tube	0.07*			312 - 50ml Grad Cyl	1.45		
				317 - Stopper	1.57		
2 items cost:	0.56	0 items		3 items cost:	4.59	5 items total cost:	5.15
(23 students)		(24 students)		(22 students)		(69 students)	
ETHANOL							
				307 - 250ml E Flask	0.60		
				309 - 10ml Grad Cyl	1.15		
				311 - Therm	2.85		
0 items		0 items		3 items cost:	4.60	3 items total cost:	4.60
(24 students)		(23 students)		(22 students)		(69 students)	

Group 100		Group 200		Group 300		Totals	
EXPERIMENT #16							
				310 - T-tube	0.07		
				313 - T-tube	0.07		
				314 - T-tube	0.07		
				316 - T-tube	0.07		
				318 - T-tube	0.07		
0 items		0 items		5 items cost:	0.35	5 items total cost:	0.35
(21 students)		(24 students)		(22 students)		(67 students)	
METHYL ETHYL KETONE							
117 - Distilling Column	8.40	217 - 3 neck RB Flask	9.83*	316 - Medicine dropper	0.05*		
123 - Therm	2.85						
2 items cost:	11.25	1 item cost:	9.83	1 item cost:	0.05	4 items total cost:	21.13
(23 students)		(23 students)		(22 students)		(68 students)	
EXPERIMENT #17							
101 - 100ml RB Flask	2.41	201 - T-tube	0.07	302 - 250ml E Flask	0.60		
117 - T-tube	0.07	207 - 250ml Beaker	0.49	304 - T-tube	0.07*		
124 - funnel	0.75*	219 - T-tube	0.07*	314 - Evaporating Dish	0.90*		
		220 - 250ml E Flask	0.60				
3 items cost:	3.23	4 items cost:	1.23	3 items cost:	1.57	10 items total cost:	6.03
(23 students)		(24 students)		(21 students)		(68 students)	
EXPERIMENT #20							
124 - Distilling column	8.40*						
1 item cost:	8.40	0 items		0 items		1 item total cost:	8.40
(20 students)		(25 students)		(22 students)		(67 students)	

Group 100		Group 200		Group 300		Totals	
BUTTER AND OLEOMARGARINE							
118 - 10ml Grad Cyl	1.15			312 - Dropper	0.05		
				312 - Vial	0.05		
1 item cost:	1.15	0 items		2 items cost:	0.10	3 items total cost:	1.25
(22 students)		(24 students)		(22 students)		(68 students)	
EXPERIMENT #35							
		215 - funnel	0.75				
0 items		1 item cost:	0.75	0 items		1 item total cost:	0.75
(24 students)		(24 students)		(21 students)		(69 students)	
EXPERIMENT #26							
116 - T-tube	0.07	205 - T-tube	0.07				
116 - 50ml Grad Cyl	1.45	211 - 50ml Grad Cyl	1.45				
2 items cost:	1.52	2 items cost:	1.52			4 items total cost:	3.04
(19 students)		(19 students)		(22 students)		(60 students)	
EXPERIMENT #30							
124 - T-tube	0.07						
1 item cost:	0.07	0 items		0 items		1 item total cost:	0.07
(20 students)		(18 students)		(21 students)		(59 students)	
EXPERIMENT #29							
115 - 50ml Grad Cyl	1.45*	204 - 250ml E Flask	0.60*	304 - 50ml Grad Cyl	1.45*		
119 - 50ml Grad Cyl	1.45*	205 - 50ml Grad Cyl	1.45	309 - 100ml RB Flask	2.41*		
		222 - 250ml Beaker	0.49	312 - 100ml RB Flask	2.41*		
2 items cost:	2.90	3 items cost:	2.54	3 items cost:	6.27	8 items total cost:	11.71
(24 students)		(23 students)		(22 students)		(69 students)	
33 items cost:	46.45	32 items cost:	34.08	43 items cost:	49.36	108 items total cost:	129.89
(444 students)		(470 students)		(440 students)		(1354 students)	

LABORATORY BREAKAGE AND COST BY EXPERIMENT, BY CLASS, AND BY INDIVIDUAL FOR CONTROL GROUP

GROUP 400		Group 500		Group 600		Group 700		Totals	
EXPERIMENT #1									
405 - 250ml Beaker	0.49	501 - T-tube	0.07	602 - 250ml E Flask	0.60	714 - 50ml RB Flask	2.51		
405 - funnel	0.75	503 - 125ml E Flask	0.58	605 - T-tube	0.07				
406 - T-tube	0.07	507 - 100ml Beaker	0.53						
406 - 250ml E Flask	0.60								
407 - West Condenser	7.36								
412 - funnel	0.75								
418 - T-tube	0.07								
423 - 125ml E Flask	0.58								
8 items cost:	10.67	3 items cost:	1.18	2 items cost:	0.67	1 item cost:	2.51	14 items total cost:	15.03
(23 students)		(18 students)		(19 students)		(23 students)		(83 students)	
EXPERIMENT #2									
422 - T-tube	0.07			622 - Thiele	4.41	719 - Therm	2.85		
1 item cost:	0.07	0 items		1 item cost:	4.41	1 item cost	2.85	3 items total cost:	7.33
(23 students)		(20 students)		(21 students)		(24 students)		(88 students)	
EXPERIMENT #3									
408 - funnel	0.75			618 - 100ml RB Flask	2.51				
413 - funnel	0.75								
2 items cost:	1.50	0 items		1 item cost	2.51	0 items		3 items total cost:	4.01
(24 students)		(19 students)		(21 students)		(23 students)		(87 students)	

Group 400		Group 500		Group 600		Group 700		Totals	
EXPERIMENT #4									
401 - 100ml RB Flask	2.41	507 - Therm	2.85	608 - Therm-Adapter	1.66	709 - Therm	2.85		
		509 - Therm	2.85			713 - Receiver Adapter	5.09		
		517 - 50ml Grad Cyl	1.45			721 - Dist. Column	8.40		
		518 - Therm	2.85			723 - 250ml RB Flask	3.11		
		519 - 100ml RB Flask	2.41						
1 item cost: (24 students)	2.41	5 items cost: (20 students)	12.41	1 item cost: (21 students)	1.66	4 items cost: (22 students)	19.45	11 items total cost: (87 students)	35.93
EXPERIMENT #5									
417 - 250ml Beaker	0.49	501 - T-tube	0.07			701 - T-tube	0.07		
424 - T-tube	0.07	502 - 250ml E Flask	1.35			716 - T-tube	0.07		
		503 - Rod	0.08			723 - T-tube	0.07		
		512 - T-tube	0.07						
		517 - T-tube	0.07						
		520 - funnel	0.75						
2 items cost: (21 students)	0.56	6 items cost: (18 students)	2.39	0 items (21 students)		3 items cost: (24 students)	0.21	11 items total cost: (84 students)	3.16
EXPERIMENT #6									
409 - Side Arm tube	2.30			611 - 10ml Grad Cyl	1.15	706 - T-tube	0.07		
413 - Side Arm tube	2.30			617 - T-tube	0.07	706 - Fusion tube	0.25		
419 - 50ml Beaker	0.53								
3 items cost: (24 students)	5.13	0 items (19 students)		2 items cost: (21 students)	1.22	2 items cost: (23 students)	0.32	7 items total cost: (87 students)	6.67

Group 400		Group 500		Group 600		Group 700		Totals	
META DINITRO BENZENE									
		502 - 10ml Grad Cyl	1.15	605 - 10ml Grad Cyl	1.15				
0 items (24 students)		1 item cost: (15 students)	1.15	1 item cost: (20 students)	1.15	0 items (21 students)		2 items total cost: (80 students)	2.30
EXPERIMENT #L#									
417 - funnel	0.75	516 - Glass Stopper	1.57	607 - Receiver Adapter	5.09	709 - 10ml Grad Cyl	1.15		
				602 - 3 Neck RB Flask	9.83	714 - Dist. Adapter	5.09		
				613 - Receiver Adapter	5.09				
1 item cost: (23 students)	0.75	1 item cost: (17 students)	1.57	4 items cost: (21 students)	20.01	2 items cost: (23 students)	6.24	8 items total cost: (84 students)	28.57
EXPERIMENT #11									
414 - 100ml RB Flask	2.41			602 - Therm	2.85				
				613 - Dist. Column	8.40				
				615 - Receiver Adapter	5.09				
				618 - Therm	2.85				
1 item cost: (23 students)	2.41	0 items (16 students)		4 items cost: (20 students)	19.19	0 items (24 students)		5 items total cost: (83 students)	21.60
METHYL SALICYLATE									
0 items (23 students)		0 items (19 students)		0 items (21 students)		0 items (23 students)		0 items (86 students)	0.00

Group 400		Group 500		Group 600		Group 700		Totals	
ETHANOL									
				605 - Dist. Column	8.40	714 - Condenser Adapter	5.09		
				607 - T-tube	0.07	720 - T-tube	0.07		
				617 - Reflux Column	7.36	723 - 10ml Grad Cyl	1.15		
				619 - Therm	2.85				
0 items		0 items		4 items cost:	18.68	3 items cost:	6.31	7 items total cost:	24.99
(23 students)		(15 students)		(21 students)		(24 students)		(83 students)	
EXPERIMENT #16									
401 - T-tube	0.07	511 - T-tube	0.07	608 - T-tube	0.07	702 - T-tube	0.07		
401 - T-tube	0.07	516 - T-tube	0.07	608 - T-tube	0.07	712 - T-tube	0.07		
403 - T-tube	0.07	517 - T-tube	0.07	611 - T-tube	0.07	716 - T-tube	0.07		
		520 - T-tube	0.07	616 - 250ml Beaker	0.49				
3 items cost:	0.21	4 items cost:	0.28	4 items cost:	0.70	3 items cost:	0.21	14 items total cost:	1.40
(23 students)		(17 students)		(21 students)		(23 students)		(84 students)	
METHYL ETHYL KETONE									
418 - 250ml RB Flask	3.11			618 - 3 Neck RB Flask	9.83	709 - 250ml RB Flask	3.11		
1 item cost:	3.11	0 items		1 item cost:	9.83	1 item cost:	3.11	3 items total cost:	16.05
(23 students)		(18 scudents)		(21 students)		(24 students)		(86 students)	
EXPERIMENT #17									
403 - T-tube	0.07	514 - 100ml RB Flask	2.41	613 - 100ml RB Flask	2.41	704 - T-tube	0.07		
404 - 100ml RB Flask	2.41			617 - 100ml RB Flask	2.41	705 - Receiver Adapter	5.09		
415 - T-tube	0.07					708 - T-tube	0.07		
418 - T-tube	0.07					723 - 100ml Beaker	0.53		
4 items cost:	2.62	1 item cost:	2.41	2 items cost:	4.82	4 items cost:	5.76	11 items total cost:	15.61
(21 students)		(14 students)		(19 students)		(23 students)		(87 students)	

Group 400		Group 500		Group 600		Group 700		Totals	
EXPERIMENT #26									
403 - T-tube	0.07			601 - 100ml Beaker	0.53	710 - 125ml Flask	0.58		
				605 - T-tube	0.07				
1 item cost:	0.07	0 items		2 items cost:	0.60	1 item cost:	0.58	4 items total cost:	1.25
(21 students)		(19 students)		(18 students)		(22 students)		(80 students)	
EXPERIMENT #30									
		502 - 50ml Grad Cyl	1.45	601 - 50ml Beaker	0.53				
				605 - T-tube	0.07				
0 items		1 item cost:	1.45	2 items cost:	0.70	0 items		3 items total cost:	2.15
(20 students)		(17 students)		(18 students)		(21 students)		(86 students)	
EXPERIMENT #29									
414 - 250ml RB Flask	3.11	516 - 50ml Grad Cyl	1.45	601 - 50ml Grad Cyl	1.45	703 - Thiele	4.41		
417 - 50ml Grad Cyl	1.45			613 - 50ml RB Flask	2.51	710 - T-tube	0.07		
418 - funnel	0.75			620 - 50ml Grad Cyl	1.45				
418 - 50ml Grad Cyl	1.45								
4 items cost:	6.76	1 item cost:	1.45	3 items cost:	5.41	2 items cost:	4.48	10 items total cost:	18.10
(22 students)		(19 students)		(20 students)		(19 students		(80 students)	
35 items cost:	45.15	25 items cost:	30.13	40 items cost:	117.87	28 items cost:	52.08	128 items total cost:	245.23
(451 students)		(356 students)		(402 students)		(451 students)		(1660 students)	
EXPERIMENT #20									
405 - West Condenser	7.36			605 - 100ml RB Flask	2.41				
408 - 50ml Grad Cyl	1.45			605 - West Condenser	7.36				
				612 - 50ml Grad Cyl	1.45				
				616 - West Condenser	7.36				
				617 - 25ml RB Flask	2.51				
				618 - Therm Adapter	1.66				
2 items cost:	8.81	0 items		6 items cost:	22.75	0 items		8 items total cost:	31.56
(23 students)		(18 students)		(20 students)		(23 students)		(84 students)	
BUTTER AND OLEOMARGARINE									
421 - T-tube	0.07	515 - Receiver Adapter	5.09			707 - Vial	0.05		
1 item cost:	0.07	1 item cost:	5.09	0 items		1 item cost:	0.05	3 items total cost:	5.21
(21 students)		(19 students)		(21 students)		(22 students)		(83 students)	
EXPERIMENT #35									
		513 - funnel	0.75						
0 items		1 item cost:	0.75	0 items		0 items		1 item total cost	0.75
(22 students)		(19 students)		(17 students)		(20 students)		(78 students)	

APPENDIX E

ATTITUDE SCALE

This is a survey of some of the experiments which you performed this semester. We invite your comments on these or any of them. This rating scale is designed to simplify your comments. You may wish to consult your laboratory manual and notebook in order to refresh your memory. Please use your own opinion and not that of your lab partner or friends.

The results of your rating will have no effect whatsoever upon your grade. Please do not write your name on these sheets. However please do write your name and laboratory section on the small piece of paper stapled to the corner. It will be removed later in order that the ratings be anonymous.

To conserve time and space the rating form is condensed on the rating sheets. It will be necessary that you consult the complete scale below.

First think about the particular experiment. Next look at the rating item, select the response number which is closest to your opinion. Then circle that number on the rating sheet. (Note that all of the scales are not in the same direction.)

A) Time required to adequately perform the experiment:

0	1	2	3	4	5	6	7	8	9	10
needed more time entirely too long		too long			about proper		somewhat short			entirely too brief

B) How interesting was this experiment?

0	1	2	3	4	5	6	7	8	9	10
highly interesting		/interesting/			average/		neither dull / nor exciting			boring

C) Value or usefulness:

0	1	2	3	4	5	6	7	8	9	10
highly valuable			useful		average		uncertain			useless

D) Academic rigor and value:

0	1	2	3	4	5	6	7	8	9	10
highly instructive					moderate					pointless

E) Difficulty level:

0	1	2	3	4	5	6	7	8	9	10
tedious and difficult					proper		easy		too easy	

F) Directions given:

0	1	2	3	4	5	6	7	8	9	10
clear and easy to follow /				fairly clear /	adequate /		somewhat /	unclear /	quite muddled	

G) Techniques learned:

0	1	2	3	4	5	6	7	8	9	10
quite useful			probably				not learned very well		none learned	

H) Techniques involved: (Manipulations)

0	1	2	3	4	5	6	7	8	9	10
too complicated					moderate				quite simple	

I) Overall experiment:

0	1	2	3	4	5	6	7	8	9	10
should be omitted				should be rewritten			slight modification		excellent as is	

EXPT #2 DETERMINATION OF MELTING POINTS

A) Time required:	0 1 2 3 4 5 6 7 8 9 10
B) How interesting:	0 1 2 3 4 5 6 7 8 9 10
C) Value or usefulness:	0 1 2 3 4 5 6 7 8 9 10
D) Academic value:	0 1 2 3 4 5 6 7 8 9 10
E) Difficulty:	0 1 2 3 4 5 6 7 8 9 10
F) Directions:	0 1 2 3 4 5 6 7 8 9 10
G) Techniques:	0 1 2 3 4 5 6 7 8 9 10
H) Manipulations:	0 1 2 3 4 5 6 7 8 9 10
I) Overall:	0 1 2 3 4 5 6 7 8 9 10

EXPT #3 DISTILLATION AND THE DETERMINATION OF BOILING POINTS

A) Time required:	0 1 2 3 4 5 6 7 8 9 10
B) How interesting?	0 1 2 3 4 5 6 7 8 9 10
C) Value or usefulness:	0 1 2 3 4 5 6 7 8 9 10
D) Academic value:	0 1 2 3 4 5 6 7 8 9 10
E) Difficulty:	0 1 2 3 4 5 6 7 8 9 10
F) Directions:	0 1 2 3 4 5 6 7 8 9 10
G) Techniques:	0 1 2 3 4 5 6 7 8 9 10
H) Manipulations:	0 1 2 3 4 5 6 7 8 9 10
I) Overall:	0 1 2 3 4 5 6 7 8 9 10

EXPT #4 FRACTIONAL DISTILLATION

A) Time required:	0 1 2 3 4 5 6 7 8 9 10
B) How interesting:	0 1 2 3 4 5 6 7 8 9 10
C) Value or usefulness:	0 1 2 3 4 5 6 7 8 9 10
D) Academic value:	0 1 2 3 4 5 6 7 8 9 10
E) Difficulty:	0 1 2 3 4 5 6 7 8 9 10
F) Directions:	0 1 2 3 4 5 6 7 8 9 10
G) Techniques:	0 1 2 3 4 5 6 7 8 9 10
H) Manipulations:	0 1 2 3 4 5 6 7 8 9 10
I) Overall:	0 1 2 3 4 5 6 7 8 9 10

EXPT #5 QUALITATIVE ANALYSIS FOR ELEMENTS

A) Time required:	0 1 2 3 4 5 6 7 8 9 10
B) How interesting:	0 1 2 3 4 5 6 7 8 9 10
C) Value or usefulness:	0 1 2 3 4 5 6 7 8 9 10
D) Academic value:	0 1 2 3 4 5 6 7 8 9 10
E) Difficulty:	0 1 2 3 4 5 6 7 8 9 10
F) Directions:	0 1 2 3 4 5 6 7 8 9 10
G) Techniques:	0 1 2 3 4 5 6 7 8 9 10
H) Manipulations:	0 1 2 3 4 5 6 7 8 9 10
I) Overall:	0 1 2 3 4 5 6 7 8 9 10

EXPT #11 n-BUTYL BROMIDE

A)	Time required:	0 1 2 3 4 5 6 7 8 9 10
B)	How interesting:	0 1 2 3 4 5 6 7 8 9 10
C)	Value or usefulness:	0 1 2 3 4 5 6 7 8 9 10
D)	Academic value:	0 1 2 3 4 5 6 7 8 9 10
E)	Difficulty:	0 1 2 3 4 5 6 7 8 9 10
F)	Directions:	0 1 2 3 4 5 6 7 8 9 10
G)	Techniques:	0 1 2 3 4 5 6 7 8 9 10
H)	Manipulations:	0 1 2 3 4 5 6 7 8 9 10
I)	Overall:	0 1 2 3 4 5 6 7 8 9 10

EXPT #13 CYCLOHEXANOL; PROPERTIES OF ALCOHOLS

A)	Time required:	0 1 2 3 4 5 6 7 8 9 10
B)	How interesting:	0 1 2 3 4 5 6 7 8 9 10
C)	Value or usefulness	0 1 2 3 4 5 6 7 8 9 10
D)	Academic value:	0 1 2 3 4 5 6 7 8 9 10
E)	Difficulty:	0 1 2 3 4 5 6 7 8 9 10
F)	Directions:	0 1 2 3 4 5 6 7 8 9 10
G)	Techniques:	0 1 2 3 4 5 6 7 8 9 10
H)	Manipulations:	0 1 2 3 4 5 6 7 8 9 10
I)	Overall:	0 1 2 3 4 5 6 7 8 9 10

EXPT #16 CARBON COMPOUNDS

A)	Time required:	0 1 2 3 4 5 6 7 8 9 10
B)	How interesting:	0 1 2 3 4 5 6 7 8 9 10
C)	Value or usefulness:	0 1 2 3 4 5 6 7 8 9 10
D)	Academic value:	0 1 2 3 4 5 6 7 8 9 10
E)	Difficulty:	0 1 2 3 4 5 6 7 8 9 10
F)	Directions:	0 1 2 3 4 5 6 7 8 9 10
G)	Techniques:	0 1 2 3 4 5 6 7 8 9 10
H)	Manipulations:	0 1 2 3 4 5 6 7 8 9 10
I)	Overall:	0 1 2 3 4 5 6 7 8 9 10

EXPT #17 ACIDS

A)	Time required:	0 1 2 3 4 5 6 7 8 9 10
B)	How interesting:	0 1 2 3 4 5 6 7 8 9 10
C)	Value or usefulness:	0 1 2 3 4 5 6 7 8 9 10
D)	Academic value:	0 1 2 3 4 5 6 7 8 9 10
E)	Difficulty:	0 1 2 3 4 5 6 7 8 9 10
F)	Directions:	0 1 2 3 4 5 6 7 8 9 10
G)	Technqiues:	0 1 2 3 4 5 6 7 8 9 10
H)	Manipulations:	0 1 2 3 4 5 6 7 8 9 10
I)	Overall:	0 1 2 3 4 5 6 7 8 9 10

EXPT #26 PROPERTIES OF AMINES

A)	Time required:	0 1 2 3 4 5 6 7 8 9 10
B)	How interesting:	0 1 2 3 4 5 6 7 8 9 10
C)	Value or usefulness:	0 1 2 3 4 5 6 7 8 9 10
D)	Academic value:	0 1 2 3 4 5 6 7 8 9 10
E)	Difficulty:	0 1 2 3 4 5 6 7 8 9 10
F)	Directions:	0 1 2 3 4 5 6 7 8 9 10
G)	Techniques:	0 1 2 3 4 5 6 7 8 9 10
H)	Manipulations:	0 1 2 3 4 5 6 7 8 9 10
I)	Overall:	0 1 2 3 4 5 6 7 8 9 10

EXPT #35 ASPIRIN (ACETYLSALICYLIC ACID)

A)	Time required:	0 1 2 3 4 5 6 7 8 9 10
B)	How interesting:	0 1 2 3 4 5 6 7 8 9 10
C)	Value or usefulness:	0 1 2 3 4 5 6 7 8 9 10
D)	Academic value:	0 1 2 3 4 5 6 7 8 9 10
E)	Difficulty:	0 1 2 3 4 5 6 7 8 9 10
F)	Directions:	0 1 2 3 4 5 6 7 8 9 10
G)	Techniques:	0 1 2 3 4 5 6 7 8 9 10
H)	Manipulations:	0 1 2 3 4 5 6 7 8 9 10
I)	Overall:	0 1 2 3 4 5 6 7 8 9 10

APPENDIX F

SUMMARY OF ATTITUDE SCALE RESPONSES

TABULATION OF FREQUENCIES, MEDIANS AND INTERQUARTILE RANGES OF THE RESPONSES TO ATTITUDE SURVEY

EXPERIMENT #2 Group 100 N=19

	0	1	2	3	4	5	6	7	8	9	10	S	Q
A	0	0	1	1	3	9	2	3	0	0	0	1.0555	2.7788
B	0	1	1	8	1	5	0	2	1	0	0	3.9373	1.8064
C	0	0	1	8	1	6	1	1	1	0	0	4.5000	1.2396
D	0	2	1	3	6	4	2	0	1	0	0	4.5833	1.9792
E	0	1	0	2	2	5	3	0	3	2	0	4.5502	3.5421
F	2	0	4	4	4	1	2	2	0	0	0	3.8751	2.5636
G	0	0	1	1	3	7	3	0	2	1	1	4.3748	2.9378
H	0	0	1	1	3	7	3	0	2	1	1	5.3572	2.6668
I	0	0	0	0	1	1	2	5	5	3	2	2.8997	1.9335
												35.1331	
												6.9037	
												6.0963	

EXPERIMENT #3 Group 100 N=19

	0	1	2	3	4	5	6	7	8	9	10	S	Q
A	0	0	0	2	1	11	1	1	2	0	1	0.8637	3.5818
B	0	0	3	3	3	5	1	2	0	2	0	5.0999	2.6677
C	0	0	2	9	0	1	3	2	2	0	0	3.8332	3.4443
D	1	0	1	5	5	3	3	1	0	0	0	4.5000	2.2000
E	0	1	1	3	0	6	5	1	2	0	0	4.1003	2.7337
F	0	0	2	7	1	4	2	3	0	0	0	4.5000	2.8040
G	0	1	5	3	5	2	1	0	2	0	0	4.0999	2.3754
H	0	0	0	1	2	5	4	3	2	2	0	4.6252	3.2502
I	0	0	0	1	0	3	1	7	3	3	1	3.3572	2.0008
												34.9794	
												3.8866	
												6.1134	

EXPERIMENT #4 Group 100 N=19

	0	1	2	3	4	5	6	7	8	9	10	S	Q
A	0	0	1	0	4	7	5	1	0	0	1	1.6252	1.9715
B	0	1	1	8	1	3	2	2	0	0	1	3.9373	2.7818
C	1	0	2	7	2	2	2	2	0	1	0	3.9286	2.8794
D	0	0	2	4	5	3	3	1	0	1	0	4.6998	2.3962
E	0	2	0	3	2	4	2	5	1	0	0	4.7381	3.3336
F	0	1	4	4	3	4	2	1	0	0	0	4.1666	2.6247
G	2	2	0	5	4	2	4	0	0	0	0	3.1501	2.4748
H	0	0	0	0	4	7	4	2	1	0	1	5.2142	2.7052
I	0	0	0	0	1	1	5	1	4	3	4	1.2502	3.1996
												32.7101	
												3.6345	
												6.3655	

EXPERIMENT #5 Group 100 N=19

	0	1	2	3	4	5	6	7	8	9	10	S	Q
A	0	2	2	0	3	7	3	1	0	0	1	1.8334	4.4468
B	2	1	1	5	3	3	2	1	0	0	1	4.1666	2.5997
C	0	0	1	5	5	4	4	0	0	0	1	4.6998	2.0628
D	1	0	0	2	9	4	1	0	1	0	1	4.7222	1.3681
E	0	1	1	2	3	7	3	1	0	1	0	4.8214	1.8334
F	1	0	4	5	1	3	1	2	1	1	0	3.8997	3.3132
G	1	1	1	4	3	6	1	1	0	1	0	4.8334	2.2709
H	0	1	0	2	4	5	2	2	1	1	1	5.5000	3.6879
I	0	0	0	1	3	3	3	3	2	3	1	4.1666	3.3747
												38.6431	
												4.2937	
												5.7063	

EXPERIMENT #13 Group 100 N=19

	0	1	2	3	4	5	6	7	8	9	10	S	Q
A	0	0	2	3	0	10	1	2	1	0	0	0.9500	3.6504
B	1	2	1	5	3	2	4	1	0	0	0	4.1666	2.9126
C	2	1	0	4	4	3	2	2	1	0	0	4.6252	2.6879
D	1	0	1	5	7	2	0	2	1	0	0	4.3572	1.5756
E	1	0	1	2	5	6	2	0	0	2	0	4.6998	2.8333
F	1	2	2	5	0	3	2	2	0	2	0	3.8997	2.5421
G	2	0	2	4	4	2	1	2	1	1	0	4.3748	2.0634
H	0	1	0	2	1	8	3	1	2	0	0	1.1666	3.6513
I	0	0	0	2	2	3	2	1	4	2	3	3.5000	3.8752
												31.7399	
												3.5267	
												6.4733	

EXPERIMENT #11 Group 100 N=19

	0	1	2	3	4	5	6	7	8	9	10	S	Q
A	0	0	1	1	2	7	4	2	1	1	0	2.1249	3.7570
B	0	0	3	3	5	3	3	1	1	0	0	4.6998	2.5003
C	0	1	0	2	4	6	2	2	2	0	0	5.4167	2.1874
D	0	1	1	3	5	4	1	1	2	1	0	4.8997	2.3346
E	0	0	1	1	3	7	3	4	0	0	0	4.5000	2.8334
F	2	0	2	2	2	5	4	0	2	0	0	5.2998	2.9375
G	0	2	1	4	3	6	0	3	0	0	0	4.8334	2.2709
H	0	0	0	3	2	7	3	3	1	0	0	5.3572	3.0712
I	0	0	0	3	2	7	3	3	1	0	0	2.8997	1.8752
												40.0312	
												4.4479	
												5.5521	

EXPERIMENT #16 Group 100 N=19

	0	1	2	3	4	5	6	7	8	9	10	S	Q
A	0	0	0	2	3	9	1	3	1	0	0	1.1666	3.0971
B	1	1	1	5	3	3	3	1	9	1	0	4.4997	1.7337
C	1	1	1	3	5	2	4	2	0	0	0	4.6998	1.7293
D	1	1	1	2	3	5	3	2	0	1	0	5.2998	2.5421
E	0	0	2	3	2	4	4	3	1	0	0	4.2142	2.8964
F	1	0	3	4	4	5	1	1	1	0	0	4.3748	2.2622
G	1	2	1	1	6	1	4	1	1	1	0	4.7498	2.8115
H	0	0	0	0	5	5	6	1	2	0	0	5.0999	1.7586
I	0	0	0	0	2	2	4	2	4	1	4	3.2498	3.0618
												37.3544	
												4.1505	
												5.8495	

EXPERIMENT #17 Group 100 N=20

	0	1	2	3	4	5	6	7	8	9	10	S	Q
A	0	0	0	0	1	10	6	1	1	1	0	0.9500	2.0668
B	1	2	1	8	3	1	2	2	1	0	0	3.6875	1.6560
C	1	0	1	4	8	2	2	1	0	1	0	4.4374	1.4380
D	0	1	1	6	4	2	1	3	2	0	0	4.3748	2.7928
E	0	0	2	1	3	1	6	3	3	0	0	3.8286	3.0006
F	0	3	4	3	2	2	3	3	0	0	1	3.8334	3.7461
G	1	2	1	4	4	4	2	2	0	0	0	4.3748	2.3749
H	0	0	0	0	2	1	11	1	3	1	1	5.3636	1.8182
I	0	0	0	0	3	2	3	2	4	3	3	2.8751	3.1665
												33.3252	
												3.7028	
												6.2972	

EXPERIMENT #26 Group 100 N=19

	0	1	2	3	4	5	6	7	8	9	10	S	Q
A	0	0	0	3	2	5	6	2	1	0	0	2.4167	2.4669
B	2	1	1	6	3	1	2	3	0	0	0	3.9167	3.0003
C	1	1	1	5	3	4	0	4	0	0	0	4.4997	2.0643
D	1	1	2	4	6	1	4	1	0	0	0	4.2498	2.0643
E	0	1	1	2	3	5	3	1	3	0	0	4.7985	2.4996
F	2	0	3	2	5	3	3	1	0	0	0	4.5000	2.8334
G	2	3	2	4	2	4	1	1	0	0	0	3.6252	3.1463
H	0	0	0	2	3	5	3	4	1	0	1	5.0999	2.3962
I	0	0	1	1	0	1	6	4	3	1	2	3.8751	2.1251
												36.9816	
												4.1091	
												5.8909	

EXPERIMENT #35 Group 100 N=19

	0	1	2	3	4	5	6	7	8	9	10	S	Q
A	0	0	0	0	4	9	3	3	0	0	0	1.1249	1.8889
B	3	1	4	6	3	0	0	2	0	0	0	3.2498	1.8960
C	2	2	1	5	4	1	1	3	0	0	0	3.8997	2.5000
D	1	1	1	7	3	3	3	0	0	0	0	3.9286	2.1667
E	1	0	1	1	6	5	3	2	0	0	0	4.5001	1.7920
F	1	0	3	4	3	0	4	3	1	0	0	4.4997	3.3749
G	1	3	0	5	3	3	0	2	1	1	0	4.1666	2.5997
H	0	0	0	2	2	7	2	3	1	1	1	5.2142	2.3095
I	0	0	0	2	1	1	1	4	5	1	4	2.8997	3.5000
												33.4833	
												3.7204	
												6.2796	

EXPERIMENT #2 Group 200 N=18

	0	1	2	3	4	5	6	7	8	9	10	S	Q
A	0	1	0	0	2	12	2	1	0	0	0	0.7500	1.3748
B	0	0	1	5	4	4	0	4	0	0	0	4.7502	2.1751
C	0	0	3	11	0	3	1	0	0	0	0	3.5454	0.8182
D	0	0	4	3	5	5	0	1	0	0	0	4.3999	2.1331
E	0	0	0	3	3	4	4	1	1	2	0	4.1665	2.3752
F	1	6	3	5	1	0	1	1	0	0	0	2.6665	2.1165
G	1	4	5	6	1	0	1	0	0	0	0	2.7999	1.7084
H	0	0	1	2	3	2	1	1	3	4	1	4.0000	4.6248
I	0	0	1	0	0	0	1	4	8	3	1	2.6251	1.3123
												29.7035	
												3.3004	
												6.6996	

EXPERIMENT #3 Group 200 N=18

	0	1	2	3	4	5	6	7	8	9	10	S	Q
A	0	0	2	0	2	11	2	0	1	0	0	0.8182	2.8411
B	0	0	2	3	6	3	0	2	2	0	0	4.6667	2.0000
C	2	0	4	6	2	3	0	1	0	0	0	3.5002	2.1247
D	0	2	2	4	4	3	3	0	0	0	0	4.2502	2.3746
E	0	0	0	6	1	8	0	0	2	1	0	4.9244	2.0625
F	0	4	3	6	3	0	2	0	0	0	0	3.3333	2.0000
G	1	0	6	9	0	2	1	0	0	0	0	3.2222	1.1389
H	0	0	0	1	4	8	1	1	1	2	0	5.5000	1.6251
I	0	0	0	1	0	0	0	6	4	7	0	2.5000	1.7739
												32.7152	
												3.6350	
												6.3650	

EXPERIMENT #4 Group 200 N=18

	0	1	2	3	4	5	6	7	8	9	10	S	Q
A	0	0	1	2	3	8	2	2	0	0	0	1.3335	2.6876
B	0	2	2	3	1	6	2	1	1	0	0	5.1668	2.7501
C	0	3	6	2	1	5	0	0	1	0	0	3.0000	3.0500
D	0	1	5	3	4	3	1	1	0	0	0	4.0000	2.4670
E	0	1	0	3	4	7	1	1	1	0	0	4.7500	1.6607
F	0	3	2	3	3	3	2	1	1	0	0	4.3335	3.0834
G	0	2	5	6	2	1	0	0	0	0	0	3.3333	1.7502
H	0	0	0	1	6	5	1	1	4	0	0	5.6001	2.9167
I	0	0	0	1	1	0	2	4	4	4	2	2.7502	2.2498
												34.2674	
												3.8075	
												6.1925	

EXPERIMENT #5 Group 200 N=17

	0	1	2	3	4	5	6	7	8	9	10	S	Q
A	0	0	2	1	2	7	4	0	1	0	0	1.7500	2.3304
B	4	0	1	3	3	3	0	2	0	0	0	4.1666	3.3300
C	1	1	2	5	1	6	0	1	0	0	0	3.9000	2.4085
D	0	1	3	5	4	2	0	2	0	0	0	3.9000	1.8875
E	0	0	1	3	1	9	1	2	0	0	0	4.9000	1.6112
F	0	2	3	6	1	1	2	2	0	0	0	3.5835	2.9999
G	0	1	4	5	5	1	1	0	0	0	0	3.7001	1.7376
H	0	0	0	3	3	6	3	1	1	0	0	5.8535	1.8329
I	0	0	0	0	0	0	2	6	4	3	2	2.8751	1.8750
												34.6288	
												3.8470	
												6.1524	

EXPERIMENT #13 Group 200 N=17

	0	1	2	3	4	5	6	7	8	9	10	S	Q
A	0	0	0	0	4	12	1	0	0	0	0	0.7083	0.8332
B	0	3	0	6	1	5	1	1	0	0	0	3.9167	2.3419
C	1	1	2	5	2	2	1	3	0	0	0	3.9000	2.8250
D	1	1	1	4	5	3	0	1	1	0	0	4.2999	1.9375
E	0	0	0	3	1	8	2	2	0	0	0	4.8751	1.3438
F	0	2	0	5	3	3	4	0	0	0	0	4.4997	2.4665
G	2	4	3	6	0	2	1	0	0	0	0	3.8334	2.0624
H	0	0	0	3	6	4	2	0	3	0	0	5.0000	2.0003
I	0	0	0	3	6	4	2	0	3	0	0	2.4168	1.7335
												33.4499	
												3.7167	
												6.2833	

EXPERIMENT #11 Group 200 N=17

	0	1	2	3	4	5	6	7	8	9	10	S	Q
A	0	0	1	2	0	13	0	1	0	0	0	0.6539	0.6539
B	0	1	0	2	3	2	2	5	2	0	0	6.2500	3.1338
C	0	1	2	2	1	5	2	2	2	0	0	5.5002	3.2500
D	0	0	0	4	3	6	3	1	0	0	0	5.2499	1.8750
E	0	0	0	2	3	9	2	1	0	0	0	4.4998	1.1111
F	0	0	3	2	2	5	2	2	0	0	0	5.2999	2.7500
G	0	0	1	6	4	2	1	2	1	0	0	4.3748	2.3332
H	0	0	0	3	6	4	2	0	3	0	0	4.5625	4.2500
I	0	0	0	0	2	1	3	5	5	1	0	2.5002	3.9329
												38.9812	
												4.3312	
												5.6688	

EXPERIMENT #16 Group 200 N=18

	0	1	2	3	4	5	6	7	8	9	10	S	Q
A	0	0	0	2	3	12	1	0	0	0	0	0.7500	1.1249
B	2	3	1	3	6	1	0	1	0	0	0	4.0000	2.9169
C	0	3	5	5	0	4	0	0	0	0	0	3.2001	2.8252
D	0	1	6	3	4	3	1	0	0	0	0	3.6665	2.2499
E	0	0	0	3	3	5	5	1	2	0	0	4.5486	2.0003
F	1	2	3	4	1	4	2	0	0	0	0	4.6252	3.0209
G	0	2	5	4	2	2	1	0	1	0	0	3.4722	2.4248
H	0	0	0	4	3	5	0	3	3	0	1	3.3994	3.3329
I	0	0	1	0	0	0	0	6	1	6	3	1.9167	2.2502
												31.5792	
												3.5088	
												6.4912	

EXPERIMENT #17 Group 200 N=17

	0	1	2	3	4	5	6	7	8	9	10	S	Q
A	0	0	0	1	5	10	1	0	0	0	0	0.8501	1.1252
B	0	0	2	1	3	2	1	4	1	1	0	6.5000	3.5211
C	0	0	1	1	1	7	0	4	2	0	0	5.7143	2.3571
D	0	1	0	1	6	5	1	2	0	0	0	5.1000	1.5748
E	0	0	0	1	2	8	4	1	1	0	0	4.8334	1.2811
F	0	3	0	4	4	2	2	1	0	1	0	4.3748	2.5626
G	0	0	1	6	4	4	2	0	0	0	0	4.3748	1.8955
H	0	0	0	1	2	8	3	3	0	0	0	5.3126	1.4274
I	0	0	0	1	0	1	2	6	2	2	2	3.4168	3.2500
												40.4768	
												4.4974	
												5.5026	

EXPERIMENT #26 Group 200 N=20

	0	1	2	3	4	5	6	7	8	9	10	S	Q
A	0	0	0	2	2	6	7	2	1	0	0	2.2857	2.1667
B	2	1	1	6	4	1	2	3	0	0	0	4.0000	2.8333
C	1	1	1	6	3	4	0	4	0	0	0	4.3333	2.4167
D	1	1	2	3	7	1	4	1	0	0	0	4.4286	2.6667
E	0	1	1	2	3	6	3	1	3	0	0	4.5663	2.3334
F	2	0	3	2	6	3	3	1	0	0	0	4.5000	2.6667
G	2	4	2	3	2	5	1	1	0	0	0	3.6667	3.6500
H	0	0	0	1	4	6	3	4	1	0	1	5.1667	3.2500
I	0	1	0	0	1	1	7	4	4	1	2	3.7500	2.0714
												36.6973	
												4.0775	
												5.9225	

EXPERIMENT #35 Group 200 N=18

	0	1	2	3	4	5	6	7	8	9	10	S	Q
A	0	0	0	0	3	10	3	2	0	0	0	0.8999	1.7168
B	3	1	4	6	3	0	0	2	0	0	0	3.2498	1.8960
C	2	2	0	6	4	1	1	3	0	0	0	3.9167	2.1259
D	1	1	1	6	3	4	3	0	0	0	0	4.1666	2.2709
E	1	0	1	0	7	5	3	2	0	0	0	5.0000	1.5427
F	1	0	3	3	3	0	5	4	0	0	0	4.8334	3.5997
G	1	3	0	5	4	3	0	2	1	1	0	4.1249	2.2666
H	0	0	0	1	2	7	2	4	1	1	1	5.0714	2.3125
I	0	0	0	1	1	1	1	5	5	1	4	2.8997	2.0989
												34.0375	
												3.7819	
												6.2181	

EXPERIMENT #2 Group 300 N=19

	0	1	2	3	4	5	6	7	8	9	10	S	Q
A	0	1	0	0	2	12	2	2	0	0	0	0.7916	1.7296
B	0	0	1	5	4	4	0	4	1	0	0	4.8751	3.3127
C	0	0	3	11	0	3	1	0	0	0	0	3.5909	1.9245
D	0	0	4	3	5	5	0	1	0	0	0	4.5000	2.1996
E	0	0	0	3	3	4	4	1	1	2	0	4.8659	2.6677
F	1	6	3	5	1	0	1	1	0	0	0	2.8334	2.2248
G	1	4	5	6	1	0	1	0	0	0	0	2.8997	1.7706
H	0	0	1	2	3	2	1	1	3	4	1	4.0000	4.6248
I	0	0	1	0	0	0	1	4	7	3	1	2.7858	1.7056
												31.1428	
												3.4603	
												6.5397	

EXPERIMENT #3 Group 300 N=19

	0	1	2	3	4	5	6	7	8	9	10	S	Q
A	0	0	2	0	2	11	2	0	1	0	0	0.7727	1.4887
B	0	0	2	3	6	3	0	2	2	0	0	4.6667	2.0000
C	2	0	4	6	2	3	1	0	0	0	0	3.5002	2.1247
D	0	2	2	4	4	3	3	0	0	0	0	4.2502	2.3746
E	0	0	0	6	1	8	0	0	2	1	0	4.7858	2.1146
F	0	4	3	6	3	0	2	0	0	0	0	3.3333	2.0000
G	1	0	6	8	0	2	1	0	0	0	0	3.2500	1.2293
H	0	0	0	1	4	8	1	1	1	2	0	5.5000	1.6251
I	0	0	0	0	0	0	0	7	3	7	0	2.4997	1.7858
												32.5586	
												3.6167	
												6.3824	

EXPERIMENT #4 Group 300 N=18

	0	1	2	3	4	5	6	7	8	9	10	S	Q
A	0	0	1	2	3	8	2	2	0	0	0	1.3335	2.6876
B	0	2	2	3	1	6	2	1	1	0	0	5.1668	2.9169
C	0	3	6	2	1	5	0	0	1	0	0	3.0000	3.0500
D	0	1	5	3	4	3	1	1	0	0	0	4.0000	2.4670
E	0	1	0	3	4	7	1	1	1	0	0	4.9177	1.6607
F	0	3	2	3	3	3	2	1	1	0	0	4.3335	3.0834
G	0	2	5	6	2	1	2	0	0	0	0	3.3333	1.7502
H	0	0	0	1	6	5	1	1	4	0	0	5.6001	2.9167
I	0	0	0	1	1	0	2	4	4	4	2	2.7502	2.2498
												34.4351	
												3.8261	
												6.1739	

EXPERIMENT #5 Group 300 N=17

	0	1	2	3	4	5	6	7	8	9	10	S	Q
A	0	0	2	1	2	7	4	0	1	0	0	1.7500	2.3304
B	4	0	1	3	3	4	0	2	0	0	0	4.1666	3.1873
C	1	1	2	5	1	6	0	1	0	0	0	3.9000	2.4085
D	0	1	3	5	4	2	0	2	0	0	0	3.9000	1.8875
E	0	0	1	3	1	9	0	2	0	0	0	4.9309	1.6695
F	0	2	3	6	1	1	2	2	0	0	0	3.5835	2.9999
G	0	1	4	5	5	1	1	0	0	0	0	3.7001	1.7376
H	0	0	0	3	3	6	3	1	1	0	0	5.6667	2.0000
I	0	0	0	0	0	0	2	6	4	3	2	2.8751	1.8750
												34.4729	
												3.8303	
												6.1697	

EXPERIMENT #13 Group 300 N=19

	0	1	2	3	4	5	6	7	8	9	10	S	Q
A	0	0	0	0	3	12	1	0	0	0	0	0.3434	0.6667
B	0	3	0	6	1	5	1	1	0	0	0	3.9167	2.3419
C	1	1	2	5	2	2	1	3	0	0	0	3.9000	2.8250
D	1	1	1	4	5	3	0	1	1	0	0	4.2999	1.9375
E	0	0	0	3	1	8	2	2	0	0	0	4.9410	2.0316
F	0	2	0	5	3	3	4	0	0	0	0	4.4997	2.4665
G	0	2	4	3	6	0	2	1	0	0	0	6.0000	3.0003
H	0	0	0	3	6	4	2	0	3	0	0	1.7501	2.2082
I													
												29.6508	
												3.2945	
												6.7055	

EXPERIMENT #11 Group 300 N=18

	0	1	2	3	4	5	6	7	8	9	10	S	Q
A	0	0	1	3	0	13	0	1	0	0	0	0.6923	2.8506
B	0	1	0	2	3	2	2	5	2	0	0	6.2500	3.1338
C	0	1	2	2	1	5	2	2	2	0	0	5.5002	3.2500
D	0	0	0	4	4	6	3	1	0	0	0	5.2499	1.8750
E	0	0	0	2	3	9	3	1	0	0	0	4.9001	1.1111
F	0	0	3	2	11	5	2	2	0	0	0	4.3282	1.0795
G	0	0	1	6	4	2	1	2	1	0	0	4.3748	4.2188
H	0	0	1	1	2	8	1	1	3	0	0	4.7498	3.0003
I	0	0	0	0	2	1	3	5	6	1	0	3.2999	3.7081
												29.3452	
												4.3717	
												5.6283	

EXPERIMENT #16 Group 300 N=19

	0	1	2	3	4	5	6	7	8	9	10	S	Q
A	0	0	0	2	3	12	1	0	0	0	0	0.7500	1.1247
B	2	3	1	3	6	1	0	1	0	0	0	3.8334	2.8750
C	0	3	5	5	0	4	0	0	0	0	0	3.1000	1.7001
D	0	1	6	3	4	3	0	0	0	0	0	3.4997	2.1458
E	0	0	2	2	5	5	1	2	0	0	0	4.6358	2.1009
F	1	2	3	4	1	4	2	0	0	0	0	3.6252	3.0209
G	0	2	5	4	2	2	1	0	1	0	0	3.3748	2.4248
H	0	0	0	4	3	5	0	3	3	0	1	5.5000	3.4996
I	0	0	1	0	0	0	0	6	1	6	3	1.9167	2.2502
												30.2356	
												3.3595	
												6.6405	

EXPERIMENT #17 Group 300 N=17

	0	1	2	3	4	5	6	7	8	9	10	S	Q
A	0	0	0	1	5	10	1	0	0	0	0	0.8501	1.1252
B	1	0	3	1	3	2	1	4	1	1	0	5.2500	4.1873
C	0	0	2	1	1	7	0	4	2	0	0	5.6428	2.4016
D	0	1	0	2	6	5	1	2	1	0	0	4.9167	1.5418
E	0	0	0	1	2	8	4	1	1	0	0	4.8334	1.7188
F	0	1	1	4	4	2	2	1	0	1	0	4.6252	2.8123
G	0	0	2	6	4	4	1	0	0	0	0	4.1249	1.8122
H	0	0	0	2	2	8	3	2	0	0	0	5.4375	1.2187
I	0	0	0	2	0	1	2	6	2	2	2	3.4168	2.2500
												39.0947	
												4.3442	
												5.6558	

EXPERIMENT #26 Group 300 N=20

	0	1	2	3	4	5	6	7	8	9	10	S	Q
A	0	0	0	2	2	6	7	2	1	0	0	2.2857	2.1667
B	2	1	1	6	4	1	2	3	0	0	0	4.0000	2.8333
C	1	1	1	6	3	4	0	4	0	0	0	4.3333	2.4167
D	1	1	2	3	7	1	4	1	0	0	0	4.4286	2.6667
E	0	1	1	2	3	6	3	1	3	0	0	4.4286	2.3334
F	2	0	3	2	6	3	3	1	0	0	0	4.5000	2.6667
G	2	4	2	3	2	5	1	1	0	0	0	3.6667	3.6500
H	0	0	0	1	4	6	3	4	1	0	1	5.1667	2.2500
I	0	0	1	0	0	1	7	4	4	1	2	3.7500	2.0714
												35.5695	
												4.0622	
												5.9378	

EXPERIMENT #35 Group 300 N=20

	0	1	2	3	4	5	6	7	8	9	10	S	Q
A	0	0	0	0	3	11	3	3	0	0	0	0.9091	0.8788
B	3	1	4	7	3	0	0	2	0	0	0	3.2857	1.5000
C	2	2	0	6	5	2	1	3	0	0	0	4.0000	1.8333
D	1	1	1	7	3	4	3	0	0	0	0	4.0000	2.2143
E	1	0	1	0	7	6	3	2	0	0	0	4.5556	2.3334
F	1	0	3	3	3	0	5	4	0	0	0	4.8334	3.5997
G	1	3	0	5	4	3	0	2	1	1	0	4.2500	2.4667
H	0	0	0	2	2	7	2	4	1	1	1	5.0000	2.3571
I	0	0	0	1	1	1	1	5	6	1	4	2.8333	1.8000
												33.6671	
												3.7408	
												6.2592	

EXPERIMENT #2 Group 400 N=14

	0	1	2	3	4	5	6	7	8	9	10	S	Q
A	0	0	0	1	2	9	1	1	0	0	0	0.7777	1.4157
B	0	1	1	2	5	2	0	1	1	0	1	4.6001	2.0000
C	0	1	2	6	2	0	2	0	1	0	0	3.6666	1.6662
D	0	2	0	1	3	5	0	3	0	0	0	5.1999	1.7334
E	0	0	0	1	1	2	3	3	4	0	0	3.0000	2.3755
F	0	4	2	2	4	2	0	0	0	0	0	3.4997	2.7501
G	0	2	3	6	2	1	0	0	0	0	0	3.3334	1.4169
H	0	0	0	0	1	5	1	2	2	3	0	4.0000	3.2503
I	0	0	0	0	1	2	1	2	5	1	1	3.0000	2.9499
												31.0774	
												3.4530	
												6.5470	

EXPERIMENT #3 Group 400 N=13

	0	1	2	3	4	5	6	7	8	9	10	S	Q
A	0	0	1	1	2	9	0	0	0	0	0	0.7222	1.0141
B	1	0	2	1	6	0	1	1	1	0	0	4.4167	1.7087
C	0	1	5	3	2	1	0	1	0	0	0	3.9168	1.9251
D	0	2	2	4	0	4	0	1	0	0	0	3.6250	2.8119
E	0	1	1	2	3	1	1	4	0	0	0	5.6112	3.6254
F	0	1	2	7	2	1	0	1	0	0	0	3.5714	1.1784
G	0	4	3	4	0	2	1	0	0	0	0	3.0000	2.0000
H	0	0	0	0	4	4	3	1	1	0	1	5.2499	2.2083
I	0	0	0	0	0	1	2	2	5	3	1	2.6001	1.9161
												32.7133	
												3.6348	
												6.3652	

EXPERIMENT #4 Group 400 N=13

	0	1	2	3	4	5	6	7	8	9	10	S	Q
A	0	0	1	1	2	8	1	0	0	0	0	0.8125	1.4690
B	0	0	4	3	2	2	1	0	1	0	0	3.8332	2.5627
C	0	1	5	5	1	0	0	1	0	0	0	3.1001	1.3000
D	0	3	1	3	5	0	0	1	0	0	0	3.8332	2.3002
E	0	0	0	2	3	4	2	1	1	0	0	4.5000	1.9584
F	0	2	3	2	3	2	1	1	0	0	0	3.7503	2.4996
G	0	1	5	4	0	3	0	0	0	0	0	3.1251	1.4875
H	0	0	2	0	1	3	2	2	2	1	0	5.7503	2.7916
I	0	0	0	0	0	1	1	2	3	6	0	2.1668	2.8333
												30.8715	
												3.4302	
												6.5698	

EXPERIMENT #5 Group 400 N=13

	0	1	2	3	4	5	6	7	8	9	10	S	Q
A	0	0	1	1	3	6	0	2	0	0	0	1.1668	3.2086
B	0	0	0	5	2	4	0	2	0	0	0	4.7503	2.0374
C	0	0	2	1	4	4	1	1	0	0	0	4.8749	1.6250
D	0	0	1	2	5	3	2	0	0	0	0	4.6999	1.5333
E	0	0	1	1	4	3	0	2	2	0	0	4.4167	3.0626
F	0	0	1	3	5	1	1	0	2	0	0	4.5000	2.0003
G	0	0	1	4	3	3	1	1	0	0	0	4.5000	2.0206
H	0	0	2	0	1	5	2	0	3	0	0	5.3001	1.8253
I	0	0	0	0	2	0	3	6	1	1	0	3.7502	1.3747
												37.9589	
												4.2177	
												5.7823	

EXPERIMENT #13 Group 400 N=13

	0	1	2	3	4	5	6	7	8	9	10	S	Q
A	0	0	0	1	4	7	0	0	1	0	0	0.9285	1.2231
B	0	0	1	5	2	4	1	0	0	0	0	4.2503	1.9873
C	0	1	1	7	3	0	1	0	0	0	0	3.6429	1.0714
D	0	0	2	5	3	2	1	0	0	0	0	3.9002	1.6663
E	0	0	0	2	4	4	1	0	2	0	0	4.8077	1.6250
F	0	1	0	7	5	0	0	0	0	0	0	3.7857	1.0286
G	0	0	4	2	3	2	2	0	0	0	0	4.1668	2.5627
H	0	0	1	1	5	2	0	1	1	2	0	6.3001	3.5004
I	0	0	1	0	0	2	1	2	5	1	1	3.9002	1.5002
												35.6824	
												3.9647	
												6.0353	

EXPERIMENT #11 Group 400 N=13

	0	1	2	3	4	5	6	7	8	9	10	S	Q
A	0	0	1	1	3	7	1	0	0	0	0	0.9285	1.4521
B	0	0	1	4	4	2	0	1	1	0	0	4.3750	1.8126
C	0	0	1	4	2	2	1	2	1	0	0	4.7503	3.1877
D	0	1	0	2	7	3	0	1	0	0	0	4.4999	0.9285
E	0	0	0	2	5	2	3	1	0	0	0	5.4584	2.0000
F	0	0	1	2	5	3	1	0	0	0	0	4.6999	1.5333
G	0	0	0	5	4	2	0	1	1	0	0	4.3750	1.7252
H	0	0	1	0	3	3	2	2	2	0	0	5.1668	2.6245
I	0	0	1	0	0	2	3	3	3	1	0	3.8332	2.1664
												38.0870	
												4.2319	
												5.7681	

EXPERIMENT #16 Group 400 N=13

	0	1	2	3	4	5	6	7	8	9	10	S	Q
A	0	0	1	0	1	8	2	0	0	1	0	0.8125	1.9690
B	0	1	3	3	2	1	3	0	0	0	0	3.8332	3.0003
C	0	1	3	3	1	2	3	0	0	0	0	3.8332	3.1252
D	0	2	1	3	4	3	0	0	0	0	0	4.1251	1.8544
E	0	0	0	1	3	3	3	3	0	0	0	4.1251	3.1664
F	0	1	2	3	3	2	0	2	0	0	0	4.1668	2.2920
G	0	1	1	5	2	2	2	0	0	0	0	3.6429	2.1251
H	0	0	1	0	3	2	1	3	2	1	0	6.9168	2.1668
I	0	1	0	1	0	1	2	2	4	2	0	3.2503	2.5626
												34.7059	
												3.8562	
												6.1438	

EXPERIMENT #17 Group 400 N=12

	0	1	2	3	4	5	6	7	8	9	10	S	Q
A	0	0	1	1	1	6	2	1	0	0	0	1.5007	3.2086
B	0	0	1	3	4	2	0	1	0	1	0	4.6250	2.1252
C	0	0	0	8	1	0	2	0	1	0	0	3.8125	2.9690
D	0	0	2	2	5	2	0	1	0	0	0	4.5000	1.7497
E	0	1	0	2	3	5	0	0	0	1	0	4.0000	1.6000
F	0	0	1	5	3	1	1	1	0	0	0	4.1668	2.3002
G	0	0	3	3	1	1	2	0	2	0	0	4.5007	3.7920
H	0	1	0	1	0	4	0	4	2	0	0	6.0000	2.5002
I	0	0	2	1	0	1	0	2	5	0	1	3.0000	3.6000
												36.1057	
												4.0117	
												5.9983	

EXPERIMENT #26 Group 400 N=12

	0	1	2	3	4	5	6	7	8	9	10	S	Q
A	0	0	0	3	1	6	0	2	0	0	0	1.0000	3.1668
B	0	1	0	4	3	3	0	0	1	0	0	4.3332	1.8330
C	0	0	3	2	3	1	2	1	0	0	0	4.3332	4.0000
D	0	1	1	2	2	3	3	0	0	0	0	5.0000	2.5003
E	0	0	0	2	2	5	0	2	0	1	0	4.8523	1.5003
F	0	1	1	6	1	1	0	2	0	0	0	3.6666	1.8334
G	0	1	2	5	0	2	2	0	0	0	0	3.6000	2.0000
H	0	0	1	0	6	2	2	0	1	0	0	6.1666	1.6666
I	0	0	0	1	0	1	1	2	7	0	1	2.7144	1.2139
												35.6663	
												3.9629	
												6.0371	

EXPERIMENT #35 Group 400 N=13

	0	1	2	3	4	5	6	7	8	9	10	S	Q
A	0	1	1	0	0	10	0	0	1	0	0	0.6500	0.6500
B	0	1	3	3	4	1	0	0	1	0	0	3.8332	1.9374
C	0	1	1	2	3	5	1	0	0	0	0	4.8332	1.9244
D	0	1	3	0	6	2	0	0	0	0	0	4.3334	1.8334
E	0	0	0	1	2	5	2	1	2	0	0	4.5000	1.8253
F	0	1	0	9	2	1	0	0	0	0	0	3.6112	0.7223
G	0	1	3	3	3	2	0	1	0	0	0	3.8332	2.1664
H	0	0	1	0	4	3	1	1	3	0	0	5.5000	3.1877
I	0	1	0	0	0	2	0	4	4	0	2	3.1251	1.6250
												34.2193	
												3.8021	
												6.1979	

EXPERIMENT #2 Group 500 N=12

	0	1	2	3	4	5	6	7	8	9	10	S	Q
A	0	0	0	0	3	6	1	2	0	0	0	1.0000	1.5000
B	0	0	0	3	2	5	0	2	0	1	0	5.3001	1.8253
C	1	0	1	2	4	3	0	1	0	0	0	4.5002	1.8335
D	0	0	1	4	3	2	1	0	1	0	0	4.3332	1.9995
E	0	0	0	3	0	3	1	2	2	1	0	4.0000	4.0000
F	0	3	3	1	1	1	1	2	0	0	0	3.0000	4.0000
G	1	1	3	1	4	1	0	1	0	0	0	4.0000	3.4169
H	0	0	0	1	0	6	1	2	0	2	0	5.1666	2.1669
I	0	0	0	0	0	0	3	1	4	2	2	2.5002	2.5003
												33.8003	
												3.7556	
												6.2444	

EXPERIMENT #3 Group 500 N=12

	0	1	2	3	4	5	6	7	8	9	10	S	Q
A	0	0	1	2	4	3	1	1	0	0	0	1.7501	1.4997
B	0	0	1	1	3	4	1	1	0	1	0	5.2499	1.6668
C	0	0	1	6	0	1	2	2	0	0	0	3.8334	3.1663
C	0	0	2	4	2	3	1	0	0	0	0	4.0000	2.0833
E	0	0	0	2	1	4	1	1	2	1	0	4.3332	3.0000
F	1	3	2	0	1	1	3	1	0	0	0	3.0000	4.6664
G	1	1	1	2	3	0	3	1	0	0	0	4.3332	3.3332
H	0	0	0	1	1	4	4	2	0	0	0	5.0000	1.5002
I	0	0	0	0	0	1	1	6	1	3	0	3.3334	1.8334
												34.8332	
												3.8704	
												6.1296	

EXPERIMENT #4 Group 500 N=12

	0	1	2	3	4	5	6	7	8	9	10	S	Q
A	0	1	2	1	3	4	0	1	0	0	0	1.6668	4.2499
B	0	1	1	2	3	2	2	1	0	0	0	4.6668	2.5003
C	0	0	1	5	6	0	0	0	0	0	0	4.0000	1.1000
D	0	0	2	3	4	0	1	2	0	0	0	4.2499	1.6668
E	0	1	0	1	0	6	2	1	1	0	0	4.6666	1.3331
F	1	1	2	3	1	3	0	0	1	0	0	3.6668	2.8335
G	1	0	3	2	2	3	1	0	0	0	0	4.0000	2.6664
H	0	1	1	0	2	5	1	2	0	0	0	5.6000	1.4997
I	1	0	1	1	0	0	0	1	5	3	0	2.6000	3.0000
												35.1169	
												3.9019	
												6.0981	

EXPERIMENT #5 Group 500 N=12

	0	1	2	3	4	5	6	7	8	9	10	S	Q
A	0	0	1	1	4	4	0	1	0	1	0	1.1249	3.0000
B	1	0	1	1	3	3	0	1	1	0	1	5.0000	2.0000
C	1	0	2	2	2	1	3	0	1	0	0	4.4997	3.3332
D	1	1	0	3	2	4	1	0	0	0	0	4.4997	2.1670
E	0	0	1	2	3	2	2	1	0	0	0	5.0000	2.4997
F	0	2	1	2	3	1	3	0	1	0	0	4.3332	3.0000
G	0	1	2	2	4	0	2	1	0	0	0	4.2499	2.0000
H	0	0	1	2	3	2	3	0	1	0	0	6.0000	2.3332
I	0	2	0	0	3	2	0	1	3	1	0	5.4997	4.0000

40.2071
4.4675
5.5325

EXPERIMENT #12 Group 500 N=12

	0	1	2	3	4	5	6	7	8	9	10	S	Q
A	0	0	1	3	0	5	3	0	7	0	0	2.3332	2.7332
B	0	0	1	3	5	1	1	0	1	0	0	4.4000	1.3332
C	0	0	2	2	5	1	1	1	0	0	0	4.4000	1.5003
D	0	2	0	1	6	2	1	0	0	0	0	4.5000	1.0000
E	0	1	0	2	2	4	2	1	1	0	0	4.8000	2.0000
F	0	2	1	1	4	2	1	0	0	0	0	4.5002	2.4997
G	0	1	3	3	2	2	1	2	0	0	0	3.6668	2.3332
H	0	1	2	1	1	2	2	1	1	0	0	6.7503	3.7498
I	0	0	2	0	0	0	1	1	3	5	0	2.3332	2.7332

37.6837
4.1871
5.8129

EXPERIMENT #11 Group 500 N=12

	0	1	2	3	4	5	6	7	8	9	10	S	Q
A	0	0	1	2	4	0	3	0	1	1	0	2.6668	2.2499
B	0	1	1	1	2	2	0	4	0	0	1	5.0000	2.0000
C	0	0	3	0	2	3	1	3	0	0	0	5.3332	4.0000
D	0	1	1	2	2	2	2	1	1	0	0	5.0000	3.0000
E	0	0	1	0	4	3	1	2	1	0	0	4.4000	2.4997
F	0	1	2	3	2	2	0	2	0	0	0	4.0000	2.4997
G	0	2	0	1	4	2	0	3	0	0	0	4.7501	2.0000
H	0	1	0	3	3	3	2	0	0	0	0	6.3332	2.0000
I	0	1	1	0	2	2	1	1	3	0	1	5.0000	3.8329

42.4833
4.7204
5.2796

EXPERIMENT #16 Group 500 N=12

	0	1	2	3	4	5	6	7	8	9	10	S	Q
A	0	1	1	2	2	4	2	0	0	0	0	2.0000	2.7496
B	0	1	1	3	3	0	1	1	2	0	0	4.3332	3.6668
C	1	0	2	3	2	1	0	2	1	0	0	4.0000	3.0000
D	0	1	3	1	3	3	0	1	0	0	0	4.3332	2.6664
E	0	0	1	1	1	4	2	3	0	0	0	4.7837	1.0000
F	0	2	2	0	1	2	4	0	1	0	0	5.4997	4.0005
G	0	1	2	1	3	3	1	0	1	0	0	4.6668	2.6668
H	0	0	1	2	2	2	0	4	1	0	0	5.4997	3.4998
I	1	0	0	2	1	2	1	0	1	3	1	5.0000	5.3332
												40.1163	
												4.4574	
												5.5426	

EXPERIMENT #17 Group 500 N=12

	0	1	2	3	4	5	6	7	8	9	10	S	Q
A	0	0	1	1	3	4	0	1	1	0	0	1.6113	3.5621
B	0	0	2	2	3	1	2	0	1	0	0	4.5002	2.6252
C	0	0	1	2	3	1	3	1	0	0	0	4.8335	2.5415
D	0	1	1	2	3	2	2	0	0	0	0	4.5002	2.2498
E	0	0	0	2	2	3	1	3	0	0	0	4.2499	2.8335
F	0	1	1	3	1	4	1	0	0	0	0	4.5006	2.3123
G	0	1	0	3	1	1	3	2	0	0	0	5.5006	3.1665
H	0	0	1	0	2	2	4	1	1	0	0	4.8751	0.0973
I	0	0	0	1	3	1	1	0	1	2	1	5.0000	4.7500
												39.5714	
												4.3968	
												5.6032	

EXPERIMENT #26 Group 500 N=12

	0	1	2	3	4	5	6	7	8	9	10	S	Q
A	0	0	0	0	6	5	0	1	0	0	0	1.1666	1.0666
B	0	1	2	3	2	1	2	1	0	0	0	4.0000	3.0000
C	0	2	1	3	0	3	3	0	0	0	0	4.0000	3.0000
D	1	1	1	0	3	4	2	0	0	0	0	5.0000	2.7501
E	0	0	1	2	2	4	2	0	1	0	0	4.6000	2.0000
F	0	2	1	0	2	2	3	2	0	0	0	5.4997	3.6668
G	0	2	2	1	2	3	2	0	0	0	0	4.4997	3.7671
H	0	0	1	1	1	5	4	0	0	0	0	5.4997	2.4998
I	0	1	1	1	2	1	0	2	2	1	1	4.0000	4.5003
												38.2657	
												4.2917	
												5.7483	

EXPERIMENT #35 Group 500 N=12

	0	1	2	3	4	5	6	7	8	9	10	S	Q
A	0	0	0	1	4	4	2	0	1	0	0	1.5002	1.7496
B	1	1	2	4	2	0	1	1	0	0	0	3.5002	2.0000
C	1	0	1	1	4	2	3	0	0	0	0	4.5002	2.0000
D	1	1	0	4	2	1	3	0	0	0	0	4.0000	2.7501
E	0	0	0	1	3	5	1	1	1	0	0	5.7000	3.5003
F	0	2	2	1	3	2	0	2	0	0	0	4.3332	3.0000
G	1	1	1	2	3	2	1	1	0	0	0	4.3332	2.4997
H	1	0	0	2	2	2	4	1	0	0	0	5.4997	2.4998
I	1	0	0	0	1	1	1	2	3	2	1	3.0000	3.0000
												33.3667	
												3.7074	
												6.2926	

EXPERIMENT #2 Group 600 N=17

	0	1	2	3	4	5	6	7	8	9	10	S	Q
A	0	0	0	3	2	9	3	0	0	0	0	0.9445	2.1108
B	1	0	1	3	5	1	0	3	1	0	2	4.7001	3.8329
C	1	2	4	6	1	2	1	0	0	0	0	3.2499	1.6458
D	1	0	2	6	1	2	1	0	0	0	0	3.9167	1.9416
E	0	0	0	1	2	5	2	4	3	0	0	3.4091	2.4377
F	2	2	2	4	4	0	0	1	1	0	1	3.6252	2.5626
G	3	3	1	4	2	2	0	0	1	0	0	3.3748	3.4586
H	1	0	0	1	1	3	1	1	2	5	2	2.7500	4.1328
I	1	0	0	0	2	2	0	0	6	2	4	2.4168	5.2500
												28.3871	
												3.1541	
												6.8459	

EXPERIMENT #3 Group 600 N=18

	0	1	2	3	4	5	6	7	8	9	10	S	Q
A	1	0	0	2	3	12	0	0	0	0	0	0.7500	1.1247
B	2	1	2	4	2	1	1	4	1	0	0	4.0000	3.2502
C	2	6	1	3	3	1	1	0	0	1	0	3.0000	2.5833
D	1	2	3	4	3	3	1	0	1	0	0	3.7502	2.6667
E	0	0	0	0	2	7	3	2	2	1	1	4.0000	2.3926
F	4	1	2	2	4	2	2	0	1	0	0	4.0000	3.7502
G	3	3	2	3	3	3	0	1	0	0	0	3.3335	3.3335
H	0	0	0	0	1	6	1	1	5	3	0	3.0000	3.3167
I	1	0	0	0	0	1	0	4	3	6	3	2.0000	2.1250
												27.8335	
												3.0926	
												6.9074	

EXPERIMENT #4 Group 600 N=18

	0	1	2	3	4	5	6	7	8	9	10	S	Q
A	1	1	0	0	2	12	2	0	0	0	0	0.7500	1.3748
B	2	1	2	4	2	1	1	4	1	0	0	4.3333	3.0000
C	2	6	1	3	3	1	1	0	0	1	0	3.0000	3.2919
D	1	2	3	4	3	3	1	0	1	0	0	4.5005	2.9582
E	0	0	0	0	2	7	3	2	2	1	1	4.0000	2.3926
F	4	1	2	2	4	2	2	0	1	0	0	5.0000	3.4999
G	3	3	2	3	3	3	0	1	0	0	0	2.7143	3.4285
H	0	0	0	0	1	6	1	1	5	3	1	4.6667	1.9167
I	0	0	2	3	6	3	0	2	2	0	0	4.6665	2.0000
												29.8098	
												3.3122	
												6.6878	

EXPERIMENT #5 Group 600 N=18

	0	1	2	3	4	5	6	7	8	9	10	S	Q
A	1	0	1	1	2	8	2	1	1	1	0	1.5005	3.9374
B	2	1	5	1	2	3	1	1	1	0	1	4.0000	3.5333
C	0	1	4	5	6	1	0	1	0	0	0	3.7999	1.7084
D	0	2	1	4	4	4	1	2	0	0	0	4.5000	2.2502
E	1	0	0	0	3	5	4	3	1	0	1	4.0000	2.1667
F	3	1	1	4	3	2	1	1	1	0	1	4.0000	3.2498
G	1	2	4	4	3	2	0	1	0	0	1	3.5000	2.4583
H	1	0	0	2	3	3	3	1	3	1	1	5.0000	3.6665
I	0	0	1	0	1	1	1	5	2	4	3	3.0000	2.5250
												33.3004	
												3.7000	
												6.3000	

EXPERIMENT #13 Group 600 N=17

	0	1	2	3	4	5	6	7	8	9	10	S	Q
A	0	0	1	2	1	11	1	0	1	1	0	0.8182	2.8411
B	1	2	4	3	2	2	1	2	1	0	0	3.6665	3.3749
C	0	2	2	6	2	3	1	1	1	0	0	3.8335	2.4163
D	0	4	1	3	4	3	1	2	0	0	0	4.2502	2.9997
E	0	1	0	0	5	6	2	3	1	0	0	4.8928	2.0999
F	2	2	1	3	2	5	2	1	0	0	0	4.5005	3.1998
G	0	3	1	6	3	4	0	0	0	1	0	3.8335	2.0417
H	0	0	0	2	5	5	0	3	1	1	0	5.7999	2.8666
I	0	0	0	0	0	3	1	3	3	4	3	2.6665	3.1251
												34.2616	
												3.8068	
												6.1932	

EXPERIMENT #11 Group 600 N=17

	0	1	2	3	4	5	6	7	8	9	10	S	Q
A	0	1	0	2	2	10	1	0	1	0	0	0.8501	2.3250
B	0	2	3	6	1	3	1	0	0	0	1	3.5835	2.4998
C	0	0	2	5	4	4	0	0	1	0	0	4.3748	1.9871
D	0	0	3	4	6	2	0	1	0	0	1	4.2499	1.6459
E	0	0	0	3	3	7	2	2	0	0	0	4.8750	2.6519
F	2	1	1	3	1	4	1	2	2	0	0	5.1249	3.6667
G	0	0	4	2	4	4	1	1	0	0	1	4.6252	2.5626
H	0	1	0	2	3	5	2	3	1	0	0	5.7999	2.8666
I	0	1	0	1	0	1	1	3	7	2	1	2.7856	1.7382
												36.2689	
												4.0299	
												5.9701	

EXPERIMENT #16 Group 600 N=18

	0	1	2	3	4	5	6	7	8	9	10	S	Q
A	0	1	1	1	1	8	3	2	1	0	0	2.0000	3.6876
B	2	2	4	1	3	5	0	2	0	0	0	4.0000	3.1748
C	0	0	6	6	1	5	0	0	0	0	0	3.5002	2.3500
D	0	3	6	2	4	3	0	0	0	0	0	3.0000	2.3752
E	0	0	0	2	4	6	1	3	2	0	0	3.6999	2.5417
F	1	2	5	1	3	4	0	0	2	0	0	4.0000	5.0750
G	1	0	3	3	8	1	2	0	0	0	0	4.2500	1.6458
H	0	0	2	1	2	5	1	4	2	1	0	5.2001	2.8753
I	0	0	1	0	1	2	3	4	5	1	0	2.7502	2.8002
												32.4004	
												3.6000	
												6.4000	

EXPERIMENT #17 Group 600 N=18

	0	1	2	3	4	5	6	7	8	9	10	S	Q
A	1	0	0	1	2	12	2	0	0	0	0	0.7500	1.3748
B	1	0	1	4	1	4	1	3	2	1	0	5.5000	3.8746
C	0	2	0	5	2	5	0	2	2	0	0	5.0000	2.3999
D	1	1	2	7	5	0	1	1	0	0	0	3.7143	1.4285
E	0	0	1	0	3	5	3	4	2	0	0	4.0000	2.2748
F	2	1	3	4	2	3	1	2	0	0	0	3.7502	3.0000
G	0	1	1	4	4	2	3	1	1	0	0	4.7502	2.8746
H	0	0	0	3	1	8	2	1	2	1	0	5.3751	1.6875
I	2	0	1	2	0	1	2	5	1	1	3	3.7999	4.7502
												36.6397	
												4.0711	
												5.9289	

EXPERIMENT #26 Group 600 N=18

	0	1	2	3	4	5	6	7	8	9	10	S	Q
A	1	0	0	1	2	7	4	2	1	0	0	2.0000	2.8575
B	1	2	2	2	4	2	1	1	2	1	0	4.5000	3.7502
C	0	2	0	5	2	5	0	2	2	0	0	4.0000	3.1501
D	1	1	2	7	5	0	1	1	0	0	0	5.0000	2.6668
E	0	0	1	0	3	5	3	4	2	0	0	4.5000	3.2709
F	2	1	3	4	2	3	1	2	0	0	0	5.0000	3.0667
G	0	1	1	4	4	2	3	1	1	0	0	5.2001	2.5417
H	0	0	0	3	1	8	2	1	2	0	0	5.3000	2.0502
I	2	0	1	2	0	1	2	5	1	1	3	3.7999	1.9166
												39.3000	
												4.3667	
												5.6333	

EXPERIMENT #35 Group 600 N=18

	0	1	2	3	4	5	6	7	8	9	10	S	Q
A	1	0	1	1	3	11	0	1	0	0	0	0.8182	1.4241
B	2	6	1	6	0	1	0	1	0	0	1	3.0000	2.3334
C	0	5	2	4	0	4	2	0	0	1	0	3.5000	3.7252
D	1	3	4	3	3	2	1	1	0	0	0	3.3335	2.7081
E	0	0	0	2	0	9	1	2	4	0	0	5.0000	2.4720
F	2	2	2	2	2	6	2	0	0	0	0	4.5005	3.3331
G	1	2	2	6	2	3	1	0	1	0	0	3.6667	2.4170
H	0	0	1	2	6	5	2	1	1	0	0	6.0000	1.6500
1	0	0	1	1	0	1	1	1	1	7	5	1.5714	2.6001
												31.3903	
												3.4878	
												6.5122	

EXPERIMENT #2 Group 700 N=22

	0	1	2	3	4	5	6	7	8	9	10	S	Q
A	0	0	0	1	1	19	0	1	0	0	0	0.5790	0.5790
B	3	1	2	0	4	9	1	2	0	0	0	5.1112	2.9720
C	0	3	0	10	2	4	0	2	1	0	0	3.8000	2.1252
D	0	1	0	7	5	7	1	1	0	0	0	4.6001	1.8573
E	0	0	0	0	1	3	7	5	6	0	0	3.0000	1.8689
F	4	3	4	1	3	3	1	2	1	0	0	3.0000	4.0000
G	1	8	2	6	1	4	1	0	0	0	0	3.0000	2.3544
H	0	1	0	2	0	4	3	1	6	3	2	3.0000	3.2919
I	0	0	0	0	1	2	1	5	9	1	3	2.7778	3.5333
												28.8681	
												3.2065	
												6.7935	

EXPERIMENT #3 Group 700 N=22

	0	1	2	3	4	5	6	7	8	9	10	S	Q
A	0	0	0	1	8	10	1	1	1	0	0	1.1251	1.2626
B	2	0	2	2	3	5	1	5	1	1	0	5.3999	3.5497
C	0	3	3	5	0	5	1	2	3	0	0	4.0000	4.4169
D	0	2	1	5	4	5	3	2	0	0	0	4.5000	2.3999
E	0	0	0	1	0	8	2	9	2	0	0	3.0000	2.0487
F	1	1	2	3	7	0	3	3	2	0	0	4.5713	3.3328
G	0	5	3	4	6	3	1	0	0	0	0	3.7503	2.5835
H	0	0	0	2	2	5	0	6	5	2	0	3.6667	3.0000
I	0	0	0	1	0	4	5	3	6	3	1	3.3336	2.4499
												34.5269	
												3.8363	
												6.1637	

EXPERIMENT #4 Group 700 N=22

	0	1	2	3	4	5	6	7	8	9	10	S	Q
A	0	0	1	1	5	12	1	2	0	0	0	0.9166	1.4414
B	0	3	4	5	4	4	0	2	0	0	0	3.7998	2.5000
C	0	3	5	8	0	3	0	1	3	1	0	3.3751	2.6666
D	0	5	0	9	2	2	3	0	0	1	0	3.6666	2.1942
E	0	0	0	0	2	7	5	4	3	1	0	3.9349	2.0000
F	1	1	3	6	3	3	4	1	0	0	0	4.0000	2.7496
G	0	6	4	6	4	0	2	0	0	0	0	3.1669	2.2081
H	0	0	0	0	2	8	1	6	3	2	0	4.0000	2.4792
I	0	0	0	0	2	1	3	4	3	8	1	2.6664	2.6040
												27.9913	
												3.1101	
												6.8899	

EXPERIMENT #5 Group 700 N=22

	0	1	2	3	4	5	6	7	8	9	10	S	Q
A	0	0	0	4	6	9	2	0	0	0	1	1.3333	2.1392
B	0	2	1	4	0	3	4	3	2	1	2	6.2503	4.2079
C	1	0	4	6	0	3	1	5	1	1	0	4.0000	4.2168
D	0	1	1	3	2	6	3	3	3	0	0	5.6667	2.9167
E	0	0	0	2	5	6	5	3	1	0	0	4.9444	2.0000
F	0	1	1	5	7	2	3	3	0	0	0	4.5713	2.4664
G	1	2	2	3	4	4	3	2	0	0	0	4.5713	3.0000
H	0	0	0	3	4	6	3	5	2	0	0	5.1669	2.4249
I	1	0	1	3	1	4	1	5	2	4	0	4.0000	3.7486
												40.5042	
												4.5005	
												5.4995	

EXPERIMENT #13 Group 700 N=22

	0	1	2	3	4	5	6	7	8	9	10	S	Q
A	0	0	2	2	4	11	1	1	0	0	1	1.0000	2.7497
B	1	1	4	5	2	5	1	3	0	0	0	4.0000	2.8249
C	1	1	3	11	3	1	2	0	0	0	0	3.5454	1.1210
D	0	2	2	9	4	3	0	2	0	0	0	3.7778	1.7084
E	1	0	1	2	5	6	1	3	2	1	0	4.9398	2.8664
F	0	1	3	4	3	4	5	2	0	0	0	5.0000	2.9249
G	0	1	6	7	2	4	1	2	0	0	0	3.5713	2.3750
H	0	0	1	2	5	4	3	6	0	0	0	4.5000	2.7832
I	0	0	0	1	1	5	0	1	8	5	1	2.6251	3.4003
												32.9594	
												3.6622	
												6.3378	

EXPERIMENT #11 Group 700 N=22

	0	1	2	3	4	5	6	7	8	9	10	S	Q
A	0	0	1	3	3	10	2	1	1	0	0	1.1666	2.7248
B	0	2	1	4	0	3	4	3	2	1	2	5.2500	1.8127
C	1	0	4	6	0	3	1	5	1	1	0	4.6001	2.3249
D	0	1	1	3	2	6	3	3	3	0	0	4.6110	1.5000
E	0	0	0	2	5	6	5	3	1	0	0	4.9324	2.0000
F	0	1	1	5	7	2	3	3	0	0	0	5.0000	2.5000
G	1	2	2	3	4	4	3	2	0	0	0	4.5006	1.3991
H	0	0	0	3	4	6	3	5	2	0	0	5.1001	2.0668
I	1	0	1	3	1	4	1	5	2	4	0	4.2002	2.8751
												35.8567	
												3.5396	
												6.4604	

EXPERIMENT #16 Group 700 N=22

	0	1	2	3	4	5	6	7	8	9	10	S	Q
A	0	1	1	1	5	11	1	1	0	0	1	1.0000	1.9989
B	1	0	4	5	3	5	0	3	1	0	0	4.3336	2.6001
C	0	1	0	9	2	5	1	0	1	0	0	4.5006	2.3998
D	0	2	1	6	8	2	1	2	0	0	0	4.2500	1.5210
E	0	0	0	6	2	5	4	4	0	1	0	4.8750	3.1774
F	0	3	4	2	4	5	2	2	0	0	0	4.5000	3.0751
G	0	0	8	5	3	4	0	1	0	1	0	3.6001	2.4373
H	0	0	1	1	3	5	3	6	2	1	0	4.6664	2.4831
I	0	0	0	1	2	2	2	4	5	5	1	3.0000	2.8506
												38.1944	
												4.2438	
												5.7567	

EXPERIMENT #17 Group 700 N=22

	0	1	2	3	4	5	6	7	8	9	10	S	Q
A	1	0	0	3	2	15	0	1	0	0	0	0.7334	1.3836
B	0	0	4	3	5	2	2	2	3	0	1	4.7998	3.7497
C	0	0	4	3	5	2	2	2	3	0	1	5.0000	2.5417
D	0	0	1	6	3	7	0	3	1	0	0	5.1430	2.1788
E	0	0	0	2	1	12	1	2	3	0	0	4.9523	2.0916
F	0	1	3	4	4	6	1	1	1	0	1	4.7503	2.3748
G	0	0	3	6	6	5	2	1	0	1	0	4.3333	1.8834
H	0	0	1	0	2	9	3	4	1	1	1	4.3336	2.0974
I	1	0	2	0	4	3	3	6	1	2	0	4.6664	2.9585
												38.7121	
												4.3103	
												5.6987	

EXPERIMENT #26 Group 700 N=22

	0	1	2	3	4	5	6	7	8	9	10	S	Q
A	0	1	3	0	4	11	1	2	0	0	0	1.0000	3.7497
B	0	1	2	6	4	5	1	2	1	0	0	4.5000	2.0832
C	0	0	4	5	4	6	1	1	1	0	0	4.5000	2.2834
D	0	1	3	5	5	5	2	1	0	0	0	4.3999	2.1998
E	0	1	3	2	1	7	3	3	1	0	0	4.8824	3.4996
F	0	1	0	4	2	8	3	1	2	0	0	5.5000	2.2503
G	0	1	2	6	2	6	3	2	1	0	0	5.0000	2.5002
H	0	0	0	1	6	8	2	5	2	0	0	5.2500	2.2376
I	0	0	0	1	4	4	3	3	4	2	1	4.3336	3.2502
												39.3600	
												4.3440	
												5.6260	

EXPERIMENT #35 Group 700 N=22

	0	1	2	3	4	5	6	7	8	9	10	S	Q
A	0	0	1	1	4	14	1	0	1	0	0	0.7857	1.2321
B	0	2	6	5	6	2	0	1	0	0	0	3.6001	2.0000
C	0	2	5	7	4	1	1	2	0	0	0	3.5713	1.9249
D	0	2	5	3	4	5	2	1	0	0	0	4.2503	2.7998
E	0	0	0	4	2	8	1	4	3	0	0	5.6251	3.1713
F	0	1	2	4	5	4	2	2	2	0	0	4.7998	2.6248
G	0	1	4	4	4	9	0	0	0	0	0	4.5000	2.2640
H	0	1	0	0	5	8	2	4	2	0	0	5.3751	2.2248
I	0	1	0	0	5	8	2	4	2	0	0	2.6664	4.1249
												33.9236	
												3.7693	
												6.2307	

APPENDIX G

MATERIALS GIVEN TO STUDENTS

CHEMISTRY 3015
LABORATORY SCHEDULE
FALL, 1969-70

WEEK OF	FIRST LABORATORY	SECOND LABORATORY
Sept. 10	NO CLASSES	CHECK--IN LAB
Sept. 15	Exp. 1, Crystallization	Exp. 2, Melting Points
Sept. 22	Exp. 3, Distillation-Boiling Pts.	Exp. 4, Fractional Distillation
Sept. 29	Exp. 5, Qualitative Analysis	Exp. 5, continued
Oct. 6	Exp. 6, Hydrocarbons	*m-Dinitrobenzene
Oct. 13	Exp. 13, Cyclohexanol; Alcohols	Exp. 13, continued
Oct. 20	Exp. 11, n-Propyl Bromide	Exp. 11, continued
Oct. 27	*Methyl Ethyl Ketone and start *Fermentation	Complete Methyl Ethyl Ketone
FIRST LAB EXAM -- TUESDAY -- OCTOBER 28 -- 5:30 P.M. -- ES 317		
Nov. 3	*Complete Fermentation	Exp. 16, Carbonyl Compounds
Nov. 10	Exp. 17, Acids	*Methyl Salicylate
Nov. 17	*Complete Methyl Salicylate	Exp. 20, Saponification of Isoamyl Acetate
Nov. 24	*Butter	Thanksgiving Vacation
Dec. 1	*Oleomargarine	Exp. 25, Acetylsalicylic Acid
Dec. 8	Exp. 26, Properties of Amines	Exp. 30, Diazo Compounds
Dec. 15	Exp. 29, Sulfanilamide	Exp. 29, continued
SECOND LAB EXAM -- THURSDAY -- DECEMBER 18 -- 5:30 P.M. -- ES 317		
Dec. 22	Christmas Vacation	
Dec. 29	Christmas Vacation	
Jan. 5	Exp. 36, Carbohydrates	CHECK-OUT OF LAB
Jan. 12	FINALS WEEK	

*Mimeographed experiments

Name________________________________ Lab. Subsection:____________________

Sex_____ Age______ Date of Birth______ Class: So Jr Sr Gr
Marital Military Status
Status:________(service, reserve, ROTC, NG,/classification)____________

Stillwater Address:__________________________ Phone______________________

Home Address:____

College:__________ Major:____________ Proposed Vocation:_______________

Do you work?_________ Approx. how many hours per week?_________________

Chemistry Background:

High School Chemistry: School____

Approx. Enrollment:_____Year Taken: Fr So Jr Sr Text Used:___________

How often did you have lab?__________Grade Received____________________

Freshman Chemistry: Number?____ Name:_________ Hrs:______ Grade:________

Institution where taken:_________________________

Other Chemistry Courses: Number:____ Name:_________ Sem. Hrs.__________

Institution:_____________________________________ Grade:_____________

Did your high school course contain any organic?_____ How much?________

Did your freshman course contain any organic?________ How much?________

Overall GPA:_______ GPA in Major:_______ GPA in Chem. Courses:_________

The next two pages contain a survey to determine your background in some laboratory techniques. Many of the names will be strange to you. Some of the names or techniques are common to anyone who has had any introduction into the chemistry laboratory.

This survey will not be used in any way to determine your grade. It is part of our program to revise our courses to make them more relevant and meaningful.

This survey will be taken in two parts. First to indicate your entering skills then at the conclusion of the course to reflect the changes. Look at the responses in the first section (1-4). These are the entering skills or behaviors. Merely place an x or a ✔ in the appropriate column after each of the 55 skills.

Chemistry 3112, 3252, 3015

8/19/69/jr

This is an inventory of the apparatus in your desk. You will be held responsible for all this equipment which must be returned clean, dry and in good condition at the end of the semester or at any time that you drop the course.

1 Beaker, 50 ml.	.49
1 Beaker, 100 ml.	.53
1 Beaker, 250 ml.	.49
1 Beaker, 400 ml.	.58
1 Beaker, 600 ml.	.73
1 Beaker, 800 ml.	.89
2 Bottles, 1 oz., glass stoppered, narrow mouth, ea.	.85
2 Bottles, 1 oz., glass stoppered, wide mouth, ea.	1.15
1 Cylinder, graduated, 10 ml.	1.15
1 Cylinder, graduated, 50 ml.	1.45
1 Cylinder guard, 10 ml.	.10
1 Cylinder guard, 50 ml.	.15
1 File, triangular, 4"	.40
1 Flask, Erlenmeyer, 125 ml.	.58
1 Flask, Erlenmeyer, 250 ml.	.60
1 Flask, filter, 125 ml.	1.95
1 Flask, filter, 500 ml.	2.67
1 Forceps	.30
1 Funnel, short stem, pyrex, 50 ml.	.75
1 Funnel, Buchner No. 1, 56 mm. with stopper	2.87
1 Funnel, Hirsch, No. 000, with stopper	1.85
2 Glass rods, each.	.08
3 Medicine droppers, ea.	.05
1 Melting point tube, Thiele	4.41
3 Rubber stoppers - 1 No. 2, solid	.03
1 No. 2, 1-hole	.03
1 No. 00, solid	.02
1 Scoopula	.30
1 Spatula, nickel, double end	1.25
6 Test tubes, 13 x 100 mm., pyrex, ea.	.07
6 Test tubes, 18 x 150 mm., pyrex, ea.	.11
1 Test tube brush, medium	.15
1 Test tube clamp	.25
1 Test tube rack, 13 place, drying pin	2.25
6' Tubing, rubber, 1/4 x 1/16"	1.08
2' Tubing, rubber, 1/4 x 1/8"	.72
1 Watch glass, pyrex, 125 mm.	.23
1 Water bath, 6"	6.50
1 Wing top	.45
1 Wire gauze, asbestos center	.27
1 Withdrawal pad	N.C.
1 Vial	.05
1 Sidearm Tube	2.30

ORGANIC KIT

1 Box Polyestyrene, Expanded	
1 Condenser, West Type, 200 mm. 19/22 joint	7.36
1 Distilling Column, 200 mm. 19/22 joint	8.40
1 Flask, Round Bottom, 25 ml. 19/22 joint	2.51
1 Flask, Round Bottom, Single Neck, 50 ml. 19/22 joint	2.51
1 Flask, Round Bottom, Single Neck, 100 ml. 19/22 joint	2.41
1 Flask, 250 ml. with side tube, 19/22 joint	3.11
1 Flask, 3-neck, angle type, 500 ml. 19/22 joint	9.83
1 Funnel, separatory, pear-shape addition, w/teflon plug, 125 ml. 19/22 joint	13.74
1 Stopper, Glass, solid, 19/22, each	1.57
1 Tube, adapter, straight, 19/22 joint Thermadapter	1.66
1 Rubber connection for straight adapter	.26
1 Tube, bleed, gas (steam)	.37
1 Tube, connecting, 3-way, paralleled side arm, 19/22 joint claisen	6.85
1 Tube, connecting, 3-way, 19/22 joint	5.81
1 Tube, connecting, distilling, 19/22 joint adapter	5.09
1 Thermometer, -10 to 360°C	2.85

Name ____________

Lab Section ________ Subsection ________

Date Part I completed ________

Date Part II completed ________

Place an x or a y in the most appropriate response.

	1. Simple filtration.	2. Simple filtration with fluted filter paper.	3. Suction filtration with a Hirsch funnel.	4. Suction filtration with a Buchner funnel.	5. Reflux condenser.	6. Simple distillation.	7. Fractional distillation.	8. Steam distillation.	9. Vacuum distillation.	10. Solvent selecting (the best for the particular conditions).	11. Salting out.	12. Washing with a carbonate.	13. Ether extraction.	14. Melting point determination.	15. Reading a thermometer.	16. Preparing and filling a melting point capillary	17. Calibrating a thermometer.	18. Boiling point determination.	19. Correct placement of a thermometer in distillation.	20. Thiele-Dennis (or Thiele) tube.	21. Separatory funnel.	22. Distilling column.	23. Diazotization.	24. Steam heating.	25. Use of fume hood.	26. Sodium fusion tests.	27. Saponification.	28. Drying ether.	29. Grignard reagent and reaction.	30. Hooking up a condenser in the water.	31. Boring a hole in a cork.	32. Boring a hole in a stopper.	33. Calibrating a thermometer.
III. I do not know when or under what circumstances this would be used.																																	
II. I feel that I know some circumstances when this could be used.																																	
I. I feel that I know when and under what conditions I would use this.																																	
8. Did not use or need this technique in this class.																																	
7. Feel that I have gained skill and am proficient in the technique.																																	
6. Can perform the technique without difficulty.																																	
5. Can perform the technique alone but lack confidence.																																	
4. Can perform the technique but feel need for some aid from a fellow student.																																	
3. Can perform the technique but feel need for some help from the instructor.																																	
2. Vague recollection of the technique.																																	
1. Had no knowledge or experience.																																	
4. Proficient in the technique.																																	
3. Some experience but no proficiency.																																	
2. Some knowledge but no experience.																																	
1. Have no knowledge or experience.																																	

Name________________________

	1. Have no knowledge or experience.	2. Some knowledge but no experience.	3. Some experience but no proficiency.	4. Proficient in the technique	1. Had no knowledge or experience.	2. Vague recollection of the technique.	3. Can perform the technique but feel need for some help from the instructor.	4. Can perform the technique but feel need for some aid from a fellow student.	5. Can perform the technique alone but lack confidence.	6. Can perform the technique without difficulty.	7. Feel that I have gained skill and am proficient in the technique.	8. Did not use or need this technique in this class.	I. I feel that I know when and under what conditions I would use this.	II. I feel that I know some circumstances when this could be used.	III. I do not know when or under what circumstances this would be used.
34. Putting standard taper glassware together.															
35. Friedel-Crafts reaction.															
36. Using a graduated cylinder.															
37. Correcting a thermometer reading.															
38. Determining sulfur in an organic compound.															
39. Determining whether bonding is saturated or unsaturated.															
40. Using the centigram or decigram balance.															
41. Removing noxious vapors from laboratory desk area.															
42. Determining presence of nitrogen in an organic compound.															
43. Determining presence of chlorine or chloride.															
44. Removing highly flammable solvents.															
45. Sharpening a cork borer.															
46. Bending glass tubing.															
47. Removing a colored impurity from a colorless sample.															
48. Determining presence of phenolic ring in compound.															
49. Use a laboratory gas burner (bunsen burner).															
50. Soxhlet extraction.															
51. Treating an acid burn.															
52. Removing traces of water from nonpolar solvent.															
53. Electric heating mantle.															
54. Distinguishing between a reducing and nonreducing sugar.															
55. Preparing an ester.															

CHEM 3015 "Experimental Sections" Suggested Film Viewing
The following list is merely a suggestion as to films recommended for a particular experiment. Subsequent experiments may repeat a technique. One may review the film if and when desired. It is also recommended that you view or preview the films during the previous laboratory period. (After you complete an experiment you may then begin to prepare for the next. It also prevents a traffic jam at the projectors.) Film #7 Methods of Heating and #24 Fume A Vapor Removal are of general interest and should be viewed as soon as convenient.

Week of	First Laboratory	Second Laboratory
Sept. 10	Expt. 1, Crystallization #1 Decolorizing #2 Supersaturation #3 Folding Fluted Filter Paper #4 Rapid Filtration #5 Reflux #6 Use of Boiling Chips #7 Methods of Heating	Expt. 2, Melting Points #8 Thermometer Correction #9 Melting Point Determination: 1: Capillary Preparation #10 Melting Point Determination 2: Thiele-Dennis Tube
Sept. 22	Expt. 3, Distillation-Boiling Pts. #12 Simple Distillation 1: Setting Up #13 Simple Distillation 2: Operational Hints #14 Thermometer Placement	Expt. 4, Fractional Distillation #11 Boring Holes in Corks #15 Fractional Distillation
Sept. 29	Expt. 5, Qualitative Analysis #16 Sodium Fusion Tests 1: Test Soin Prep. #17A Sodium Fusion Tests 2: Nitrogen Detn.	Expt. 5, cont. #17B Sodium Fusion Tests 3. Sulfur determination #17C Sodium Fusion Tests 4. Halogen determination
Oct. 6	Expt. 6, Hydrocarbons	m-Dinitrobenzene
Oct. 13	Expt. 13, Cyclohexanol, Alcohols #18 Steam Distillation #19 Sep & Pur 1: Washing with a Carbonate #20 Sep & Pur 2: Salting Out #21 Sep & Pur 3: Extraction	Expt. 13, cont. #22 Sep & Pur 4: Drying #23 Sep & Pur 5: Ether Removal
Oct. 20	Expt. 11, n-Propyl Bromide	Expt. 11, cont.
Oct. 27	Methyl Ethyl Ketone	MEK cont.
Nov. 3	Fermentation	Expt. 16, Carbonyl cpds
Nov. 10	Expt. 17, Acids	Methyl Salicylate
Nov. 17	Methyl Salicylate cont.	Expt. 20, Saponification
Nov. 24	Butter	xxx
Dec. 1	Oleomargarine	Expt. 35, Acetylsalicylic acid

Week of	First Laboratory	Second Laboratory
Dec. 8	Expt. 26, Amines	Expt. 30, Diazo Compounds #25 Diazotization I #26 Diazotization II
Dec. 15	Expt. 29, Sulfanilamide	Expt. 29, cont.
Jan. 5	Expt. 36, Carbohydrates	

SYNOPSIS OF SINGLE CONCEPT FILMS FOR LABORATORY TECHNIQUES IN ORGANIC CHEMISTRY

#1 DECOLORIZING (2.02 min.)

Shows a solution of a colorless compound which contains a trace of a colored impurity. Shows that filter paper does not remove the colored matter. Solution is mixed with a small amount of decolorizing carbon (Norit A) and then filtered.

#2 SUPERSATURATION (1.02 min.)

Shows methods of disturbing a supersaturated solution including adding a seed crystal and scratching the inner surface.

#3 FOLDING FLUTED FILTER PAPER (2.23 min.)

Shows an efficient method for folding fluted filter paper. Also shows two methods for the regular folding of filter paper.

#4 RAPID FILTERING (3.40 min.)

Shows both Hirsch and Buchner funnels. Be certain to wash the precipitate with small applications of the wash solvent rather than large applications lest the precipitate appreciably dissolve.

If the solvent is corrosive to metal a trap should be placed in-between the filter flask and the aspirator. This also is helpful if the volume of liquid is greater than the filter flask and there would be a possibility of the solvent being pulled into the aspirator. This can be avoided by halting the operation and emptying the filter flask then resuming the filtration.

#5 REFLUX (3.17 min.)

Shows the reflux condenser in operation. Shows the proper method of assembling the apparatus.

#6 USE OF BOILING CHIPS (1.55 min.)

Shows erratic boiling without boiling chips. Shows smooth even boiling due to the irregularities on the chips which allow the formation of bubbles.

#7 METHODS OF HEATING (2.38 min.)

Using a reflux condenser as an example heating on a hot water (or boiling water) bath, steam bath, burner flame with a wire screen, and burner flame without a wire screen is shown. Heating a beaker is also shown on the steam bath.

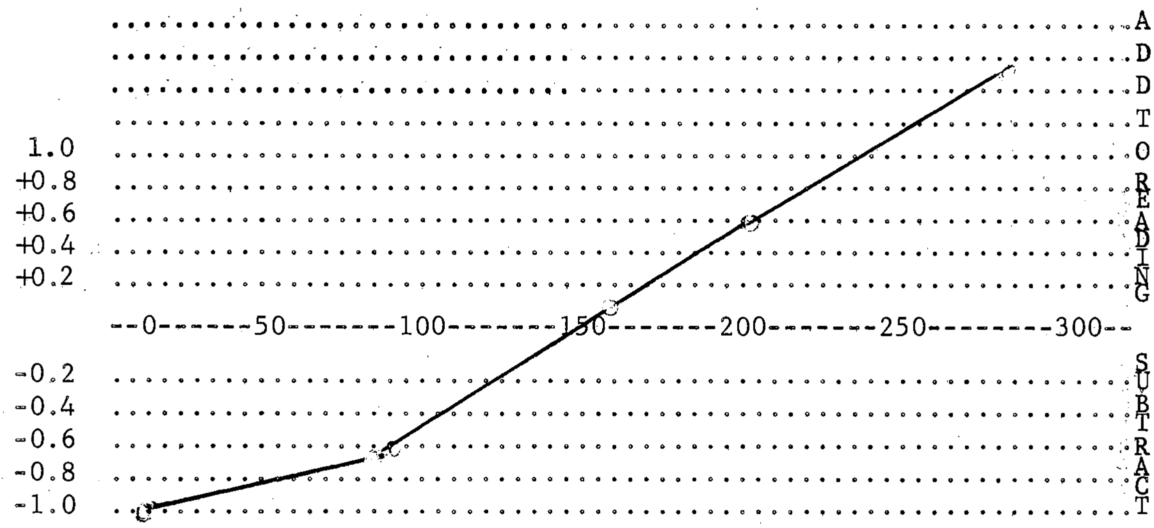
Note the possibility which occurs when a burner without a screen is used with a flammable solvent.

#8 THERMOMETER CORRECTION (3.43 min.)

Shows several laboratory grade thermometers immersed in the same bath. Shows one thermometer placed in various materials whose temperatures are accurately known. It is necessary to use amounts sufficient to cover the thermometer to its immersion depth. This amount of material also will change temperature more slowly than would a melting point capillary immersed in wax or oil.

What are the actual melting (or boiling) points? The following are <u>not</u> those which appear on the film but are given to present a similar example.

cpd:	actual ^{o}C	therm. reading	correction (add to reading)
water (m.p.	0	+ 1.0	- 1.0
m-dinitrobenzene	89.5	90.2	- 0.7
water (b.p.)	99.7	100.4	- 0.7
salicylic acid	156.0	155.9	+ 0.1
isatin	200.0	199.4	+ 0.6
anthraquinone	286.0	284.5	+ 1.5



#9 MELTING POINT DETERMINATION Part 1: Capillary Preparation (2.30 min.)

Shows two methods of preparing and sealing melting point capillaries. Shows the filling of capillaries and their insertion in the rubber ring on the thermometer. Shows some poor capillaries (red background: bent, misshapen and/or not quite sealed) and some good capillaries (blue background.)

#10 MELTING POINT DETERMINATION Part 2: Thiele-Dennis Tube (1.35 min.)

Shows the capillary in the Melting Point Tube. (An alternate method not shown would be to clamp the tube as indicated and clamp the cork holding the thermometer somewhere above the maximum temperature to be determined. This allows reading temperatures near the mouth of the Tube and it would not be necessary to cut a channel in the cork to allow pressure equalization.

Shows the melting of the sample in the capillary. Note the temperature when the melting begins and the temperature when the melting is complete. (If heating occurs too fast the thermometer reading when the last crystal metls will be higher than the melting point actually is. What is the melting point range of this sample?

#11 BORING HOLES IN CORKS (2.33 min.)

Shows cork selection, cork borer selection, and sharpening the cork borer. On boring the hole note that merely pressing down on the borer does <u>not</u> drill the hole easily. However by pressing down and turning the cutting occurs easily. A quarter turn is quite convenient--then turn the cork and twist again. Note also that the cork is drilled through from both ends toward the middle. This avoids "blown out" ends--see the bad holes as compared to the good examples. Shows putting the cork on tubing (in this case a thermometer). Be certain to lubricate the tubing with water or glycerol.

#12 SIMPLE DISTILLATION Part 1: Setting Up (3.22 min.)
Shows proper methods of setting up a simple distillation apparatus. It includes the recommended order of placement as well as placement of clamps. Shows recommended methods of securing the receiver adapter and clamping the receiver.

#13 SIMPLE DISTILLATION Part 2: Operational Hints (2.38 min.)
Shows what happens when either the receiver or adapter is not clamped. Shows filling the flask and insertion of the thermometer. Note flask should not be filled more than 2/3 full. If more liquid must be distilled use a larger flask or distill in several portions--then mix the distillates and distill again.

#14 THERMOMETER PLACEMENT (2.38 min.)
Using a known compound (aniline) it shows the relation of the pot temperature to the temperatures in the column above, at, and below the outlet. What is the temperature you actually wish to measure? If it is the temperature of the vapor which is leaving then where should the thermometer bulb be placed?

#15 FRACTIONAL DISTILLATION (4.03 min.)
Shows two column types. Shows receiver changing. No distillate will be lost if when the temperature is reached for the change, the heat is removed and the few drops of distillate present in the condenser are allowed to come over. The temperature as registered on the thermometer will drop slightly. Change the receivers then resume heating. Note that no distillate will come over until the temperatures at which heating was stopped is reacted.

#16 SODIUM FUSION TESTS Part 1: Solution Preparation (3.49 min.)
Shows the method of using soft glass test tubes in a transite square. Be certain to place the piece of sodium on filter paper to absorb the kerosine. Be certain to use distilled water in the beaker. (What would you expect to find if you used tap water?)

#17A SODIUM FUSION TESTS Part 2: Nitrogen Determination (1.45 min.)
Shows the procedure for determining the presence of nitrogen. The blue or blue-green color may not appear for several minutes. If in doubt filter the solution. The blue is due to Prussian (or Turnbull's) Blue--the iron (11)(111) cyanide.

#17B SODIUM FUSION TESTS Part 3: Sulfur Determination (1.01 min.)
Shows the procedure for determining the presence of sulfur.

#17C SODIUM FUSION TESTS Part 4: Malogen Determination (1.26 min.)
Shows the halogen test (for Cl, Br, and 1, but not F.) Frequently seen though distilled water is used there is some chloric contamination which will produce a thin white precipitate. If a halogen is present in the sodium fusion extract it will normally manifest itself as a dense heavy white silver halide precipitate.

#18 STEAM DISTILLATION (3.41 min.)

Shows the steps to assemble and operate steam distillation. Before commencing operation (after preliminary running of the steam and before solution is added or the steam inlet is connected) make certain that the valve is open so that the pressure in the flask and the steam trap is equalized. If this is not done the steam present in the adapter will condense thus reducing the pressure and causing the material present in the distilling flask to be forced into the adapter and perhaps worse--into the sink.) (It is rather difficult to distill when one's preparation is in the adapter or down the sink) rather the solution is placed in the distilling flask turn on the steam then place the inlet stopper in place.

#19 SEPARATION AND PURIFICATION Part 1: Washing with a Carbonate (1.19 min.)

Shows the addition of a saturated aqueous solution of sodium carbonate as well as solid potassium carbonate (or sodium carbonate) to the solution which contains some traces of unused acid. Be careful not to add too much carbonate so that the solution foams over and sample is lost.)

#20 SEPARATION AND PURIFICATION Part 2: Salting Out (3.40 min.)

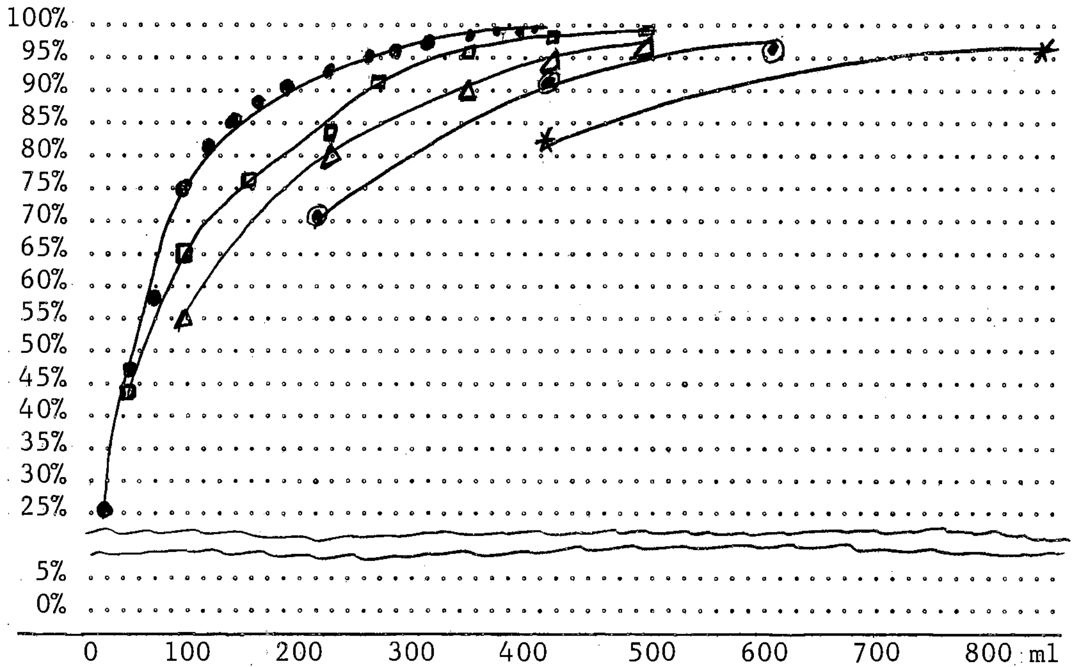
Shows the addition of sodium chloride to the mixture of water and an organic compound. As the polarity of the aqueous phase is increased by the addition of the salt the organic compound comes out of solution.

If there is a sufficient quantity of the organic compound the aqueous phase is removed for ether extraction and the organic layer (usually on top) is reserved to be combined with all of the ether extractions. Otherwise if there is only a small amount of the organic compound the first portion of ether will dissolve it. (See next film.)

#21 SEPARATION AND PURIFICATION Part 3: Extraction (3.20 min.)

Shows the addition of ether to the aqueous solution containing some dissolved organic compound. K_D for this compound in ether and water must begreater than 1 for efficient separati n. Which is more efficient--one large application or several smaller ones? The following graph represents pyrogallol in ether and water.

$K_D = \frac{83.3 \text{ g/100 ml ether}}{62.5 \text{ g/100 ml water}} = 1.33$ Assuming 100 ml aqueous solution.



Cumulative total amount of solvent used.
(To determine the size of each individual extraction follow a particular curve to its initial point. This amount of solvent was used for each extraction. The number of points on the time indicate the number of extractions.)

Three questions usually present themselves. 1) Which layer should be saved? 2) Which layer is which? 3) Where should the interface between the two liquids be stopped? How does the density of water compare to most organic liquids? Most of the common solvents have a density between 0.8 and 0.99. However there are some common organic liquids whose densities are greater than 1.0. You should be able to name several. (If in doubt look in the handbook...) Because dissolved solutes alter the density a mere comparison of handbook densities may not yield the correct information. It is a simple technique to add 1 drop of water to the separatory funnel and watch whether the drop remains in the top layer or passes through to the bottom layer. (This also could be done with the extracting solvent--in fact it would be more logical to test with the extracting solvent because the purpose of the operation is to cause the solute to preferentially go into the extracting solvent rather than the water. However one drop is not critical at this stage.) Which layer should be saved? Of course the organic layer should be saved. But the aqueous layer will contain some of the dissolved compound therefore it must be saved for subsequent extractions. After the final separation the aqueous layer may be discarded. When in doubt save it with a label until you are certain. Where should the interface be stopped? Just before (or as) the top layer meets the stopcock or when it enters the stopcock? Ask yourself what will become of each layer? During initial extractions the idea is to separate the ether and water layers then add more ether to the water layer. Under these conditions one would not want water in the ether. Therefore the ether layer (top layer) would be allowed to enter the stopcock. If a drop of the ether layer happened to get through to the water layer it would not matter--more ether will be added to it anyway. However if this will be the last extraction one would not want to lose any ether. Therefore the interface should just touvh the stop-cock. (Note: in the film for demonstration purposes the aqueous layer is dyed blue. Notice that first the separation is stopped just as the colorless upper layer (ether) reaches the stopcock. Note that the color of the liquid in the hole in the stopcock is blue indicating that it contains the aqueous layer. Then one drop is allowed to be released. Now the color of the liquid in the hole in the stopcock is colorless indicating that it contains the upper layer. If a tiny trace of water should get into the ether it would not be too detrimental. Anhydrous potassium carbonate or some other dessicant will be added to absorb the small amount of water which is dissolved in the ether.

#22 SEPARATION AND PURIFICATION Part 4: Drying (1.36 min.)
Shows the use of one dessicant (anhydrous potassium carbonate) employed to remove small amounts of water which are dissolved in the ether solution. Other dessicants may be used. Some are mentioned in the film.

#23 SEPARATION AND PURIFICATION Part 5: Ether Removal (1.12 min.)
Boiling off ether can be quite dangerous. This shows a relatively safe method using a distillation apparatus and the steam bath as the heat source. Ice surrounds the receiver to reduce the evaporation of the ether. Even so there should be NO FIRES OR FLAMES in the laboratory during this operation. Note that in this case when the solution quits boiling the ether has been removed. The boiling point of this compound (cyclohexanol) happens to have a boiling point greater than 100°C. What if your preparation has a boiling point between that of ether (35°C) and that of steam?

#24 FUME AND VAPOR REMOVAL (3.27 min.)
Shows the fume hood in operation. (Using NO_2 to demonstrate the fume removal visually.) Shows the use of the water aspirator and funnel for fume removal at the desk and sink. (NOTE: Avoid corrosive vapors which could damage the metal parts of the water aspirator.) Shows methods of vapor removal from distillation receivers and reflux columns.

#25 DIAZOTIZATION I (2.52 min.)
Shows the diazotization reaction using sulfuric acid to produce the aniline sulfate. In this example a 500 ml 3-neck flask is used. This simplifies the process if further reactions yield products which will be steam distilled.

#26 DIAZOTIZATION II (2.08 min.)
Shows the diazotization reaction using HCl to produce the aniline hydrochloride. This example uses a single-neck flask for the diaxoti-zation reaction.

A word of caution for both examples. Make certain that the pieces of ice are small enough to enter the neck of the flask--do not force them and break the neck.

A slow steady drop (one drop every two to three seconds) of the sodium nitrite solution is preferable to dumping in larger amounts periodically. The nitrite has a greater probability of reacting in the desired manner.

FILM SECTIONS ONLY

1. Circle the numbers of the films which you have viewed:

1	2	3	4	5	6	7	8	9	10	11	12	13
14	15	16	17A	17B	17C	18	19	20	21	22	23	24
25	26											

2. List the numbers of the films which were particularly helpful:

____

3. List the numbers of the films which were NOT particularly helpful:

____

4. If you did not view a particular film, how did you learn the technique?

   Watch classmates? Watch lab. partner?
   Lab. manual? Other:________________

5. What suggestions would you make regarding the films?

   more fewer shorter longer sound

____

6. What topics not covered in the films do you feel would be helpful?

____

#1	Decolorizing	#15	Fractional Distillation
#2	Supersaturation	#16	Sodium Fusion: Solution Prep.
#3	Folding Fluted Filere Paper	#17A	Sodium Fusion: Nitrogen Det'n
#4	Rapid Filtering	#17B	Sodium Fusion: Sulfur Det'n
#5	Reflux	#17C	Sodium Fusion: Halogen Det'n
#6	Use of Boiling Chips	#18	Steam Distillation
#7	Methods of Heating	#19	Washing with a Carbonate
#8	Thermometer Correction	#20	Salting Out
#9	Melting Point (Capillary Prep'n.)	#21	Extraction
#10	Melting Point (Thiele-Dennis Tube)	#22	Drying
#11	Boring Holes in Corks	#23	Ether Removal
#12	Simple Distillation (Setting-up)	#24	Fume and Vapor Removal
#13	Simple Distillation (Operation)	#25	Diazotization I
#14	Thermometer Placement	#26	Diazotization II

APPENDIX H

SUMMARY OF FILM VIEWING

RESULTS OF QUESTIONNAIRE SUBMITTED TO FILM GROUP

	100	200	300	Total
More films	1	0	8	9
Fewer films	5	5	0	10
Shorter films	0	0	1	1
Longer films	4	1	3	8
Sound	10	8	8	26
More copies	0	0	1	1
Slow motion	0	0	1	1
Better viewing area	0	3	2	5
Information source other that from the films:				
Lab partner	3	1	0	4
Classmates	6	8	10	24
Lab manual	14	9	13	36
Instructor	7	9	3	19
Took course before	1	2	0	3
Guessed	1	1	0	2
Number responding	19	16	21	46

Suggestions for other films or modification of present films:

More safety precuations (What to do when something is spilled, handling glassware.)

Care in handling samples (maintaining purity, avoidance of contamination)

What to look for, more on topics "which the instructors take for granted that students know . . . sometimes we don't know!"

Explanation of reaction mechanisms, more on reactions, films are useful if the students take the time to view the films.

SUMMARY OF FILM VIEWING BY STUDENTS

Film Nr.	Group 100	Nr found film Helpful	/ not	Group 200	Nr found film Helpful	/ not	Group 300	Nr found film Helpful	/ not
1	18	2	3	7	0	2	8	1	5
2	19	3	4	8	1	1	10	3	2
3	19	2	3	12	3	3	13	1	6
4	16	6	1	6	3	0	15	8	1
5	19	6	0	10	3	1	20	2	6
6	14	2	3	7	0	2	14	2	6
7	11	3	2	7	3	0	7	4	2
8	11	2	2	8	0	3	2	2	0
9	16	5	0	9	3	1	17	10	0
10	13	4	1	4	0	0	12	7	0
11	9	2	2	3	0	0	7	2	2
12	14	6	2	8	4	0	18	12	0
13	12	4	4	7	4	0	17	4	0
14	9	4	2	3	2	1	4	4	0
15	11	3	1	6	3	0	17	13	0
16	6	7	2	8	0	0	13	10	0
17A	8	3	2	6	1	0	12	9	0
17B	7	4	1	6	1	0	12	9	0
17C	7	4	1	6	1	0	12	9	0
18	6	3	1	3	3	0	15	10	0
19	1	0	0	0	0	0	7	0	1
20	4	0	0	3	3	0	9	2	0
21	1	0	0	1	0	0	3	1	0
22	2	0	0	1	0	0	6	2	0
23	2	0	0	1	1	0	7	3	0
24	0	0	0	0	0	0	2	1	0

APPENDIX I

STATISTICAL FORMULAS

TABLE OF FORMULAS

Mann-Whitney U Test.

$$U = n_1 n_2 + \frac{n_1(n_1+1)}{2} - R_1$$

$$U = n_1 n_2 + \frac{n_2(n_2+1)}{2} - R_2$$

Select the smaller U value.

Correction for ties.

$$T = \frac{t^3 - t}{2}$$

$$z = \frac{U - \frac{n_1 n_2}{2}}{\sqrt{\left(\frac{n_1 n_2}{N(N-1)}\right)\left(\frac{N^3 - N}{12}\right) - \Sigma T}}$$

When no ties appear, the - T value may be eliminated.

U = The Mann-Whitney U statistic. It is interpreted from a table of U values or is placed in the z distribution formula.

n_1 = Number of items in group 1.

n_2 = Number of items in group 2.

N = Total number of items.

R_1 = Sum of ranking of group 1.

R_2 = Sum or ranks in group 2.

t = Number of items which are tied in value or rank.

T = Tie correction value for each tied rank.

ΣT = Tie correction value (sum of T values).

z = Distribution value. May be interpreted directly in probability.

Friedman Two Way Analysis of Variance

$$x_r^2 = \frac{12}{Nk(1+1)} \sum_{J=1}^{k} (R_j)^2 - 3N(k+1)$$

x_r^2 = Friedman statistic, interpreted from a table of chi square values.

N = Number of rows.

k = Number of columns.

R_j = Sum of ranks for column j.

$\Sigma(R_j)^2$ = Sum of squares of the sums of ranks in the columns.

Randomization test for Two Independent Samples or Student's t test.

$$\bar{X}_1 = \frac{\Sigma X}{n}$$

$$x^2 = \Sigma X^2 - \frac{(\Sigma X)^2}{n}$$

$$s^2 = \frac{\Sigma x^2}{n-1} = \frac{\Sigma X^2 - \frac{(\Sigma X)^2}{n}}{n-1}$$

$$S = \sqrt{s^2} = \sqrt{\frac{x^2}{n-1}} = \sqrt{\frac{\Sigma x^2 - \frac{(\Sigma x)^2}{n}}{n-1}}$$

Homogeneity of variance test.

$$F_{a,b} = \frac{S^2}{S^2}$$ (Larger value over smaller

Separate Variance formula

$$t = \frac{\bar{X}_1 - \bar{X}_2}{\sqrt{\frac{S_1^2}{n_1} + \frac{S_2^2}{n_2}}}$$

Pooled Variance Formula (May also be used for Randomization Test.)

$$t = \frac{\bar{X}_1 - \bar{X}_2}{\sqrt{\left(\frac{x_1^2 + x_2^2}{n_1 + n_2 - 2}\right)\left(\frac{1}{n_1} + \frac{1}{n_2}\right)}}$$

t = Student's t statistic and statistic for Randomization test. May be interpreted from a table of t values.

X = Sum of values.

$\bar{X}$ = Mean value.

n = Number of values.

S^2 = Variance (also σ^2) (S symbol is used when a sample rather than a population is used.)

s = Standard deviation. (also σ)

$F_{a,b}$ = Homogeneity of variance. Interpreted by a table of F values. a is the (n-1) value of the numerator and b is the (n-1) value of the denominator.

Edwards Median and Interquartile Range

Median

$$S_{50} = \ell + \frac{(0.50 - \Sigma b)}{Pw} W$$

$$C_{25} = \ell + \frac{(0.25 - \Sigma b)}{Pw} W$$

$$C_{75} = \ell + \frac{(0.75 - \Sigma b)}{Pw} W$$

Where ℓ = interval containing the median or the quartile

Σb = summation to the summation of frequencies to interval below (cumulative frequency of interval below)

Pw = frequency within the interval

W = width of interval (1 in all cases in this study.)

Interquartile Range

$$Q = C_{75} - C_{25}$$

Chi Square

$$x^2 = \frac{(obs - exp)^2}{exp}$$

rows columns

where:

x^2 = Chi square statistic

obs = the observed frequency

exp = the expected frequency

$$exp = \frac{(\text{row total})(\text{column total})}{\text{grand total}}$$

Spearman Rank Order Correlation

$$r_s = 1 - \frac{6 \quad d^2}{n^3 - n}$$

where: r_s = Spearman statistic (sometimes written as rho.

d^2 = sum of squares of deviations between ranks

n = number of ranked items

$$t = r_s\sqrt{\frac{n-2}{1-r_s^2}}$$

where: t = equivalent to student's t statistic thus the probability may be interpreted from a table of t values.

Kuder-Richardson Formula #21

$$r = \frac{\left(n \; s_t^2\right) - \bar{R}\bar{W}}{(n-1) \; s_t^2}$$

where:

r = Kuder-Richardson reliability statistic

$\bar{R}$ = mean of entire examination

$\bar{W}$ = N - R

N = total number of items on examination

n = number of examination scores

s_t^2 = variance of entire examination

Kruskal-Wallis One Way Analysis of Variance

$$H = \frac{12}{N(N+1)} \sum_{j=1}^{k} \left(\frac{\Sigma r_j}{n_j}\right) - 3(N+1)$$

where:

H = Kruskal-Wallis statistic. For cases of large values of N, H may be interpreted from a chi square table.

N = Total number of ranked items

k = number of groups

n_j = number of items in a particular group

Σr_j = sum of ranks in a particular group

VITA

Harry Baldwin Herzer III

Candidate for the Degree of

Doctor of Education

THESIS: A STUDY OF THE EFFECTS OF SINGLE CONCEPT LOOP FILMS UPON LABORATORY TECHNIQUES WHEN USED FOR PRE-LABORATORY INSTRUCTION IN THE INTRODUCTORY ORGANIC CHEMISTRY LABORATORY

Major Field: Higher Education

Biographical:

Personal Data: Born February 1, 1934, in Emporia, Kansas, the son of Mrs. Louise Spencer Herzer Currier and the late Charles M. Herzer.

Education: Graduated from Emporia High School, Emporia, Kansas, May, 1952. Graduated from The College of Emporia with a Bachelor of Arts degree in chemistry and a Bachelor of Science degree in natural science, June, 1956. Attended NSF Summer Institutes at University of Kansas, Lawrence, 1959, Kansas State Teachers College, Emporia, 1960 and 1961. Received Master of Science degree in physical science from Kansas State Teachers College, Emporia, August, 1961. Attended Kansas State College, Pittsburg. Shell Merit Fellow, Stanford University, Stanford, California, summer 1964. Completed requirements for Doctor of Education degree from Oklahoma State University, July, 1970.

Professional Experience: Chemistry, mathematics, and general science teacher, Atchison County Community High School, Effingham, Kansas, 1958 through 1961. Chemistry teacher, Shawnee-Mission East High School, 1961 through 1966. Visiting instructor in chemistry, Kansas State College, Pittsburg, Kansas, Summer 1966. Chemistry teacher and chairman of the Science Department, Shawnee-Mission South High School, 1966 through 1968. Graduate Teaching Assistant, Department of Education, Oklahoma State University, 1968 through 1969. Graduate Teaching Assistant, Department of Chemistry, Oklahoma State University, 1969 through 1970.

Professional Organizations: American Chemical Society, National Science Teachers Association (Life Member), American Association for the Advancement of Science, National Science Supervisors Association, Kansas Academy of Science, Kansas Association of Teachers of Science.