Program Instruction in use of Lithographic Camera

Clayton Ransom Kinney

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PROGRAM INSTRUCTION IN USE OF LITHOGRAPHIC CAMERA

by

CLAYTON RANSOM KINNEY

A Thesis Submitted in Partial Fulfillment of the Requirements for the Degree Master of Science, Major in Printing Management, South Dakota State University

1968
PROGRAM INSTRUCTION IN USE OF LITHOGRAPHIC CAMERA

Acknowledgments

This thesis is approved as a creditable and independent investigation by a candidate for the degree, Master of Science, and is acceptable as meeting the thesis requirements for this degree, but without implying that the conclusions reached by the candidate are necessarily the conclusions of the major department.
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CHAPTER I
INTRODUCTION

Programmed learning is probably as old as mankind. In theory the essentials of this method consist of three major interdependent factors: 1) immediate feedback or knowledge to the learner of the adequacy of the responses, 2) the presenting of material in small enough units to allow rapid assimilation and reinforcement, and 3) the arrangement of such units in a sequence which continues to build upon and reinforce the prior learning.

It would be difficult to believe that some of the more apt to teach of any generation would not have capitalized upon such a program in presenting to an apprentice or son the proper method of executing some particular work needed in a trade or profession. A master carpenter first showing an apprentice how to drive a nail would have been utilizing programmed learning if he divided the task into a number of "steps" and reinforced the proper execution of each by an approving comment such as "That's right, that's right."

In more recent years programmed learning has tended to be associated quite closely with a format utilizing a mechanical or electronic device to provide the immediate feedback. Indeed, some such programs even require an electronic computer to check the correctness or incorrectness of a given response and select the next sub-unit of material to present to the learner.
It was felt that most instructional programs in the graphic arts would probably not be fortunate enough to acquire equipment such as that used in the more complex designs. However, it appeared very possible that the underlying principles of programmed learning might be utilized to advantage with at least some portions of the instruction in this field and that research into the advantages and disadvantages of such use might be profitable.

Review of Selected Literature

A review of the literature was executed in an attempt to both clarify the problem and to gain from the prior work of others in the field. The earliest reference to programmed instruction is not of recent vintage. In the largest percentage of books and periodical articles touching on the subject, historical reference gave credit for the revival of programmed instruction to Sidney Pressey. At Harvard Psychological Laboratories, B. F. Skinner and his associates reviewed the previous efforts expended, and added to the worth of programmed learning.1

Although it could not be considered as having all the features of today's self-teaching machines, the first contrivance termed "teaching machine" was patented in 1866. A little over half a century later, just prior to 1920, Pressey produced a machine which proved efficient as a teaching device. Though students learned much through

the use of his machine, educators and psychologists showed little interest in the device, which was for the most part a multiple-choice mechanism. His punchboard provided learners a choice of four or five answers. The student would press a button indicating the answer he felt was correct. If he pressed the one representing the right answer, a new question would appear in the window. If an incorrect button was pressed, the question remained. The error was recorded on a counter and the student was expected to try again. This was similar to the program of today.\(^2\)

Educators did not show sufficient interest in Pressey's teaching device to assure success in its use. They did not visualize the process of learning in the same light in which it is regarded today. Skinner believed that Pressey worked in a period of inadequate knowledge of research and theory in psychology and that effective laboratory techniques were lacking at that time.\(^3\)

Since the time of Pressey's rather crude devices, many effective laboratory techniques have been developed through experimentation in the field of learning. It has also been found that certain conditions contribute to or hinder learning. Skinner had wide experience in research which accounted for the marked difference between


\(^3\) Deterline, p. 10.
his teaching machine and that of Pressey, whose efforts reached back forty years prior to Skinner's. 4

Although Skinner has concentrated upon the use of a 'machine' to control the learning sequence, this does not preclude the possibility of other means of control such as that of 'paper teaching machines' or a 'programmed textbook.' 5

In his paper, "Science of Learning and Art of Teaching," presented at a Conference on Current Trends in Psychology and the Behavioral Sciences, March 12, 1954, Skinner stated: "We are on the threshold of an exciting and revolutionary period, in which the scientific study of man will be put to work in man's best interests." 6

In 1954 another paper by Skinner was published in two journals. Its content introduced many educators to the possibilities of programmed instruction. Since then the method has been gradually reaching public notice and according to Schramm it is being discussed by school boards and educators and is being used by educational publishers and by makers of films. It is also being placed on trial in schools to a limited degree. 7

4 Deterline, p. 10.
7 Wilbur Schramm, Programmed Instruction Today and Tomorrow The Fund for the Advancement of Education, p. 5.
In 1957, programming was first used for a complete course in Skinner's "The Analysis of Behavior," a course outlined to teach principles of behavior which are the basis of programmed instruction. The method has had a long past but a short history; possibly innovators are loathe to admit they might have had a predecessor. Lee Garner in Programmed Instruction (1966) stated:

Programming for instruction, rightly regarded as both product and process, is part of a long-lived concern with the principles and practices of education and training. The perfectability of man has been a prominent theme in American intellectual history.

Traces of Programmed Learning From Socrates to Pressey

In ancient Greece, Socrates attempted to introduce a form of programming in his teaching, according to Garner. However, his methods differed greatly from contemporary methods. Slaves as well as sons of aristocrats were led by cues through "leading questions, giving responses in a permissive atmosphere in gaining immediate feedback." Socrates proceeded step by step and frequently guided students through a debate with a number of verbal helps. He also illustrated his method but possibly did not realize one important truth—that in the end prompting must be eliminated to allow the student to use his own initiative.

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10 Garner, p. 2.
Garner quotes Horace as speaking of reward given to children as they received instruction. However, his report of Quintilian's comments even more resemble the examples of programmed instruction:

The individual student must be queried often and rewarded with praise; by arrangement, the student must achieve results quickly without error; the student must discover for himself, and eventually cut the apron strings to the teacher and become a self-reliant learner; motor skills have to be taught by guiding the student's muscles through the necessary exercises and routines.¹¹

In medieval times, guildsmen and craftsmen had programs in apprenticeship which were intended to carry young artists through difficult practices and exercises.¹²

In the 17th century, according to Glaser, Comenius believed in teaching in small steps, and advocated that no step was to be greater than the student was able to take.¹³

A generation ago, Chatauqua mail-order courses in art, in which painting was directed by numbers, were similar to present-day painting number-kits.¹⁴

The foregoing teaching methods illustrate some of the beginnings of programming. Even as some contemporary ideas may seem of little worth, one should not eschew these small beginnings, for who knows "which shall prosper, this or that."¹⁵

¹¹ Garner, p. 3.
¹² Garner, p. 3.
¹³ Glaser, p. 15.
¹⁴ Garner, p. 3.
¹⁵ Garner, p. 3.
Early Recognition of Principles of Programmed Learning

Individual tutors have led students through steps that the majority of programmers would not think of attempting. Garner reports that Helen Keller's teacher accomplished an almost unbelievable feat in teaching her the early fundamentals of communication.16

In 1912 Thorndike wrote:

If, by miracle of mechanical ingenuity, a book could be so arranged that only to him who had done what was directed on page 1 would page 2 become visible, and so on, much that now requires personal instruction could be managed by print.17

Finn and Perrin have written of Thorndike, "Here are the insights of a genius. History can very often teach a lesson in humility--and it does here."18

Individual instruction plans were known and used in public schools before 1900. Two successful types were the Winnetka Plan first used in 1919, and the Dalton Plan inaugurated in 1920. In the first of the two, students made progress at their "own rate." The plan utilized "self-instructional materials and self-administered diagnostic tests. Students had to master one unit before they could take up the next." In the Dalton Plan, "promotion was on an individual basis; students proceeded at their own rate. A mastery test preceded each new unit or one-month in 'contract.'"19

17 Glaser, p. 16.
18 Glaser, p. 16.
19 Garner, p. 4.
Audio-visual aids, learning records, and language tapes provided in sequential steps are also a part of programmed learning.  

Types of Programming

Various methods of presenting programmed instruction have evolved in the past decade or more. A few of the more popular have been described briefly:

**Skinner.** B. F. Skinner's paradigm, a linear sequence of "frames" consisting of a stimulus (a few words), a response (a blank to fill), and reinforcement (correct answer) was the first well-known pattern of development.

**Crowder.** The next well-known method following Skinner was developed by Norman A. Crowder. His frames are longer. They consist of an expository statement, multiple-choice questions, and the student is "branched" to other frames according to his answers.

**Hybrid.** Hybrid programming is found in program texts using both the Skinner and the Crowder Models.

**Eclectic.** Eclectic programming has resulted after years of controversy. This programming consists of a variation of styles and combinations being used, but one now finds the Skinner pattern

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20 Garner, p. 4.
modified by a few amenities of textbooks that had to be abandoned for machine presentation. 21

According to Skinner the student should master the program at about the 95 per cent level. Crowder felt that it was normal for students to make occasional errors. His method made greater provision for both rapid learners and slow learners. 22

Prietz has stated that there are two basic types of programming:

A program can be classified as straight line or linear (Skinnerian) or as branching or intrinsic program (Crowder). The most obvious distinction between a linear and a branching program is the length of the frames and the correct answer which immediately confirms the student's response. 23

Utilization of Programmed Learning

By 1962 programmed teaching units were available in many areas of instruction. The experience of the Eastman Kodak Company in developing programmed instruction for employees working with IBM cards has been given by Margulies and Eigen as an example of the adoption of such methods by industry. The Eastman Kodak Company introduced a card system for use in their plants. Because of the coded holes punched in

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21 Kenneth O. May, Programmed Learning and Mathematical Education Committee on Educational Media, San Francisco, California and Mathematical Association of America, Buffalo, N. Y. (1964), pp. 1, 2.


the cards on the line where signatures were to be placed, the girls handling the cards became curious. Kodak felt that this appeal to curiosity would snare "inquisitive souls" and intrigue volunteer students to engage in a programmed learning course.

Since there was little available material on the techniques of program item construction, the company personnel department constructed its own principles and rewrote them as preliminary student feedback was experienced. At the end of several weeks--and the development of 70 frames of a programmed course--workers could actually read the punchings in the data cards.

It was found through this experiment that programming for employee training was worthwhile to the company. A question still remained. Was it a practical venture? Many areas of training compatible with Eastman Kodak Company's needs were explored in order that reasonable priorities for programming effort might be established. As objectives, the first study was to study cost, effectiveness, and student reaction to this new and different approach. There was also a need to train additional programmers. To meet this need, trainees were chosen to represent not only industrial training personnel, but also, production and staff departments. The training program included an extended workshop, with actual programmed sequence instruction being stressed. Not all of the trainees became programmers, but approximately 75 per cent of the graduates have programmed industrial training course material.

Some of the findings of the study indicated that there is some correlation between intelligence and programming ability, and between
knowledge of the subject matter and ability to program such matter. 

More important than either of these components, however, is the sincere personal interest of the programmer in dedicating himself to this work.24 

J. W. Laurie, president of Trinity University, at the first annual meeting of the National Society for Programmed Instruction, stated that it is most important that new methods for disseminating new knowledge in nearly all fields of learning be found, for--

... information is accumulating at such a fast pace. ... Any program that will speed up our task and sharpen the best brains of the future, more wisely and rapidly, deserves the very careful assessment of everyone who says he believes in education.25 

This increase in knowledge led the late President John F. Kennedy to say in a message to Congress: 

Education is both the foundation and the unifying force of our democratic way of life--it is the main-spring of our economic and social progress--it is the highest expression of achievement in our society, ennobling and enriching human life.26 

Kneller (1961) in addressing the American Psychological Association commented, "Whether we like it or not, automated teaching is here to stay."27 

24 Margulies and Eigen, pp. 26, 27. 


26 Ofiesh, p. 4. 

27 Ofiesh, p. 4.
Some people make much of this new type of auto-instruction. Chagy stated, "The greatest contribution to an enhanced status for the American teacher in our decade will be made by programmed learning and the teaching machine."\(^{28}\)

Public Recognition of Programmed Instruction

Starting in the late 1950s, programmed instruction has been widely publicized. Many schools have been and are experimenting in the use of programmed instruction and teaching machines to teach such subjects as electronics, English, grammar, mathematics, and even driver education.

The Soviet Union both on the elementary and high school levels, according to Vogt, has detected defects in methods of teaching which it feels could be remedied by combining a scientifically designed feedback device in conjunction with programmed instruction and teaching machines. These methods of teaching originated in the United States. Russia rejected them at first, then realizing their value, adapted the methods to high school vocational and technical curricula. The purpose of the technical high schools in Russia is to provide technicians as well as to educate teachers for vocational training institutions and for the technical and vocational departments in institutions of general education.\(^{29}\)


Because the textbook is an ever-present aid to teaching, much effort has been invested in its improvement with respect to read-
ability, legibility, and pictorial and graphic presentation. Glaser has felt, however, that its basic method of transmitting information to the student has remained much the same. Essentially, information has been asserted in the form of declarative sentences on the assumption that learning will occur by some means of passive transfer. In the light of modern learning theory the adequacy of this procedure can be seriously questioned. It appears reasonable that techniques can be developed which provide more specific control and adequate monitoring of the reader's behavior. This factor should result in more effective transmission of knowledge. If textbooks can be constructed so that a student's learning is carefully guided, it is possible that present-
style textbooks will become outmoded as teaching aids. 30

Public acceptance of programmed instruction may be judged by the many subjects that have been programmed for the benefit of students. In his book, Programmed Learning, A Bibliography of Programs and Presentation Devices, Hendershot lists nearly 100 different subjects that have been programmed including art, business, typing, English,

grammar, writing, foreign languages, history, industry methods, quality and cost controls, transportation, insurance, law, mathematics, and various sciences.31

In an earlier edition, Hendershot listed proofreading as being programmed. An attempt was made to procure this program but it was found to be out of print. The 1967 edition of Hendershot does not list it.

Little if any work concerning the field of Graphic Arts was found in the literature of programmed instruction. Letters written to editors of journals and research foundation directors for information about this subject also were fruitless. A reply from Graphic Arts Technical Foundation stated that no programming had been done to their knowledge in printing, although the Foundation was planning to have one of its personnel learn to be a programmer.

Statement of the Problem and Objectives of the Study

Instruction in the graphic arts is most commonly considered to be in an area requiring major emphasis upon laboratory work. However, both theory and principles must be mastered by the student if he is to be more than just a skilled artisan. The time which the student spends in preparation for laboratory work, either in study of a text or in listening to lectures is thus of prime importance; proper preparation not only enhances the readiness with which the student may grasp the lecture and

laboratory presentation but also helps to develop the proper theoretical bases for understanding the work.

A careful survey of the literature has revealed very little programmed material presently available for study in the graphic arts. Therefore it was felt that the development and experimental use of a limited unit of programmed learning for study by the student in preparation for lecture and laboratory work constituted a problem of worth.

**Objectives of the Study**

The purpose of the study was to compare the effectiveness of two methods of presenting information concerned with graphic arts. One method utilized only the lecture as commonly conducted by the instructor. The other method added use of printed material to the lecture, presenting the information in programmed fashion. This material was studied by the experimental group before attending the lecture. Effectiveness of the two methods was evaluated from group mean scores on a common test administered to both the experimental and the control groups at the termination of the presentation. The test used was designed to measure readiness for laboratory work.

To determine if a statistically significant difference existed between the mean scores of the control groups and the experimental group on the test of readiness for laboratory work, the test data from each group were compared with those from each of the other two groups. The following null hypothesis was adopted as representing a reasonable level of acceptance or rejection.
Statistically significant differences will not be found between the mean scores of the control and experimental groups on the test of readiness for laboratory work. The .05 level of confidence will be accepted as significant.
CHAPTER II

METHOD OF THE STUDY

The investigation of effectiveness in methods of teaching is a complex matter involving many variables. Of these variables, the design of the study, methods used, selection of subjects, materials involved, and analysis of data are among the most important. The discussion of these factors has been presented in this chapter in the order named.

Design of the Study

The experimental design may be described as one using three groups of thirty subjects each with subjects matched between groups for grade level and achievement in chemistry as evaluated by their teachers. Subjects in each control group were taught by different methods. One control group studied only a programmed unit before being tested for readiness for laboratory work. The other control group attended only a lecture-discussion period before being administered the same test. The experimental group both studied the programmed unit and attended the lecture-discussion period before being tested. Thus, method of presentation varied between the two control groups while method of presentation and time exposed to the unit being studied varied between the experimental group and each of the control groups. The criterion of teaching effectiveness
used was mean group scores on the test of readiness for laboratory work in use of the lithographic camera.

The design of the study allowed the results of combining student study of a programmed unit with a following lecture-discussion period to be compared with use of the programmed unit alone or with use of the lecture-discussion period alone. It was felt that comparison between the two groups representing those studying the programmed unit only and those attending the lecture-discussion period only would be inadequate. While such comparisons were made at certain points of the investigation, these were only for purposes of analysis; the investigation was not concerned with a contrast of live instructor versus non-live instructor methods. The purpose of the study was to evaluate the effectiveness of using a programmed unit for pre-lecture-discussion period student study.

It will be readily noted that the experimental group had an exposure time to the material presented which was approximately twice that of either of the control groups. It is quite possible that two lecture-discussion periods would have obtained as good student readiness as the combination of programmed unit study and lecture-discussion period, or even better. The point in question, however, is of little practical significance. Although student preparation time cannot be assumed to be unlimited, a certain amount of this may legitimately be required. Student time itself within such limits is, therefore, not an important factor. Rather it is the effective use of such available student time which is of concern. The instructor's time available for lecture-discussion is limited, both by his own schedule and by that of
the students. Thus, the important factor to be investigated appeared to involve materials which students could use effectively alone and within reasonable time limits, rather than the most effective use of an arbitrarily set time interval. For this reason, student time spent in preparation, while controlled for each group, was allowed to vary between the control groups and the experimental group. The design of the study was predicated upon practical teaching conditions rather than an experimental basis controlling as many factors as possible.

Method of the Study

The method of investigating the worth of a programmed unit for pre lecture-discussion period student use was straightforward. A programmed unit was developed as described in a later section. One control group (C) at each school involved, studied this unit for 35 minutes under the supervision of their classroom teacher. The students were not allowed to discuss the material with one another or the teacher. This could have reduced the value of the programmed material for some students who might have sought assistance from others in a truer-to-life study situation. This study group, using the programmed material only, immediately moved to the common testing room upon completion of their 35-minute study period and were administered the readiness test with the other subjects.

The second control group (B) at each school was not provided the programmed unit material at any time during the investigation. These students attended only a 30-minute lecture-discussion period with the experimental groups.
The method used in teaching the experimental groups has almost been described by inference in discussing the control groups. The experimental groups first studied the programmed unit under the same conditions as the control groups (C), (program-study-only). The (B) control groups (lecture-discussion-only) then joined the experimental group and both attended the lecture-discussion period. Finally the programmed-unit-study-only group (C) joined the lecture-discussion-only group (B) and the experimental group (A). All were administered the readiness test.

Possession of the printed material by the experimental group during the lecture-discussion period may have affected the performance of subjects in the control group (B) also attending the lecture. This advantage, however, represented a true-to-life one to the experimental group subjects who would have these materials in the regular classroom should a programmed unit be used for pre-lecture student study.

**Subjects**

The selection of subjects used in the investigation presented a major problem. Attitude of subjects toward the work involved in an investigation is of great importance and one which is very difficult to control. The subject matter involved was one which was not thought to be of interest to a general college population, while use of enrollees in specific courses entailed the danger of too great pre-experimental subject knowledge.

The subjects chosen for the investigation were 90 eleventh-grade chemistry students from two boarding academies. All eleventh-
grade chemistry students enrolled in both academies were initially included in the study with 62 participating at one school and 31 at the other. At each school the students were divided by their teachers into three groups, matched as nearly as possible for range and level of performance in chemistry. One student each from two groups at the larger school and one student from the other school were deleted by random selection to equate groups at each school for number.

It was felt that high school-level chemistry students would, perhaps, have as much maturation as the general college freshman population, while not representing such heterogeneity of ability and interest. The time factor was also important in that the design required a 90-minute session for the experimental group and 65 minutes for the control groups. The use of boarding school students allowed the investigation to be executed during the evening study period. Although no research is available to support the hypothesis, the attitude of the students toward participating in the research appeared to be better than that often found among the more sophisticated college population.

Program and Test Instruments

The design of the study required that a programmed unit of study, a lecture paralleling the program both in sequence and explanation, and a test of readiness for laboratory work of the unit, be available.

Several factors determined the choice of material to be presented in the unit. Time available for student preparation and lecture attendance was a determining factor. Because of the lack of knowledge
of the high school students concerning use of photographic processes it was necessary to choose material which introduced a major segment of work if the programmed unit and lecture were to be meaningful to the subjects. The inclusion of two distinct types of work, one more in the theoretical and one more in the applied field, was thought to be of value in that different methods of instruction might not be equally suitable for all types of information to be presented.

When obtaining the cooperation of faculty and students at the boarding academies, it appeared that 90 minutes would be the longest unbroken time interval available for execution of the actual experimental work. After some trial in integrating this experiment into the schedule, this period was divided into three intervals: 35 minutes for study of the programmed unit, 30 minutes for the lecture and discussion, and 25 minutes for administration of the readiness test.

The Programmed Unit. Review of books, magazines, and pamphlets on programming indicated that suitable programmed material was not available for student pre-lecture study. It was thus necessary to develop a programmed unit. Because of the limited time available for student study, an initial draft using a five-option multiple-choice format was discarded in favor of one using alternate choice. Use of the alternate choice form required that the instruction move forward in smaller steps, a decided advantage; it also provided a greater rationale of explanation to problem.

As used, the program consisted of 30 items. The first 20 items provided information directly concerning the action of light upon film
emulsion while the remaining ten items dealt with the variables of light intensity and exposure time as encountered in reproducing line drawings with a lithographic camera.

The program was printed on six sheets of 8½" x 11" paper in 10-point Simplicitas Simoncini using light and bold face type. Two columns were used with the information and questions printed in the left column; the answers and explanation in the right. Drawings and reproductions of printing resulting from properly and improperly exposed film were employed when their use was anticipated as helpful. A copy of the program has been included in the appendix.

The lecture. Studies comparing lecture with other forms of instruction have several inherent weaknesses unless one does not wish to generalize from the exact situation as presented in a specific investigation. The manner of presentation varies from lecturer to lecturer. Also, the advantages and disadvantages of different methods of presentation may vary from student to student. Some may learn better under one method, some may learn better under another.

In order to hold the variances in lecture presentation under control as much as possible, the investigator presented the lecture and discussion in both schools. The lecture notes were developed to parallel exactly both the information presented in the programmed unit and the sequence in which this information was presented. It was, however, not feasible to reproduce illustrations on the chalkboard, presented in the programmed unit.
Development and Use of the Readiness Test

The amount of time available for execution of the actual experimental work imposed severe limitations upon testing, particularly because it was desirable to include computation of exposure times by formula in the testing. The investigator, although aware of the lack of reliability inherent in short, objective tests, was forced to compromise in relation to several factors. For these reasons the test as used presented 11 alternate choice items and 5 problems involving use of a formula. Student fear of even simple, unfamiliar, mathematical formulas and their tendency to disregard instruction containing, or based upon, such formulas is common knowledge. Thus, it was felt that the inclusion of this type of work would provide a crucial test of the values to be gained in using programmed pre-lecture student study.

For purposes of the investigation, therefore, the alternate-choice items were considered as readiness tests in more verbally transmitted areas of information, while the 5 computation problems were considered tests in abstract thinking and the interpretation of symbols. A copy of the readiness test has been included in the appendices.

Statistical Treatment of Data

The statistical treatment of data in any investigation bears an intimate relationship to the choice of subjects, procedures and instruments used for measurement. At one time a much more sophisticated statistical analysis of data was considered for the study. It would have been possible in the time available to have administered a longer, more homogeneous readiness test not involving computation. It
would have also been possible to have statistically controlled for such variables as test intelligence and level of reading achievement. However, use of such scores would have reduced the sample size considerably, because these were not available for all subjects. In addition, when lack of accuracy, as found in most high school administered tests of this nature is considered, the equating by the classroom teachers of the three groups on the basis of performance in chemistry classes appeared as effective as other means, if not as impressive.

Once having decided upon the more practical approach, it was easy to abandon the advantages provided by a highly reliable criterion test in favor of one which provided a sampling in two well-defined areas.
CHAPTER III

FINDINGS

The procedures described in Chapter II were completed as required by the design in one session at each of the participating schools. The experiment was conducted without difficulty. Working rapport was considered excellent.

Results of the investigation have been tabulated and findings presented for alternate-choice items separately from results of computation problems for reasons discussed later in the chapter.

Comparison by Groups on Alternate-Choice Item Responses. The number of students responding correctly to each alternate choice item of the readiness test is shown in Table I.

Data presented in Table I would indicate that while items varied in difficulty (or adequacy of instruction provided), groups did not differ in responses to individual items more than would be expected to occur by chance.

Analysis of Differences; Alternate Choice Items. The total number of correct responses for groups does not vary significantly between the two control groups; the totals are almost identical. The difference between totals for the experimental and the lecture-only groups was not significant although significance at the .05 level of confidence is approached very closely. \( \chi^2 = 3.744 \) was obtained with a value of 3.841 required. The experimental group, however, was found
TABLE I
CORRECT RESPONSES TO READINESS TEST
ALTERNATE CHOICE ITEMS BY GROUPS

<table>
<thead>
<tr>
<th>ITEM</th>
<th>A PROGRAM AND LECTURE</th>
<th>B LECTURE ONLY</th>
<th>C PROGRAM ONLY</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>26</td>
<td>22</td>
<td>26</td>
</tr>
<tr>
<td>2</td>
<td>24</td>
<td>27</td>
<td>26</td>
</tr>
<tr>
<td>3</td>
<td>30</td>
<td>30</td>
<td>27</td>
</tr>
<tr>
<td>4</td>
<td>15</td>
<td>8</td>
<td>15</td>
</tr>
<tr>
<td>5</td>
<td>20</td>
<td>20</td>
<td>22</td>
</tr>
<tr>
<td>6</td>
<td>23</td>
<td>19</td>
<td>15</td>
</tr>
<tr>
<td>7</td>
<td>23</td>
<td>24</td>
<td>23</td>
</tr>
<tr>
<td>8</td>
<td>29</td>
<td>25</td>
<td>24</td>
</tr>
<tr>
<td>9</td>
<td>27</td>
<td>24</td>
<td>24</td>
</tr>
<tr>
<td>10</td>
<td>30</td>
<td>28</td>
<td>25</td>
</tr>
<tr>
<td>11</td>
<td>26</td>
<td>26</td>
<td>25</td>
</tr>
<tr>
<td></td>
<td>273</td>
<td>253</td>
<td>252</td>
</tr>
</tbody>
</table>
significantly better than the program-study-only group with a difference between total scores significant at the .05 level of confidence $\chi^2_1 = 4.106$. The one point difference between total scores of the two control groups was responsible for this rather unusual pair of findings. Chi square was used to determine significance of differences between means:

Chi square is a test of significance. This statistic is a very useful one in research because no particular assumptions have to be made about the shape of the distributions of the frequencies being tested. It is most commonly used when data are in frequencies such as in the number of responses in different categories. It can be used with any data that can be reduced to proportions and percentages. ... 32

Analysis of Differences; Computation Items. As has been discussed previously, the differences between groups with use of formula in computing exposure time was analyzed separately from differences in responses to alternate choice items.

Testing at any time involves a number of major difficulties if inference from performance to assumed knowledge, or, in this case, readiness, is to be undertaken. One major difficulty involves motivation, and this is particularly pertinent in experimental work of the nature undertaken. Some poor performing students may not be motivated to work up to capacity in an experimental situation which either does not threaten them or excite their interest. A second difficulty is encountered in the lack of a true zero measurement of knowledge. Scoring

## TABLE II
TOTAL SCORES ON ALTERNATE CHOICE ITEMS
BY GROUPS

<table>
<thead>
<tr>
<th>GROUP</th>
<th>TOTAL CORRECT</th>
<th>TOTAL ERRORS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group A (program and Lecture)</td>
<td>273</td>
<td>57</td>
</tr>
<tr>
<td>Group B (Lecture Only)</td>
<td>253</td>
<td>77</td>
</tr>
<tr>
<td>Group C (Program Only)</td>
<td>252</td>
<td>78</td>
</tr>
<tr>
<td>Average Correct Groups A and B</td>
<td>263.00</td>
<td></td>
</tr>
<tr>
<td>Average Error Groups A and B</td>
<td>67.00</td>
<td>Chi²₁ = 3.744</td>
</tr>
<tr>
<td>Average Correct Groups A and C</td>
<td>262.50</td>
<td></td>
</tr>
<tr>
<td>Average Error Groups A and C</td>
<td>67.50</td>
<td>Chi²₁ = 4.106*</td>
</tr>
</tbody>
</table>

*Significant at the .05 level of confidence.
usually involves only correct or incorrect responses. There are no means provided of identifying students who may be almost able to solve correctly all, or many, of the problems, but who actually are unable to solve any of them as given. The third hazard would be found in variance in difficulty of problems presented. All problems are usually scored as of the same value, but such scoring can seldom be considered accurate.

In attempting to compensate for difficulties of measurement, subjects in each group were divided into three categories, according to scores on computation problems. 1. Those who did not solve any problems correctly were classified as either insufficiently motivated to learn or insufficiently ready at time of testing. 2. Those who solved one or two of the problems were considered as possibly poorly motivated and/or just starting to master the type of problem presented. 3. Correct solution of three or more problems was judged as representing readiness for laboratory work. Although probably all of these subjects would require a great deal more experience before becoming really proficient in such computation, such experience would normally be a part of work following the first lecture-discussion period. The number of computational problems correctly solved by each group has been shown in Table III. The number of subjects scoring in each of the three categories may be found in Table IV.
TABLE III

NUMBER COMPUTATIONAL PROBLEMS CORRECTLY SOLVED BY GROUPS

<table>
<thead>
<tr>
<th>GROUP</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>4</td>
<td>2</td>
<td>4</td>
<td>6</td>
<td>7</td>
<td>7</td>
<td>30</td>
</tr>
<tr>
<td>B</td>
<td>11</td>
<td>2</td>
<td>5</td>
<td>2</td>
<td>5</td>
<td>5</td>
<td>30</td>
</tr>
<tr>
<td>C</td>
<td>18</td>
<td>7</td>
<td>1</td>
<td>3</td>
<td>0</td>
<td>1</td>
<td>30</td>
</tr>
</tbody>
</table>

The Chi square values obtained as shown in Table IV indicate the experimental group performed significantly better on the text of readiness than either of the control groups when three or more correct solutions is arbitrarily accepted as the criterion of readiness.

It should be noted that the absolute gain in numbers of subjects solving more than three problems is the same between the experimental group and the lecture-only group as it is between the lecture-only group and the programming-study-only group. Thus the program used alone was found in this investigation to be the poorest method of presentation; when combined with the lecture, however, the combination was as much superior to lecture-only as the lecture-only was to programming-only. The same differences were noted among those failing to solve any of the computation problems. Again, partly by coincidence, the absolute gain in numbers between programmed-study-only and lecture-only is the
same as between the lecture and the combination of programmed-study-and-lecture.

<table>
<thead>
<tr>
<th>GROUP</th>
<th>1-2</th>
<th>3-5</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>6</td>
<td>4</td>
<td>10</td>
</tr>
<tr>
<td>B</td>
<td>11</td>
<td>9</td>
<td>20</td>
</tr>
<tr>
<td>C</td>
<td>12</td>
<td>8</td>
<td>20</td>
</tr>
</tbody>
</table>

Note: Groups A and B average 10.0

No. subjects in Group A: 20

Comparison of Groups A and B: A - C - D - E

Comparison of Groups B and C: A - B - C - D - E

Comparison of Groups C and D: A - B - C - D - E

Comparison of Groups D and E: A - B - C - D - E

Comparison of Groups E and F: A - B - C - D - E

Comparison of Groups F and G: A - B - C - D - E

Comparison of Groups G and H: A - B - C - D - E

Comparison of Groups H and I: A - B - C - D - E

Comparison of Groups I and J: A - B - C - D - E

Comparison of Groups J and K: A - B - C - D - E

Comparison of Groups K and L: A - B - C - D - E

Comparison of Groups L and M: A - B - C - D - E

Comparison of Groups M and N: A - B - C - D - E

Comparison of Groups N and O: A - B - C - D - E

Comparison of Groups O and P: A - B - C - D - E

Comparison of Groups P and Q: A - B - C - D - E

Comparison of Groups Q and R: A - B - C - D - E

Comparison of Groups R and S: A - B - C - D - E

Comparison of Groups S and T: A - B - C - D - E

Comparison of Groups T and U: A - B - C - D - E

Comparison of Groups U and V: A - B - C - D - E

Comparison of Groups V and W: A - B - C - D - E

Comparison of Groups W and X: A - B - C - D - E

Comparison of Groups X and Y: A - B - C - D - E

Comparison of Groups Y and Z: A - B - C - D - E

Comparison of Groups Z and AA: A - B - C - D - E

Comparison of Groups AA and AB: A - B - C - D - E

Comparison of Groups AB and AC: A - B - C - D - E

Comparison of Groups AC and AD: A - B - C - D - E

Comparison of Groups AD and AE: A - B - C - D - E

Comparison of Groups AE and AF: A - B - C - D - E

Comparison of Groups AF and AG: A - B - C - D - E

Comparison of Groups AG and AH: A - B - C - D - E
### TABLE IV

**NUMBER COMPUTATIONAL PROBLEMS CORRECTLY SOLVED (CATEGORIZED)**

<table>
<thead>
<tr>
<th>GROUP</th>
<th>0</th>
<th>1-2</th>
<th>3-5</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>4</td>
<td>6</td>
<td>20</td>
<td>30</td>
</tr>
<tr>
<td>B</td>
<td>11</td>
<td>7</td>
<td>12</td>
<td>30</td>
</tr>
<tr>
<td>C</td>
<td>18</td>
<td>8</td>
<td>4</td>
<td>30</td>
</tr>
</tbody>
</table>

No. with 3-5 Correct--Groups A and B Average 16.0

No. below 3-5 Correct Groups--A and B Average 14.0

Difference between Groups A and B--Chi² = 4.286*  

No. with 3-5 Correct--Groups B and C Average 8.0

No. below 3-5 Correct--Groups B and C Average 22.0

Difference between Groups B and C--Chi² = 4.176* (Yates correction used)

No. with 3-5 Correct--Groups A and C Average 12.0

No. below 3-5 Correct--Groups A and C Average 18.0

Difference between Groups A and C--Chi² = 15.624** (Yates correction used)

*Significant at .05 level of confidence.

**Significant at .001 level of confidence.
CHAPTER IV

SUMMARY AND CONCLUSIONS

The summary, conclusions and recommendations for further study have been presented briefly in that order.

Summary

The study was designed to allow comparison between an experimental and two control groups on scores of a test of readiness for laboratory work in use of the lithographic camera. The experimental group first studied a programmed unit of instruction and then attended a lecture-discussion period presenting the same material. Subjects were then administered the common readiness test. The first control group attended the lecture-discussion period but did not study the programmed material before being tested. The second control group studied the programmed material in another room during the lecture period and were then tested for readiness without further preparation.

Chi square was used as the statistical technique considered most appropriate for testing the significance of difference in scores between groups.

The data obtained from the investigation supported the hypothesis that differences sufficient to be statistically significant at the .05 level of confidence would not be found when the experimental group was compared with the lecture-only group on total scores for
alternate choice items. The Chi square value very closely approached this level, however.

The programmed-study-only group earned one less point than the lecture-only group (252 of a possible 330 correct responses) on the alternate choice items. The hypothesis was rejected at the .05 level of confidence when comparing the programmed-study-only group with the experimental group. (The experimental group had 273 correct responses.)

Differences were more marked when the experimental group was compared to the lecture-only group on problems requiring computation. If one assumes correct solution for three, or more, of five problems as indicating satisfactory readiness for laboratory work, the study of the programmed unit contributed significantly to the readiness of the experimental group. The difference between the experimental and the lecture-only group required rejection of the hypothesis at the .05 level of confidence. Although the lecture-only group was significantly superior (.05 level of confidence) to the programmed-study-only group, the combination for programmed study and lecture was, in turn, significantly better (.05 level of confidence) than the lecture-only group. The programmed-study contributed learning which apparently was insufficient to record accurately with the test items used, but when reinforced with the lecture was found to be of significant value.

Conclusions

Results of the statistical analysis of group mean differences indicated that use of the programmed instructional unit by the experimental group did not contribute significantly to their readiness
for laboratory work insofar as understanding of theory was concerned. The lecture-only group, however, obtained almost the same mean score as the program unit study-only group (8.40 vs. 8.43). It would thus be concluded that the study of the programmed unit or attending the lecture resulted in equal understanding of theory as measured by the readiness test used. The shortness of the test and low ceiling may have prevented valid findings.

Use of the programmed unit by the experimental group did result in significantly superior readiness over the lecture-only group in computation of problems by formula. In this area, the lecture-only group was actually significantly superior to the programmed-study-only group. However, the experimental groups, combining both study of the programmed unit and lecture attendance was, in turn, significantly superior to the lecture-only group.

Any tendency to label the study as a comparison between lecture and programmed presentation of material should be earnestly avoided. The lecture was stringently limited to the material presented and sequence of presentation used in the programmed unit. This was necessary to allow comparison of the experimental group (program plus lecture) with the program-study-only control group. The assumption underlying this design was simply that the two methods were basically complementary. It was felt that the detailed examination of data provided by programmed instruction would be undertaken with profit by the student before lecture, while the welding of the material into an interrelated whole could best be accomplished later by lecture and discussion methods. The careful step-by-step restudy of a topic obtained
by this method cannot be found in the usual study of a textbook followed by lecture and discussion. The textbook tends to be more of a well organized printed lecture.

While the design of the study was intended to provide data of practical application, the imposition of experimental control tends to also impose artificial conditions. Some variation from true-to-life conditions should be noted. Subjects of the experimental group (A) still retained the programmed materials for use during the lecture which followed the exact sequence and presented the same examples as those used in the programmed unit. While the conditions of the experiment had been described to all subjects before the actual work began, this rather evident advantage of the experimental group of subjects would be expected to affect the performance of subjects in the control group. Some individuals, (the clutch hitters), would be expected to strive harder to overcome the conditions imposed by the experiment, while other subjects would be expected to admit some defeat even before the start. That all students of the control group did not admit defeat was indicated in the larger number of questions asked by this group (B) during the discussion period.

A second factor, introduced above, lay in the availability of the printed material to the experimental group during the lecture-discussion period. They could mark on the paper and actually work out the problems as presented. The lecture-only subjects did not have this advantage.

Another major difference between program and lecture would be found in the questions asked by subjects during the discussion period.
The lecture-discussion-only group (B) asked many more questions than the experimental group (A). It is debatable 1) whether the students in the experimental group (A) understood the material better than the lecture-only group (B) and did not ask so many questions, 2) whether the experimental group (A) could answer their own questions better by combining the information received during the lecture with reference to the program material which was all still available to them, or 3) whether the lecture-only group (B) was more insecure and hence asked more questions.

After allowing for weaknesses of the study, some anticipated, and some surprising, it may be concluded from the findings that the pre-lecture study of a programmed unit, even under highly artificial conditions, did contribute significantly to subject readiness for laboratory work in use of the lithographic camera. It would even appear possible that in one isolated instance the programmed unit served to cover either an error or omission in the lecture (item 4 of the alternate choice test).

**Recommendations for Further Study**

Several factors which would have improved the study were painfully evident to the investigator even before its initiation. As reported elsewhere, the choice of subjects was dependent upon other considerations than the wishes of the one conducting the study. The motivation of students in a graphic arts course involving the lithographic camera would be different from that of the students used in the experiment. The effect of motivation provided by actual course enroll-
ment remains an unsolved problem when attempting to generalize from results of the study.

The programmed unit, itself, as used, also presents some questions. Possibly a different type of programming, or improvement on the one used would alter results. In conjunction with this, the lecture also would be involved as it was developed to parallel the programmed unit rather than also supplement it. Another feature of demonstrated weakness was in the short test of basic theory, using only eleven alternate choice items. Although all items passed analysis satisfactorily, the lack of reliability inherent in such a short instrument was a disadvantage. It was also evident that both the low test ceiling and the factual nature of the material tested in the alternate choice items may have interfered with obtaining a true evaluation of the worth of the programmed unit. It is difficult to discriminate between very easy test items and the results of thorough instruction.

Pilot studies using sufficient numbers of students beginning a course in photographic reproduction should be conducted 1) to establish the needed improvements in the programmed material to be used, 2) to establish the validity of the readiness test used, and 3) to control for motivation.
APPENDIX
UNIT IN PRE-LABORATORY USE OF THE LITHOGRAPHIC CAMERA
( Graphs and Line Drawings )

The making of plates to be used in printing graphs, line drawings, and material of similar nature is one of the everyday jobs of a cameraman working in the printing industry. Often the plate to be produced must be of a different size than that of the copy provided.

In order to make a plate to be used in printing, it is necessary to first produce a negative of the desired size. This negative is very much like the negatives returned with "pictures" one takes with an ordinary camera and leaves at the drug store to be sent to a laboratory for development and printing.

Commercial film is packaged in sheets of various sizes commonly used. It is made of a fully transparent backing coated on one side with a chemical emulsion. This emulsion (the dull side of the film) is very sensitive to light and changes its composition when light strikes it. This, of course, is the basis for photography. Light reflected from the material being copied is focused on the film through the camera lens during the time of exposure and "bombards" the sensitive chemical coating on the film. This changes the emulsion so that the portions which had light focused on them will turn black and not wash away during development. The unexposed portions will represent the dark parts of the material copied as light does not reflect from dark surfaces as well as from light surfaces.

Item 1. A black and white drawing of a checkerboard is placed on the copyboard and the camera adjusted for focus. Which portions of a sheet of film in the holder will receive reflected light when an exposure is made?
   a. those portions representing the black squares of the checkerboard.
   b. those portions representing the white squares of the checkerboard.

Item 2. Which portions of the film should be solid black on the developed negative?
   a. those portions of the negative representing the white squares of the checkerboard.
   b. those portions of the negative representing the black squares of the checkerboard.

Item 3. Which portions of film should be clear of an emulsion after development?
   a. those portions representing the white squares of the checkerboard.
   b. those portions representing the black squares of the checkerboard.

Item 4. If a piece of light sensitive paper were placed under the negative and exposed to light shining through the negative; could the light sensitive paper be developed into a picture of the checkerboard?
   a. yes.
   b. no.

Answer: "b" The white squares of the checkerboard would reflect light much better than the black squares.

Answer: "a" Light was reflected from the white squares through the lens of the camera and focused on the film. These portions of the film would turn black and remain as the film was developed into a negative.

Answer: "b" Those portions of the film corresponding to the black squares of the checkerboard received little or no reflected light. The emulsion in these places would not turn black and would wash away during development of the negative.

Answer: "a" Yes. The light would pass through the clear portions of the negative and cause the corresponding portion of the light sensitive paper to turn black when developed. These black portions on the developed picture would represent the black squares of the checkerboard. The light would not pass through the black portions of the negative representing the white squares and these portions would remain white in the picture when it was developed. This should explain why the term negative is used for the developed film. After development the film is the negative, or reverse, of the material photographed and of the picture or plate that is produced.
Item 8. Which portion of the developed negative cross section shown in Illustration 1 represents the transparent backing of the film?
   a. X.
   b. Y.

Answer: "b" The transparent backing remains under all portions of the film.

Item 6. Which portion of the developed negative cross section shown in Illustration 1 represents a portion that has been "bombarded" with light reflected from the material being copied?
   a. X.
   b. Y.

Answer: "a" Exposure to light changes the chemical composition of the emulsion on the film so that developing further solidifies the emulsion and causes it to turn black.

Item 7. If the image of the checkerboard is not sharply focused on the film which of the following would be expected, in the developed negative?
   a. the division between black and white squares will be sharp and clear.
   b. the division between squares will be fuzzy.

Answer: "b" The division between squares will be fuzzy because the reflected light rays from the checkerboard have been allowed to scatter on the film.

Item 8. If lines and edges of solid sections of the negative are not sharply defined, will it be possible to make a plate from the negative which will print sharp, clear-cut illustrations?
   a. yes.
   b. no.

Answer: "b" No. The plate is in many ways similar to the light sensitive paper of an earlier item. In making a plate, high intensity light is passed through the negative and onto a sensitized sheet of metal instead of onto paper as in making a usual picture. The plate can be no better than the negative from which it is made.

Item 9. The reflected light from the checkerboard brings about a chemical reaction on the film in the camera when the lens is opened. If the lens is opened for an insufficient time (under-exposure) would the portions of the film representing the white squares be as black and opaque on the developed negative as would result from longer exposure?
   a. yes.
   b. no.

Answer: "b" No. Not enough chemical reaction will be obtained and the contrast will be poor. The portions of the negative that should be black may have "thin spots" which will result in the finished product showing specks and smudges. Of even more importance, the edges of the black parts of the material copied will spread and the printed copies will have the black overemphasized.

Item 10. If the lens is opened for a longer time than needed (overexposure) will the portion of the film representing the black squares of the checkerboard remain clear in the developed negative?
   a. yes.
   b. no.

Answer: "b" No. The result from overexposure is an eating away of the edges of the clear portions of the negative replacing these with black solidified emulsion so that the plate made from such a negative will not print fine details of the copy provided.

Item 11. Fine line detail from the provided copy is very quickly affected by underexposure. If the film is underexposed, lines printed from the plate produced will appear:
   a. thicker than in the provided copy.
   b. thinner than in the provided copy.

Answer: "a" The underexposure does not allow sufficient time to change the chemicals on the film. Thus the white portions of the provided copy are under represented on the negative by black areas and the black printing over represented by clear areas. The plate made from such a negative will continue to over represent the black—thus losing detail in the printing. The black lines will be thicker or may even blend together in places.
Item 12. If the film is overexposed, lines printed from the plate produced will appear:
   a. thicker than in the provided copy.
   b. thinner than in the provided copy.

Answer: "b" With over exposure the white portions of the provided copy are over-represented by black areas and the black printing under-represented by clear areas in the developed negative. The plate made from such a negative will continue to over-represent the white, thus losing detail. The black lines of the provided copy will print thinner or may be lost.

Item 13. Which of the above negatives would result from overexposure?
   a. A.
   b. B.
   c. C.

Answer: "c" Note that not only the white areas of the printed paper are represented by black on the negative but also part of the black letters.

Item 14. Which of the negatives of Illustration 2 would result from underexposure?
   a. A.
   b. B.
   c. C.

Answer: "a" Note that in this negative the white portions of the printed paper are under-represented. The black letters (clear negative area) appear larger.

Item 15. Which of the above would represent printing of a plate made from an underexposed negative?
   a. A.
   b. B.
   c. C.

A new lithographic camera has just been purchased and the camera man wishes to determine the proper exposure time for obtaining a negative of the same size as the copy provided. He will do this by setting up copy in the camera and making a series of test exposures on a strip of film. All but a narrow portion of the strip of film is covered with a dark mask and the first exposure is made, possibly for five seconds. The mask is then moved to uncover more of the film strip and another five-second exposure made. This is continued until seven exposures have been made, with an additional portion of the film strip being uncovered each time.

Lighting and size of lens opening remains the same throughout the process. In this way, the first part of the film strip receives 7 five-second exposures or a total of 35 seconds exposure. The second portion uncovered receives 6 exposures of five seconds each or a total of 30 seconds exposure, the third portion receives 25 seconds, the fourth 20, the fifth 15, the sixth 10 and the seventh and last 5 seconds exposure. The film is then developed and inspected.
Item 16. If the 35-second exposure test portion of the negative shows gray portions to represent white areas on the material being copied, which of the following is true?
   a. another test strip should be run starting with 35 seconds exposure for the first portion and adding 6 five-second exposures.
   b. another test strip should be run starting with 20 seconds exposure for the first portion and adding 6 five-second exposures.

Item 17. After the camera man has determined the correct exposure time for making a negative of the same size as provided copy, will this exposure time remain the same for future work with plates to print same size as provided copy?
   a. yes.
   b. no.

Item 18. If the copy provided is not the same size as the desired plate, will the exposure time remain the same?
   a. yes.
   b. no.

Item 19. If the desired negative is to be larger than the provided copy will the exposure time be increased?
   a. yes.
   b. no.

Item 20. If one had previously determined the correct exposure time for making a negative the same size as provided copy, would it be possible to compute the correct exposure time for a given size of enlargement or reduction?
   a. yes.
   b. no.

Item 21. The change in size of desired negative from provided copy is represented by the symbol “M” in the formula for computing new exposure time. “M” is the ratio of the size of desired negative to size of provided copy. If the length of the desired negative were thirty inches and the length of provided copy were ten inches “M” would equal
   a. 3.
   b. .5.
   c. neither a nor b.

Answer: “a” If the negative is not a good solid black for portions representing white areas of the material being copied, underexposure is indicated.

Answer: “a” Yes. If lighting, lens opening and film characteristics are not changed, this procedure need be performed only once for a given camera set-up.

Answer: “b” No. The intensity of the light acting upon the chemical emulsion of the film and the length of time the light acts upon the emulsion determine the correct exposure time. When enlarging or reducing the size of the negative in relation to the size of provided copy the distance of the film from the copy is changed in focusing. This change in distance the light travels from copy to film also changes the intensity of the reflected light striking the film and thus requires a change in exposure time.

Answer: “a” Yes. The intensity of light decreases as the square of the distance from source to point at which intensity is measured. For example, a source providing 10 candle power at one foot would only provide one fourth as much light at two feet ($2^2 = 4$) and only one nineth as much light at three feet ($3^2 = 9$).

Answer: “a” Yes. The ratio of the desired size copy to provided copy is also a measure of change in area to be illuminated by the light focused through the lens of the camera. If the amount of light is not changed the exposure time for new sizes may be calculated.

Answer: “a” The ratio of desired size negative to provided copy would be 30 divided by 10 or 3.

$$M = \frac{\text{size of desired negative}}{\text{size of provided copy}}$$

$$M = \frac{30}{10} = 3$$
Item 22: The desired size of negative is ten inches long and the provided copy is five inches long. Which of the following equals "M"?

a. 2.

b. .5.

c. neither a nor b.

Item 23. As explained in Item 19 the intensity of light decreases as the square of the distance from source is increased. If the desired negative were to be twice as long as the provided copy, would the exposure time

a. be twice as long as for making a negative the same size as provided copy.

b. be more than twice as long as for making a negative the same size as provided copy.

Answer: "b" The exposure time changes according to the formula:

\[
\text{New exposure time} = \text{Exposure time for same size negative} \times \left(\frac{M+1}{4}\right)^2
\]

If the negative were to be twice as long as the provided copy, \(M = 2\) according to the formula for \(M\). Substituting 2 for \(M\) in the full formula:

\[
\left(\frac{2+1}{4}\right)^2 = \frac{3^2}{4} = \frac{3 \times 3}{4} = \frac{9}{4} = 2.25
\]

The new exposure time would be 2.25 times longer than for making a negative same size as provided copy. In other words, multiply the exposure time for same size negative by 2.25.

Answer: "b" Yes. Just add the value of \(M\) to the constant, one. (One is always the amount added to the value of \(M\).) To square, multiply \(M+1\) \(\times\) \(M+1\). Finally, divide by 4. (Four is always the divisor).

Item 24. To remove the parentheses from the term \((M+1)^2\) in the formula

\[
\text{New exposure time} = \text{Exposure time for same size negative} \times \left(\frac{M+1}{4}\right)^2
\]

First find the value of \(M\), and add this to one.

a. yes.

b. no.

Item 25. The length of the desired negative is fifteen inches. The length of the provided copy is five inches.

a. \(\left(\frac{M+1}{4}\right)^2 = 4\)

b. \(\left(\frac{M+1}{4}\right)^2 = 3\)

Item 26. The length of the desired negative is five inches. The length of the provided copy is ten inches.

a. \(\left(\frac{M+1}{4}\right)^2 = .56\)

b. \(\left(\frac{M+1}{4}\right)^2 = .72\)
Item 27. The length of desired negative is twenty inches. The length of provided copy is four inches.

\[ \frac{(M + 1)^2}{4} = 8 \]

\[ \frac{(M + 1)^2}{4} = 9 \]

Item 28. Joe is using a lithographic camera with a correct exposure time of twenty seconds for making a negative same size as provided copy when all lights are burning and lens opening is at f/22. If he wishes to make a negative twelve inches long from provided copy four inches long, the correct exposure time would be:

a. 100 seconds.

b. 80 seconds.

c. neither a nor b.

Item 29. Joe is asked to make a negative five inches long from provided copy fifteen inches long using the same camera as used in Item 28. The new exposure time would be:

a. 10 seconds.

b. 15 seconds.

c. neither a nor b.

Item 30. Using the same camera as in the two preceding items, Joe is to make a negative thirty inches long from provided copy ten inches long. The new exposure time would be:

a. 90 seconds.

b. 120 seconds.

c. neither a nor b.
1. A black and white line drawing is being photographed. Which of the following is true?

( ) a. The most light will be reflected through the lens and on to the film from white areas of the drawing.

( ) b. The most light will be reflected through the lens and on to the film from the black lines of the drawing.

2. Because of a mistake a film that has never been exposed is being developed. Which of the following will occur under the proper procedures?

( ) a. Nothing will occur. The film may be dried and used as if the error had not occurred.

( ) b. The chemical emulsion on the film will work away during development leaving only the clear backing.

3. A black and white line drawing has been photographed and the negative developed. Which of the following best describes the negative?

( ) a. The black lines of the drawing will appear as white lines on the negative. That is why it is called a negative.

( ) b. The black lines of the drawing will appear as black on the negative and the white areas as white on the negative. The reflected light acts in negative fashion on the film.

4. A black and white line drawing has been photographed and the negative developed. Which of the following best describes the negative?

( ) a. The negative will be thicker in those parts representing the white areas of the drawing.

( ) b. The negative will be black and white but will be of uniform thickness over all of its surface.
5. A black and white line drawing has been photographed and the negative developed. The plates made from this negative prints black specks and smudges in areas that should be white. Which of the following would most probably cause this result?

( ) a. The exposure time was too short and the negative did not build up good, solid, black deposits to represent the white areas.

( ) b. The exposure time was too long and the resulting negative showed specks and smudges on the drawing not visible to the human eye.

6. A black and white line drawing has been photographed and the negative developed. The plate made from the negative prints the black lines as thinner than in the original drawing. Which of the following would most probably cause this result?

( ) a. The exposure time was too short and did not allow the lines to be clearly imprinted on the negative.

( ) b. The exposure time was too long. The light from the white areas has scattered along the edges of the areas on the film representing the black lines.

7. A black and white line drawing has been photographed with the lens improperly focused. The negative is "fuzzy." Which of the following is true?

( ) a. When making the plate, the exposure time should be lengthened enough to provide sharper edges between black and white.

( ) b. There is no way in which an improperly focused film may be corrected for printing purposes.

8. A newspaper camera man reproduces many black and white line drawings as part of his work. Which of the following would be true.

( ) a. He must compute the exposure time needed for each photograph, carefully, measuring the light with a meter.

( ) b. He should establish the exact exposure time for the particular camera he uses under standard lighting and developing conditions.
9. The negative from which a plate for printing is to be made must be twice as large as the copy to be photographed. Using standard lighting and developing conditions, the exposure time required will be:

( ) a. Twice as long as for making a negative of same size as photographed material.

( ) b. More than twice as long as for making a negative of same size as photographed material.

10. The formula for computing the ratio of the desired size negative to the material to be photographed is which of the following?

( ) a. \( \frac{\text{Size of desired negative}}{\text{Size of provided copy}} \)

( ) b. \( \frac{\text{Size of provided copy}}{\text{Size of desired negative}} \)

11. If a negative is to be made which will be twice as long as the provided copy, the ratio of size of desired negative to size of provided copy is:

( ) a. 2

( ) b. \( \frac{1}{2} \)
Find new exposure time if exposure time for original size at 100% is 20 seconds.

1. New desired size is 9 inches, original size is 6 inches.

2. New desired size is 3 inches, original size is 6 inches.

3. New desired size is 4.5 inches, original size is 9 inches.

4. New desired size is 10 inches, original size is 5 inches.

5. New desired size is 4 inches, original size is 5 inches.
BIBLIOGRAPHY


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