A COMPARISON OF INSTRUCTIONAL METHODS USED IN
COLLEGE BASED MEDICAL TECHNOLOGY PROGRAMS

by

Marie Elaine Likins Kotter

A thesis submitted to the faculty of the
University of Utah in partial fulfillment of the requirements
for the degree of

Master of Science

Department of Medical Technology
University of Utah
December 1973
SUPERVISORY COMMITTEE APPROVAL

of a thesis submitted by

Marie Elaine Likins Kotter

I have read this thesis and have found it to be of satisfactory quality for a master's degree.

Chairman, Supervisory Committee

I have read this thesis and have found it
degree.

Date

I have read this thesis and have
to be a satisfactory quality
degree.

Date

Claude W. Grant

Member, Supervisory Committee
To the Graduate Council of the University of Utah:

I have read the thesis of Marie Elaine Likins in its final form and have found that (1) changes suggested by the Supervisory Committee have been completed in the manuscript; (2) reference citations and bibliography are consistent and in an acceptable form; (3) all illustrative materials including figures, tables, and charts are in place; and (4) the final manuscript is satisfactory and ready for submission to the Graduate School.

[Signatures]

Member, Supervisory Committee

Approved for the Major Department

Sarah A. Wise
Chairman/Dean

Approved for the Graduate Council

Sterli M. McMurrin
Graduate Dean
ACKNOWLEDGMENTS

I would like to express my sincere appreciation to Dr. Lamar Robbins, Chairman of the Thesis Committee, who initiated the new program in medical technology education and provided constant encouragement and guidance.

Special thanks are due to Dr. Claude W. Grant for his assistance and interest. Without his help this medical technologist could have foundered in the unfamiliar area of educational psychology.

Thanks should also be extended to Dr. Frank B. Jex who acted as a reader and provided valuable suggestions in the writing of this thesis.

Dr. Paul Carter, Garth Croft and Britt Adams are acknowledged for their cooperation in the testing of their students and recognition is given to the excellent typing job provided by Marsha Perrin.

Finally, I would like to express my appreciation to my husband, Bruce, whose help, encouragement and understanding made it possible for me to continue my education.
# TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>ACKNOWLEDGMENTS</th>
<th>iv</th>
</tr>
</thead>
<tbody>
<tr>
<td>LIST OF TABLES</td>
<td>vii</td>
</tr>
<tr>
<td>ABSTRACT</td>
<td>viii</td>
</tr>
</tbody>
</table>

## CHAPTER

### I. INTRODUCTION

<table>
<thead>
<tr>
<th>Statement of the Problem</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td>The Purpose</td>
<td>4</td>
</tr>
<tr>
<td>Hypotheses</td>
<td>5</td>
</tr>
<tr>
<td>Methodology</td>
<td>6</td>
</tr>
<tr>
<td>Definitions</td>
<td>6</td>
</tr>
<tr>
<td>Delimitations</td>
<td>7</td>
</tr>
<tr>
<td>Significance of the Study</td>
<td>8</td>
</tr>
</tbody>
</table>

### II. REVIEW OF RELATED LITERATURE

<table>
<thead>
<tr>
<th>Educational Methods</th>
<th>10</th>
</tr>
</thead>
<tbody>
<tr>
<td>Competency Based Education</td>
<td>12</td>
</tr>
<tr>
<td>Summary</td>
<td>16</td>
</tr>
</tbody>
</table>

### III. METHODOLOGY

<table>
<thead>
<tr>
<th>Sample</th>
<th>17</th>
</tr>
</thead>
<tbody>
<tr>
<td>Instructional Method</td>
<td>18</td>
</tr>
<tr>
<td>Data Collection</td>
<td>19</td>
</tr>
<tr>
<td>Instruments Used</td>
<td>21</td>
</tr>
<tr>
<td>Statistical Methods</td>
<td>23</td>
</tr>
</tbody>
</table>
LIST OF TABLES

<table>
<thead>
<tr>
<th>TABLE</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Comparison of Competency Based Education and Traditional Methods</td>
<td>13</td>
</tr>
<tr>
<td>2.</td>
<td>Means and Standard Deviation of Students' Pre and Post Scores</td>
<td>28</td>
</tr>
<tr>
<td>3.</td>
<td>Paired t Values on Pre and Post Test Scores</td>
<td>29</td>
</tr>
<tr>
<td>4.</td>
<td>One-Way Analysis of Variance Source Table for Pre Tests, Post Tests and Gain Scores</td>
<td>30</td>
</tr>
<tr>
<td>5.</td>
<td>Results of Newman-Keuls 2 Step Comparison of Means on Pre, Post and Gain Scores</td>
<td>31</td>
</tr>
</tbody>
</table>
ABSTRACT

This study was concerned with comparing instructional methods used in three schools, the University of Utah, Utah State University and Weber State College, in training medical technologists.

The University of Utah medical technology group consisted of 28 students. The instructors were practicing medical technologists from the University Medical Center Laboratory and they employed an instructional model similar to the classical lecture and demonstration method. The Utah State University group contained 16 students and also employed the classical lecture and demonstration model. The instructor was a Doctor of Microbiology on the college faculty with no previous training in medical technology. The Weber State College group contained 17 students. The competency based educational model was used with this group. The instructor was a medical technologist on the faculty of the Department of Health Occupations.

In order to compare these three instructional methods, a module was designed around one specific component of basic hematological knowledge, the different blood count. Included in the module was: (1) topic; (2) suggested teaching and student preparation time; (3) de-
scription of tests and sample test items; and (6) learning resources available. Statistical comparisons were computed on scores of pre tests, post tests and gain scores between pre test and post test scores.

Analyses of variance, t tests and Newman-Keuls two-step comparison of the means were used to evaluate the following:

1. Differences, if any, across the three colleges on pre test scores of students enrolled in the Introductory Hematology classes.
2. Differences, if any, across the three colleges on post test scores of students after exposure to the three instructional methods.
3. Differences, if any, across the three colleges on gain scores of students taught by the three instructional methods.

The results of these analyses are summarized below:

1. Post test scores of all three groups were significantly higher than pre test scores \(p < .001\) regardless of instructional methods used.
2. Significant differences among the three groups were obtained for pre test scores \(p < .01\), post test scores \(p < .001\) and gain scores \(p < .001\).
3. Both Utah State University and the University of Utah groups obtained significantly higher mean scores than the Weber State
College group (p < .01) on the pre test. Differences between the University of Utah and Utah State University groups on the pre test were not significant.

4. Both the University of Utah and Weber State College groups obtained significantly higher mean scores than the Utah State University group (p < .01) on the post tests. Differences between Weber State College and the University of Utah groups on the post tests were not significant.

5. Both the University of Utah and Weber State College groups obtained significantly higher mean gain scores than the Utah State University group (p < .01).

6. The significant difference in scores on the pre tests between the University of Utah group and the Weber State College group was not reflected in differences in gain scores as their mean gain scores did not differ significantly.
CHAPTER I

INTRODUCTION

Contemporary psychological and educational literature is filled with research designed to examine the merits or potential merits of new instructional methods for use in academic settings. Some methods have proved useful in limited settings on limited subject matters. No method has been universally acclaimed for all students, subject matters and settings.

One particular area, paramedical personnel training, is curiously devoid of documented studies comparing the effects of different instructional methods. This may be a result of the type of training programs developed.

Historically, most paramedical personnel were trained entirely in health care facilities. Learning was experientially and behaviorally oriented since the students were interning in working institutions and not restricted to classrooms and student laboratories. Mastery of various procedures and skills was accomplished along alternate routes in variable amounts of time depending on the individual student. Evaluation was conducted by registered technologists when the student indicated he was ready. Once mastery was demonstrated the student was allowed
to work with patient samples. Certification was accomplished by national registry examinations in the various specialties after completion of a specified period of training.

Registered personnel had no formal background in education and teaching often took a back seat to the routine work load. As a result, teaching methods were haphazard with little standardization or control.

Today with the greater need for trained health care manpower and the cry for accountability, pressure is being applied to have colleges and universities assume more of this training. With the advent of Medicare and second party payers, the cost of training and teaching facilities can no longer be incorporated into patient care fees. As the cost of these programs is high, the hospital cannot afford to provide the entire training. Colleges and universities must, then, provide the teaching and training on campus.

As this training was accomplished in hospitals for such a long period of time, there is little data available on teaching health care specialties in an academic setting. In the health care field where one is dealing with life and death daily, competence is a matter of necessity. A training program cannot be content with simple validation of course content. The student must be required to demonstrate certain skills upon completion of the program. Appropriate teaching techniques must be employed to insure that stated objectives are attained. There is an urgent need for standardization and accountability in health care training.
To begin to meet this need this study investigated three methods used at the present time to train medical technologists in academic settings.

Statement of the Problem

This investigation was concerned with comparing instructional methods used in three schools, the University of Utah, Utah State University and Weber State College, in training medical technologists. The program at Utah State University utilized the classical or "conventional" method of instruction characterized by formal lectures from a professor with demonstrations in a student laboratory. The program at the University of Utah also utilized the conventional format with one important difference. Instructors were registered medical technologists affiliated with the University Medical Center Laboratory. The program at Weber State College utilized a competency based model of instruction with registered medical technologists as instructors.

In order to study these three instructional methods a module was designed around one specific component, the differential blood count, a part of a complete blood count and a routine hematological procedure.

To accomplish an accurate differential count the student must integrate many of the concepts and principles he has learned about blood cells and their morphology. He must interpret what he sees with a microscope into a concise numerical evaluation for the physician. As
this task involves many levels of hematological knowledge, it was de-
cided that it would be most representative of overall knowledge and
skills obtained in an introductory hematology course.

This module was used to evaluate the various instructional meth-
ods. Included in the module was: (1) topic; (2) suggested teaching and
student preparation time; (3) description of the intended learners;
(4) unit objectives; (5) description of tests and sample test items; and
(6) learning resources available. Comparisons of student performance
under the three instructional methods were made using scores obtained
from pre tests and post tests and gain scores calculated from differences
between pre test and post test score.

Purpose

The purpose of this study was to compare the following:

1. Differences, if any, across the three colleges on pre test
scores of students enrolled in the Introductory Hematology
classes.

2. Differences, if any, across the three colleges on post test
scores of students after exposure to the three instructional
methods.

3. Differences, if any, across the three colleges on gain scores
of students taught by the three instructional methods.
The hypotheses are divided into two groups - those applying to comparisons made within each group and those applying to comparisons made along the groups.

Comparisons Within Groups

The following null hypotheses apply to comparisons made between pre test and post test scores within each group:

1. There are no significant differences between scores on pre test and post tests of students in the University of Utah group.

2. There are no significant differences between scores on pre tests and post tests of students in the Utah State University group.

3. There are no significant differences between scores on pre test and post tests of students in the Weber State College group.

Comparisons Among Groups

4. There are no significant differences across the three colleges in mean scores on the pre tests.

5. There are no significant differences across the three colleges in mean scores on the post tests.

6. There are no significant differences across the three colleges in mean gain scores from pre testing to post testing.
Methodology

The module on the differential count was similar in design to the packets used to measure teaching proficiency in the Danforth Project at the University of Utah. The module and the Danforth Project are described in Chapter III under the heading, "Instruments Used."

The objectives and content of the packet were evaluated by experts in the field of hematology for validity of goals and educational objectives used to obtain these goals. The pre tests and post tests were also evaluated for clarity and adherence to the objectives.

After evaluation and revision the packets were presented to the instructors of the college based hematology classes taught at the University of Utah, Utah State University and Weber State College. Pre tests were administered to students in these classes. After the instruction period, post tests were administered to the same students.

Mean scores on pre tests, post tests and gain scores were statistically analyzed. Analyses of variance, t tests, and Newman Keuls multiple range test were used when applicable to test for the existence of significant differences. Bartlett's test for homogeneity of variance was also run on the pre test scores.

Definitions

"Conventional" instructional model - Instructional model charac-
terized by formal lectures and demonstrations in a lecture hall by an
instructor on the college faculty usually with an educational ranking.

Competency based instructional model (CBE) - Instructional model
characterized by written goals and objectives with pacing of learning
experiences and evaluations determined by student progress and ability.

Differential blood count - Hematological procedure performed on
a stained blood smear under a microscope.

Hematology - That branch of biology which deals with the morpho­
ology of blood and blood forming tissues.

Hematology expert - Registered Medical Technologist who has
worked in a hematology laboratory for a minimum of three years.

Paramedical personnel - Personnel having a secondary relation­
ship to medicine. This excludes medical doctors who are defined as
having a primary relationship to medicine.

Registered personnel - Personnel having completed a specified
period of training and successfully passed a national registry examin­
ation in their particular specialty.

**Delimitations**

This study was limited to undergraduate students who were enrolled
in introductory courses in hematology based in an academic setting rather
than a clinical facility.

No attempt was made to limit the number enrolled in each group.
Students were not sub grouped by sex, grade point average or number
of quarter hours completed prior to enrolling in the class.

No attempt was made to control number of hours students were enrolled in concomitantly with the introductory class.

Significance of the Study

At the present time there is a lack of documented studies concerning the effects of various instructional methods on paramedical personnel training in academic settings. As the pressure is mounting to have colleges and universities assume more and more of this training, research is needed to provide data for administrators, curriculum planners and faculty who will be involved in setting up these college-based programs. The results of this study should be useful to these people in selecting instructional methods and backgrounds and training required of faculty for these specialized fields of study.

The education of health care personnel is too important and too vital to be relegated to the trial and error developmental method. Standardization and accountability are vital if the colleges and universities are to efficiently fill the gap left by the dismanteling of hospital training programs.
CHAPTER II

REVIEW OF RELATED LITERATURE

According to Kuhli (1971) health and education are two of the largest occupational groups in the country. He estimated that four million people were employed in the health occupation fields in 1971. The ratio of allied health workers to physicians was approximately twelve to one. With the greater need for trained health care manpower and the cry for accountability, pressure is being applied to have colleges and universities assume more of the health care training previously provided by hospital programs.

Published data concerning college-based allied health care educational programs and instructional methods is confined to the field of nursing and medical schools. Articles concerning other allied health fields are limited to those relating technical developments and tests. These are alternated with philosophical discussions of ethics, management and characteristics of the ideal health care worker. Many universities are now slowly evolving colleges of allied health occupations which should result in an increase of research relating to allied health education.
The investigator could find no published studies relating to comparisons of different instructional methods in college-based medical technology programs or other allied health professions. Stinnet (1969) has summarized work done on competency based teacher education but, again, little research has been done with competency based education in the health occupation fields.

The literature relating to educational methods used in health occupations fields is examined first. The literature relating to competency based education, the instructional method used with the Weber State College group, is then described.

**Literature Related to Educational Methods**

Sand and Belcher (1958) have reported on a five year curriculum research project in basic nursing education at the University of Washington School of Nursing. Two of the problem areas they identified were: (1) developing an effective sequence and organization of learning activities to attain essential professional competencies; and (2) determining the minimum length of time required to prepare a competent bedside nurse. Their findings relative to these questions supported their newly designed, shortened experimental program as the students in the experimental program did comparable work to those in the longer degree program as measured by performance on the nursing boards.
Their conclusions based on this data were rather general. They are as follows:

1. Shortening the time needed to prepare a professional nurse can be accomplished if at the same time the program is improved.

2. Shortening the time required to prepare a professional nurse required identification of those understandings, attitudes and skills that can best be learned on the job through in-service education, (Sand & Belcher, 1958, p. 138).

There also have been some studies done relating the new educational innovations of programmed instruction, television and video tapes to nursing education.

Seedor (1963) reported on the success of a programmed unit of instruction concerning asepsis. She concluded that nursing curriculum content could be programmed successfully. The majority of students using the teaching machines learned the material in roughly one half the usual time.

Griffin, Kinsinger and Pitman (1965) studied the use of closed circuit television to teach clinical nursing. They concluded that the use of closed circuit television in the hospital enables an existing number of nursing instructors to teach an increased number of students effectively utilizing the same clinical facilities.

McKay and Harrison (1972) utilized video tapes in a slightly different approach. They designed a study to determine if self critique by video tapes of a practice session was as effective as teacher critiques
of the practice session. Their results indicated that the self critique and teacher critique methods produced the same learning levels with the anxiety levels of the students not affecting the results significantly.

**Competency Based Education**

Competency based education (CBE) is one of the most recent and more important approaches on the educational scene. The significance attributed to this new concept was demonstrated in November, 1972, when the "Journal of Educational Technology" devoted an entire issue to the elucidation of its major view and developments. In this issue Andrews states that all fifty states will soon be moving toward the direction of competency based education and certification.

CBE is best described by comparing it with conventional systems of instruction. Young and Van Mondfrans (1972) summarized a comparison between the two as seen in Table 1.
<table>
<thead>
<tr>
<th></th>
<th>Competency Based</th>
<th>Traditional</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Goals and Objectives</td>
<td>Both teacher and student involved; student is aware of objectives and is often allowed some choice.</td>
<td>Teacher usually sets the goals; students usually not told what they are.</td>
</tr>
<tr>
<td>2. Procedures of Instruction</td>
<td>Student often has a choice of route and controls amount of time spent on goal.</td>
<td>Teacher usually controls materials and presents all students with the same materials in the same amount of time.</td>
</tr>
<tr>
<td>3. Knowledge Learned</td>
<td>Student usually learns how to do something.</td>
<td>Student may learn about something.</td>
</tr>
<tr>
<td>4. Evaluation Procedures</td>
<td>Teacher ensures evaluation is consistent with objectives.</td>
<td>Teacher gives test of own design which is often unknown to the student.</td>
</tr>
<tr>
<td>5. Timing of Evaluation</td>
<td>When student indicates he is ready.</td>
<td>When teacher is through teaching the unit.</td>
</tr>
<tr>
<td>6. Timing of Next Set of Learning Goals</td>
<td>When student has mastered last set of goals and objectives.</td>
<td>When last unit has been taught and evaluated.</td>
</tr>
</tbody>
</table>
Upon analysis of Young and Van Mondfran's comparisons there seem to be certain advantages implicated for a competency based system. One is the achievement of better learning with less frustration and anxiety on the part of the student. Conflict between teacher and student goals is minimal. Evaluations are consistent with objectives and take place when the student is ready.

Another inherent advantage of this system is the manifestation of better student accountability. This advantage is seen in conjunction with the better measurements obtained. As the student is aware of all the objectives which must be met to reach a specific goal he is, therefore, necessarily accountable for all of these objectives. Measurements are also more reliable as they evaluate only achievement of prescribed goals. In essence the students are not trying to out guess the teacher and his particular test design and, therefore, the student's true mastery of the subject is evaluated.

Corroboration is added to Andrew's prediction by the results of a California survey taken to determine the current status of competency based education. These results were reported in "Performance Based Teacher Education" (1972). Twenty-two of thirty-three colleges reporting believe they are participating in the competency based education movement.

CBE has been criticized for the use of criterion referenced tests
and the requirement of objectives stated in behavioral terms. There is a danger that objectives involving difficult to measure qualities such as appreciation may be slighted. Millman (1970) replies that if such objectives are taken seriously by the faculty they have a responsibility to provide learning experiences for developing such qualities.

Criterion referenced testing has been criticized on the basis of the difficulty of specifying the universe of tasks and the setting of proficiency standards. Millman (1970) uses these problems to emphasize that the wording of the objective is often less important than the selection of tasks and criteria. He feels that these problems will be minimized with experience in using this type of evaluation.

Validation reports on CBE programs in the literature do not appear to have kept pace with the proliferation of programs. Validation is usually done on course content by experts in the field. The literature contains little evidence with respect to surveys conducted of student performance after completion of the programs.

Despite the criticisms of the CBE system it appears to have many similarities with the hospital paramedical training described in the introduction. Thus, it was decided to use this method in the experimental group at Weber State College.
Summary

A review of the literature has indicated a paucity of findings with respect to comparison studies of instructional methods used in college-based paramedical training programs. There are some published data on nursing programs and medical schools. The nursing studies reviewed were related to educational innovations such as video taping and programmed learning methods and the development of nursing curricula. The studies concluded that programmed learning and video taping could be effective tools but that no definite conclusions could be drawn about curricula without more data.

Literature relating to competency based education is still in the philosophical stages. There have been some studies regarding competency based education teachers but no data relating to the paramedical training area.
CHAPTER III

METHODOLOGY

This study was concerned with a comparison of the instructional methods used in three college-based medical technology classes, Spring Quarter, 1973.

Comparisons were made with emphasis on student learning relative to gains calculated from pre test scores and post test scores of students enrolled in introductory courses in Hematology at the University of Utah, Utah State University and Weber State College.

Sample

Three sample groups were utilized in this study. The size of each sample was dictated by the number of students enrolled in each class and the number of students who completed both a pre test and a post test.

Complete data were obtained on 28 students out of the 45 students enrolled in the introductory medical technology class at the University of Utah, Spring Quarter, 1973. All of these students were considered upper classmen having completed at least 90 quarter hours prior to
enrollment in the class.

Complete data were available on all 16 of the students enrolled in the introductory Hematology class at Weber State College, Spring Quarter, 1973. This group was predominantly underclassmen. Only three of the 17 students had completed over 90 quarter hours prior to enrollment in the class.

Complete data were available on all 16 of the students enrolled in the introductory Hematology class at Utah State University, Spring Quarter, 1973. Thirteen of these students were just completing their 90 hours and three had completed over 90 hours prior to enrollment in the class.

The three samples were not subgrouped by age, sex or college grade point averages as such subgrouping did not appear to add anything to the experimental design.

**Instructional Method**

The instructional method used in the introductory Hematology class at the University of Utah was an adaptation of the "classical" or conventional instructional model used in universities and colleges. The conventional model is characterized by formal lectures and demonstrations in a lecture hall or laboratory by an instructor who is usually a professor on the college faculty. The instructional model for the University of Utah group varied from the conventional model in one way. The instructors were working medical technologists associated with the University Medical Center Laboratory. These technologists work in the
hematology laboratory full-time performing hematological tests. They are not considered part of the full-time instructional staff in the Department of Medical Technology. As the instructors were expected to keep up their routine work, lectures and demonstrations were divided among three technologists.

The instructional method used in the introductory Hematology class at Utah State University was the "classical" instructional method previously described. The professor was a Doctor of Microbiology with no experience as a medical technologist.

The instructional method used in the Weber State College introductory hematology class was an adaptation of the competency based educational model described in the "Review of Literature." The instructor was a registered medical technologist with an academic ranking in the Department of Health Occupations.

In the student laboratories the instructor to student ratio in all three groups was approximately 1:10.

Approximately the same course outline and objectives were used in all three groups for the entire quarter but the class at Utah State University included some clinical chemistry.

Only one of the three colleges, Weber State College, offers the class to freshmen students.

Data Collection

After consulting with and obtaining the approval of the instructors
for the three classes, copies of the instructional materials and objectives were distributed to the three instructors.

Prior to administering the pre tests, the instructors were again consulted to insure that objectives, time limits and testing methods would be adhered to in each class.

Pre tests were administered by the individual instructors before any lectures or demonstrations on blood cells and their identification were given.

After the instructional period the individual instructors administered the post tests. Students in the Utah State University class and the University of Utah class were informed that the tests would not be used in computing their grades for their respective classes. Weber State College students were being taught using a competency based educational method. The students were required to reach a certain level of competency on each objective. They had the option of taking the written examinations three times without penalty to reach this level of competency. The three examinations were parallel forms but only the first examination on differential blood counts was used in the comparison study.

Lectures were recorded in the classes at University of Utah and Weber State College. Using these recordings, required reading lists, and class outlines from the Utah State University class, the investigator compared material covered with the written objectives in the packet.
All materials in the objectives were covered either in lectures or assigned reading in all three classes. Different aspects were emphasized in all three classes but all the required material was available.

**Instruments Used**

The primary instruments used in this study were packets similar in design to those initially developed by W. James Popham, John D. McNeil and others at UCLA in 1964. Their initial concept was modified in a series of teaching proficiency tests developed as a result of a teaching improvement project, the Danforth Project conducted by the University of Utah's Center to Improve Learning and Instruction, during 1971-72. This modified version was used in designing the module on the evaluation of stained blood smears used in this study.

The module contained the following:

1. **Topic** - Evaluation of stained blood smear.

2. **Suggested Lesson Time Limit** - Four hours preparatory study time. Four class periods (three hours each) of in-class instruction and laboratory applications.

3. **Intended Learners** - Undergraduate medical technology students enrolled in introductory Hematology classes in various Utah universities.

4. **Unit Objectives** - Complete list found in Appendix A.

5. **Description of Tests and Sample Test Items** - Complete description found in Appendix A.

6. **Learning Resources Available** - Complete list of references found in Appendix A.
The objectives and content of the packet were evaluated by five experts in the field of Hematology for validity of goals and educational objectives used to obtain these goals. The pre test and post test were also evaluated for clarity and adherence to the objectives. These experts were drawn from the various hospital facilities in the Utah area.

They all concurred on the validity of the goals and objectives used. However, they questioned several of the items on the pre test and post test. Any of the items which did not meet the approval of all five experts were discarded.

The pre tests and post tests congruent with the objectives contained in the packet were parallel forms containing thirty items, four of which referred to Kodachrome slides of actual blood smears (see Appendix B). The items were drawn from all three levels of learning - knowledge, comprehension and application - as described in Bloom's Taxonomy of Educational Objectives. The objectives were written in ascending levels according to Bloom's classification. An application level objective was measured with an application level question and so on. The questions were all multiple choice items which were answered on a separate answer sheet. The answer sheets were hand scored by the investigator on both the pre test and post test.
Statistical Methods

The following statistical procedures were used to analyze the data: (1) analyses of variance; (2) t tests; (3) Newman-Keuls two-step comparison of the means; and (4) Bartlett's test for homogeneity of variance.

Senter (1969) describes analysis of variance as a statistical method for comparing samples of measurements for the purpose of estimating whether the observed differences among the samples is of a magnitude small enough to be attributable to sampling variation alone. It is a multi-group test of the null hypothesis which is how it has been used in this study.

The following steps for calculating the analysis of variance were followed: (1) the total sums of squares were divided into two parts - a within groups and a between groups sum of squares; (2) these sums of squares were divided by the associated degrees of freedom to obtain $s_w^2$ and $s_b^2$ which are the within and between groups variance estimates; and (3) the f ratio was calculated by using the following formula: $s_b^2/s_w^2$ and referring to a table of $f$ for the significance level. In this study, if the probability of obtaining the observed $f$ value was .05 or less, the null hypothesis was rejected.

Paired t tests were run on the matched pre test and post test scores. To insure that the data did not violate the assumption of homogeneity of variance which Senter (1969) states is an important assumption when
using the t ratio, Bartlett's test for homogeneity of variance was calculated for the pre test scores.

Senter (1969) in describing the reasoning behind this assumption states that the t ratio requires that the variance for the groups involved in the analysis to be about equal. This assumption is usually true but groups with unequal n's should have this verified before assuming the t ratio calculations are valid.

As the n for the University of Utah is larger than the other two groups, this assumption was verified and checked before running the paired t tests.

A paried t test differs from the standard t test on one important point - the amount of chance variability expected in the scores is considerably less than if the scores were randomly selected (Senter, 1969). In all other respects the t ratio that results from the paired t testing is the same statistic with the same application and interpretation as the standard t test.

In the standard t test the significance of the difference between two independent means is calculated using the following formula:

\[ t = \frac{D}{SE_D} \]

Here \( D \) is equal to the difference of the two means and \( SE_D \), the standard error of the difference of the two means is calculated by: (Senter, 1969)
The paired t ratio calculated in this study was obtained by using the following formula:

\[ t = \frac{M_D}{SE_{MD}} \]

In this formula \( SE_{MD} \) is equal to the standard error of the mean of the differences and \( M_D \) is the mean difference.

A t table was then consulted. The degrees of freedom for paired t tests is \( n-1 \) where \( n \) equals the number of pairs, unlike standard t tests where the degrees of freedom is represented by \( (N_1 - 1) + (N_2 - 1) \).

Significance levels were accepted at or beyond the .05 level of confidence.

To measure the amount of actual gain from pre test scores to post test scores and to determine whether these gains were significantly different one-way analysis of variance on the gain scores was calculated as previously described.

After determining that the f ratios obtained from the one-way analysis of variance run on the pre test and post test scores and gain scores showed significant differences among the three groups, the Newman-Keuls two-step comparison of means was run to see whether any two selected means
differed significantly.


The Newman-Keul Method is based on the criterion that the probability of rejecting the null hypothesis when it is true should not exceed .01 or .05 for all ordered pairs regardless of the number of steps they are apart.

In using this method the means are first ranked in order of magnitude. Then the difference between every mean and every other mean is calculated. This difference is then divided by $S_x$ which is calculated using the following formula:

$$S_x = \sqrt{\frac{S_{W2}}{n}}$$

$S_{W2}$ is the sum of the mean squares within obtained on the analysis of variance. This gives the studentized range, $Q$, which is then compared to criterion values of $Q$ by entering a Newman-Keuls table of critical values of studentized range statistic using degrees of freedom, $k$ and the level of significance desired.

Two means were considered to differ significantly if values were obtained at the .05 level of significance or beyond.
CHAPTER IV

FINDINGS

The results are presented and discussed individually in sequence according to the two sets of hypotheses investigated. The following statistical procedures were used to arrive at these results: (1) t tests; (2) analyses of variance; (3) Newman-Keuls two-step comparison of means; and (4) Bartlett's test for homogeneity of variance.

Comparisons Within Groups

The following null hypotheses apply to comparisons made between pre test and post test scores within each group:

1. There are no significant differences between scores on pre tests and post tests of students in the University of Utah group.

2. There are no significant differences between scores on pre tests and post tests of students in the Utah State University group.

3. There are no significant differences between scores on pre tests and post tests of students in the Weber State College group.

The first step undertaken was to compute the means and standard deviations for pre test and post test scores of students in each group. The results are shown in Table 2.
TABLE 2

Means and Standard Deviation of Students' Pre and Post Scores

Tests X Groups

<table>
<thead>
<tr>
<th></th>
<th>University of Utah</th>
<th>Utah State University</th>
<th>Weber State College</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M</td>
<td>S.D.</td>
<td>n</td>
</tr>
<tr>
<td>Pre Test Scores</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12.68</td>
<td>3.53</td>
<td>28</td>
<td></td>
</tr>
<tr>
<td>Post Test Scores</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>22.68</td>
<td>4.18</td>
<td>28</td>
<td></td>
</tr>
</tbody>
</table>
Paired t tests were run on each group of pre test and post test scores.

This data is represented in Table 3.

**TABLE 3**

Paired t Values on Pre Test and Post Test Scores

<table>
<thead>
<tr>
<th>Institution</th>
<th>Paired t Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>University of Utah</td>
<td>11.08</td>
</tr>
<tr>
<td>Utah State University</td>
<td>6.05</td>
</tr>
<tr>
<td>Weber State College</td>
<td>10.68</td>
</tr>
</tbody>
</table>

Post test scores of all three groups were significantly higher than pre test scores ($p < 0.001$) regardless of instructional method used. Thus, all three of the null hypotheses were rejected.

To insure that the groups did not violate the assumption of homogeneity of variance, Bartlett's test for homogeneity of variance was calculated for the pre test scores. The value obtained was 1.59 which is within the limit of 3 which indicates that the scores in all groups had a normal distribution.

**Comparisons Among Groups**

The following null hypotheses apply to comparisons made among the three groups of students taught by three instructional methods:

1. There are no significant differences across the three colleges in mean scores on the pre tests.
5. There are no significant differences across the three colleges in mean scores on the post tests.

6. There are no significant differences across the three colleges in mean gain scores from pre testing to post testing.

Analyses of variance were run and pre test scores, post test scores, and gain scores calculated from pre test and post test scores. The one-way analysis of variance source table for these values is listed in Table 4.

### TABLE 4

One-Way Analysis of Variance Source Table for Pre Tests, Post Tests and Gain Scores

<table>
<thead>
<tr>
<th>SOURCE</th>
<th>DEGREES OF FREEDOM</th>
<th>SUM OF SQUARES</th>
<th>MEAN SQUARES</th>
<th>f RATIOS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Pre Test Scores</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Between</td>
<td>2</td>
<td>127.37</td>
<td>63.68</td>
<td></td>
</tr>
<tr>
<td>Within</td>
<td>58</td>
<td>607.39</td>
<td>10.47</td>
<td>6.08</td>
</tr>
<tr>
<td>Total</td>
<td>60</td>
<td>734.75</td>
<td></td>
<td>(p&lt; .01)</td>
</tr>
<tr>
<td><strong>Post Test Scores</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Between</td>
<td>2</td>
<td>303.79</td>
<td>151.90</td>
<td></td>
</tr>
<tr>
<td>Within</td>
<td>58</td>
<td>940.80</td>
<td>16.22</td>
<td>9.36</td>
</tr>
<tr>
<td>Total</td>
<td>60</td>
<td>1244.59</td>
<td></td>
<td>(p&lt; .001)</td>
</tr>
<tr>
<td><strong>Gain Scores</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Between</td>
<td>2</td>
<td>464.36</td>
<td>232.18</td>
<td></td>
</tr>
<tr>
<td>Within</td>
<td>58</td>
<td>1178.88</td>
<td>20.33</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>60</td>
<td>1643.25</td>
<td></td>
<td>11.42</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(p&lt; .001)</td>
</tr>
</tbody>
</table>
The results of these analyses show that there were significant differences among the pre test scores ($p < .01$), post test scores ($p < .001$) and the gain scores ($p < .001$). Thus, all three of the null hypotheses were rejected.

After determining that the $f$ ratios obtained from the one-way analyses of variance on the pre test scores, post test scores and gain scores were significant, Newman-Keuls two-step comparison of means was done to evaluate whether any two selected means differed significantly. The results of these analyses are shown in Table 5.

**TABLE 5**

Results of Newman-Keuls Two-Step Comparison of Means on Pre, Post and Gain Scores

<table>
<thead>
<tr>
<th></th>
<th>PRE TESTS</th>
<th>POST TESTS</th>
<th>GAIN SCORES</th>
</tr>
</thead>
<tbody>
<tr>
<td>University of Utah x Utah State</td>
<td>N.S. *</td>
<td>1.35</td>
<td>7.25</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$p &lt; .01$</td>
<td>$p &lt; .01$</td>
</tr>
<tr>
<td>Utah State x Weber State</td>
<td>.04</td>
<td>1.09</td>
<td>2.97</td>
</tr>
<tr>
<td></td>
<td>$p &lt; .01$</td>
<td>$p &lt; .01$</td>
<td>$p &lt; .01$</td>
</tr>
<tr>
<td>Weber State x University of Utah</td>
<td>.21</td>
<td>N.S. *</td>
<td>N.S. *</td>
</tr>
<tr>
<td></td>
<td>$p &lt; .01$</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Not Significant
The comparison of means on pre test scores revealed that both the Utah State University and the University of Utah groups had significantly higher means than the Weber State College group (p < .01). Differences between the University of Utah group and the Utah State University group were not significant.

The comparison of the means of the post test scores showed that both the University of Utah and Weber State College groups had significantly higher means than the Utah State University group (p < .01).

Differences between the means of the Weber State College and the University of Utah groups were not significant.

The comparison of the means of the gain scores paralleled the results of the post test scores. Both the Weber State College and the University of Utah groups showed significantly higher gain scores than the Utah State University group (p < .01).

The significant difference in scores obtained on the pre test between the University of Utah group and the Weber State College group was not reflected in a significant difference in gain scores. Weber State College and the University of Utah mean scores did not differ significantly.
CHAPTER V

SUMMARY, DISCUSSION AND CONCLUSIONS

Summary

This investigation was concerned with comparing three instructional methods used in training medical technologists at the University of Utah, Utah State University and Weber State College.

There were 28 students in the group at the University of Utah where an instructional model similar to the "classical" lecture and demonstration method was employed. Instructors were practicing medical technologists from the University Medical Center Laboratory. The Utah State University group contained 16 students and also employed the "classical" lecture and demonstration model. The instructor was a Doctor of Microbiology on the college faculty and had no training in medical technology. The Weber State College group contained 17 students. The competency based model was used with this group. The instructor was a medical technologist on the faculty of the Department of Health Occupations.

In order to compare these three instructional methods, a module
was designed around one specific component of basic hematological knowledge, the differential blood count. Included in the module were:

(1) topic; (2) suggested teaching and student preparation time; (3) description of the intended learners; (4) unit objectives; (5) description of tests and sample test items; and (6) learning resources available.

Comparisons of student performance were made using scores obtained from pre tests and post tests and gain scores calculated from differences between pre test and post test scores.

The purpose of these comparisons was to evaluate the following:

1. Differences, if any, across the three colleges on pre test scores of students enrolled in the Introductory Hematology classes.

2. Differences, if any, across the three colleges on post test scores of students after exposure to the three instructional methods.

3. Differences, if any, across the three colleges on gain scores of students taught by the three instructional methods.

To implement this purpose six hypotheses were tested for significance. They are as follows:

1. There are no significant differences between scores on pre tests and post tests of students in the University of Utah group.

2. There are no significant differences between scores on pre tests and post tests of students in the Utah State University group.

3. There are no significant differences between scores on pre tests and post tests of students in the Weber State College group.
4. There are no significant differences across the three colleges in mean scores on the pre tests.

5. There are no significant differences across the three colleges in mean scores on the post tests.

6. There are no significant differences across the three colleges in mean gain scores from pre testing and post testing.

Analysis of variance, t tests, Newman-Keuls two-step comparison of the means and Bartlett's test for homogeneity of variance were used in testing these hypotheses. The results of this testing are summarized below:

1. Post test scores of all three groups were significantly higher than pre test scores (p < .001) regardless of instructional method used.

2. Significant differences among the three groups were obtained for pre test scores (p < .01), post test scores (p < .001) and gain scores (p < .001).

3. Both Utah State University and the University of Utah groups had significantly higher means than the Weber State College group (p < .01) on pre test scores. Differences between the University of Utah and Utah State University groups were not significant.

4. Both the University of Utah and Weber State College groups had significantly higher means than the Utah State University group (p < .01) on the post tests. Differences between Weber State College and the University of Utah groups were not significant.

5. There are no significant differences across the three colleges in mean scores on the post tests.

6. There are no significant differences across the three colleges in mean gain scores from pre testing to post testing.
Analysis of variance, t tests, Newman-Keuls two-step comparison of the means and Bartlett's test for homogeneity of variance were used in testing these hypotheses. The results of this testing are summarized below:

1. Post test scores of all three groups were significantly higher than pre test scores ($p < .001$) regardless of instructional method used.

2. Significant differences among the three groups were obtained for pre test scores ($p < .01$), post test scores ($p < .001$), and gain scores ($p < .001$).

3. Both Utah State University and the University of Utah groups had significantly higher means than the Weber State College group ($p < .01$) on pre test scores. Differences between the University of Utah and Utah State University groups were not significant.

4. Both the University of Utah and Weber State College groups had significantly higher means than the Utah State University group ($p < .01$) on the post tests. Differences between Weber State College and the University of Utah groups were not significant.

5. Both the University of Utah and Weber State College groups had significantly higher means than did the Utah State University group ($p < .01$) on gain score comparisons.

6. The significant difference in the pre test scores between the University of Utah group and the Weber State College group was not reflected in the gain scores as their mean gain scores did not differ significantly.

**Discussion**

Although all groups gained significantly between pre testing and post testing, two of the groups had significantly higher means on the
post tests and significantly higher mean gain scores. These two groups, the University of Utah and Weber State College, had medical technologists as instructors. This seems to suggest that it is advisable even in an academic setting to have medical technologists teaching medical technologists on a subject which is integrally related to the routine work of the same profession.

The significantly lower pre test scores of the Weber State College group when compared to the University of Utah and Utah State University groups are probably a result of this group being composed of predominantly underclassmen in contrast to the upper classmen composition of the other two groups.

Although the field of Hematology is relatively specialized, upper class medical technology students would have had more exposure to classes in biology and physiology in which they could become familiar with general concepts relating to blood and blood cells. This familiarity might be reflected in the higher pre test scores of the groups composed of upper classmen.

From a cursory examination of the data one would be led to believe that the significantly lower pre test scores of the Weber State College group coupled with their comparable post test scores when compared to the University of Utah group would give a significant difference in gain scores between the groups. However, when the data was statistically analyzed for significance, the mean Weber State College group gain
score did not differ significantly from the University of Utah. This may be a result of the large increase in scores of both groups from pre to post testing which would tend to "dilute" the effects of the differences in pre test scores.

Another possibility is that error inherent in the computation itself may account for the statistically insignificant value. With several methods available for performing multiple comparisons much debate concerning their use and appropriateness in different situations has arisen. As this study was not concerned with statistical variations in multiple comparison lists and since the computations are rather involved no other multiple comparisons were run.

With respect to this controversy, Winer (1962) has compared the six methods commonly in use today and, interestingly enough, obtained widely disparate indications of significance depending on the method used. The values he obtained for the Newman-Keuls method were intermediate to those values obtained with the conservative Scheffe method and the more liberal Duncan multiple range method. Without more evidence it appears there is no one definitive method which can be employed to conclusively determine multiple range significance.

Although the statistical analysis did not reveal a significant mean gain score comparison, when comparing the fact remains that the instructional method, competency based education, used with the Weber
State College group appeared effective. It succeeded in bringing a significantly lower group of students as measured by their pre test scores to a level comparable to that reached by the University of Utah group using the traditional method.

**Conclusions**

**Pre Test Scores**

The Weber State College group was significantly lower on pre test scores when compared with the University of Utah and Utah State University groups. This may be due to the fact that the Weber State College group was composed of predominantly lower classmen in contrast to the upper classmen composition of the other two groups. There was no significant difference between the two upper classmen groups from the University of Utah and Utah State University.

**Post Test Scores**

All groups gained significantly between pre testing and post testing. The University of Utah and Weber State College groups scored significantly higher on the post test than the Utah State University group. This may be a result of the background of the instructors. Both the University of Utah and Weber State College groups had medical technologists as instructors whereas the instructor of the Utah State University group was a Professor of Microbiology. There was no significant difference
between the University of Utah and Weber State College groups with medical technologists as instructors.

Mean Gain Scores

Similar to the results of the post test score comparison, the University of Utah and Weber State College groups showed significantly higher gain scores than the Utah State University group. Despite the significantly lower pre test scores of the Weber State College group and their subsequent increase on post test scores to a level comparable with the University of Utah group, there was no statistical difference between the two schools when the mean gain scores were compared. The reason for this result is not readily apparent. It may be derived from the fact that both groups showed large increases from pre testing to post testing or from the error inherent in formulas used presently in calculating multiple range comparisons.
REFERENCES


APPENDIX A

DIFFERENTIAL BLOOD COUNT MODULE

Topic:

Evaluation of Stained Blood Smear.

Suggested Lesson Time Limit:

Four hours preparatory study time. Four class periods (three hours each) of in-class instruction and laboratory applications.

Intended Learners:

Undergraduate medical technology students enrolled in Introductory Hematology classes in various Utah universities.

Unit Objectives:

Are described in separate enclosure.

Description of Tests:

The pre test and post test are identical in format but contain different parallel questions. Each test is composed of multiple choice test items with separate answer sheets. There will be a total of thirty items. Items will be included which utilize Kodachrome slides of stained blood cells. Items will be drawn from all three levels of learning - knowledge, comprehension and application - as described in Bloom's Taxonomy of
of Educational Objectives. The objectives are also written in ascending level according to Bloom's Taxonomy. An application level objective will be measured with an application level question and so on.

Sample Items:

Knowledge Level
The largest cell found in normal blood is the:
   a. Lymphocyte
   b. Neutrophilic band cell
   c. Neutrophilic segmented cell
   d. Monocyte
   e. Eosinophilic segmented cell

Comprehension Level
If a patient has a white cell count of 10,000 and a differential showing 30% monocytes and 70% lymphocytes, his absolute monocyte count could be:
   a. 7,000/mm$^3$
   b. 10,000/mm$^3$
   c. 3,000/mm$^3$
   d. 15,000/mm$^3$
   e. Could not calculate from above data

Application Level
In a good Wright stain the film will appear pink. If the smear is too blue you should:
   a. Use more stain and more diluent
   b. Use more stain and less diluent
   c. Time of staining may be increased and washing decreased
   d. Time of staining may be decreased and washing increased
   e. Use more stain and increase time of staining.

Objectives

A. Smears - Preparation and Staining

  1. The student will be able to describe:
a. Methods used for preparing coverslip and slide smear and advantages and disadvantages for each method.

b. Principle of polychrome stains and two modifications of original Romanowsky's stain.

c. Characteristics of a well prepared smear including stain and distribution of cells.

2. The student will be able to demonstrate proper procedure for making a blood smear using both coverslip and slide techniques.

3. The student will be able to demonstrate proper procedure in staining the cells using Wright's stain.

B. Smear Evaluation

1. The student will be able to describe:
   a. Characteristics of normal and abnormal red blood cells with respect to staining, size, shape and inclusion bodies.
   b. Characteristics of normal and abnormal white blood cells.
   c. Characteristics of normal and abnormal platelets.
   d. Changes which take place in RBC and WBC as they mature.

2. The student will be able to evaluate a smear for staining and distribution of cells.

3. The student will be able to evaluate and describe erythrocytes for size, shape, color and abnormal forms.

4. The student will be able to evaluate and describe platelets for estimated number and morphologic abnormalities.

5. The student will be able to evaluate and describe leukocytes for number and morphologic abnormalities.

6. The student will be able to perform a differential count on leukocytes.
7. The student will be able to evaluate and describe ten unknown smears. RBC, WBC and platelets will be evaluated for number, morphology and abnormalities. Differential counts must be within two standard deviations of assigned value obtained by medical technologists in the hematology laboratory.

Suggested Hematology Texts


APPENDIX B

Pre Test

Instructions

This is a test to assess any background or prior knowledge you may have concerning blood smear evaluations and differential counts. It will not be used to determine your grades. Although it will not be used for grading purposes, try to answer as many questions as you can. Do not spend too much time on any one question.

The questions have only one answer. Circle the letter corresponding to your answer on the separate answer sheet. You may use the question booklet for calculations and figuring.

1. The major advantage of coverslip blood smear preparations over slide preparations is that they:

   a. Give good distribution of WBC's.
   b. Give poor distribution of WBC's.
   c. Give poor distribution of RBC's.
   d. Are easier to handle.
   e. Are easier to store.
2. Romanowsky's original polychrome stain was based upon the following principle:

- A mixture of acid and basic dyes gives a neutral dye.
- A mixture of acid and basic dyes retains individual staining properties and develops new staining properties.
- A mixture of acid and basic dyes gives an acid dye.
- A mixture of acid and basic dyes loses individual staining properties but develops new staining properties.
- A mixture of acid and basic dyes gives a basic dye.

3. Wright's stain is a methyl alcohol solution of:

- An acidic dye, methylene blue and a basic dye, eosin.
- An acidic dye, eosin, and a basic dye, methylene blue.
- An acidic dye, hematoxylin and a basic dye, brilliant cresyl blue.
- An acidic dye, brilliant cresyl blue and a basic dye, hematoxylin.
- An acidic dye, methyl violet and a basic dye, prussian blue.

4. In a good Wright stain the film will appear pink. If the smear is too blue you should:

- Use more stain and more diluent.
- Use more stain and less diluent.
- Time of staining may be increased and washing decreased.
- Time of staining may be decreased and washing increased.
- Use more stain and increase time of staining.

5. A well prepared smear stained with Wright's stain:

- Will appear pink to the naked eye.
- Will appear blue to the naked eye.
- Will have precipitated stain in area between cells.
- Will have eosinophils with blue black granules.
- Will have basophils with red granules.

6. The largest cell found in normal blood is the:

- Lymphocyte.
- Neutrophilic band cell.
- Neutrophilic segmented cell.
- Monocyte.
- Eosinophilic segmented cell.
7. In a normal differential white cell count which cell would be present in the least amount?

   a. Neutrophilic segmented cell.
   b. Eosinophilic segmented cell.
   c. Basophilic segmented cell.
   d. Lymphocyte.
   e. Monocyte.

8. If a patient has a white cell count of 10,000 and a differential showing 30% monocytes and 70% lymphocytes, his absolute monocyte count would be:

   a. 7,000/mm³
   b. 10,000/mm³
   c. 3,000/mm³
   d. 300/mm³
   e. 700/mm³

9. Which of the following is not considered an erythrocyte inclusion?

   a. Howell-Jolley bodies.
   b. Basophilic stippling.
   c. Cabot rings.
   d. Heinz bodies
   e. Auer bodies.

10. When the hemoglobin in the erythrocytes is below normal, the condition is referred to as:

    a. Microcytosis.
    b. Poikilocytosis.
    c. Anisocytosis.
    d. Hypocytopenia.
    e. Hypochromia.

11. The immediate precursor of the neutrophilic band cell is the:

    a. Neutrophilic segmented cell.
    b. Progranulocyte.
    c. Neutrophilic myelocyte.
    d. Myeloblast.
    e. Neutrophilic metamyelocyte.
12. A young red cell with blue-gray tinge to the cytoplasm is:
   a. Dermatophilic.
   b. Psychophilic.
   c. Acidophilic.
   d. Orthochromatophilic.
   e. Polychromatophilic.

Match the following RBC descriptions with their definitions:

13. ____ Anisocytosis
    a. Oval in shape
14. ____ Schistocytes
    b. Variation in size
15. ____ Poikilocytosis
    c. Variation in shape
16. ____ Target cell
    d. Red cell fragment
17. ____ Elliptocytes
    e. Leptocytes

Match the following WBC descriptions with their description:

18. ____ Monocyte
    a. Sausage shaped nucleus, chromatin coarse, deep blue.
19. ____ Basophil
    b. Lobulated nucleus, fine pink granules.
20. ____ Lymphocyte
    c. Usually two lobes, large red granules.
21. ____ Eosinophil
    d. Nucleus eccentric, sky-blue cytoplasm.
22. ____ "Band"
    e. Delicate indented nucleus, light gray vacuolated cytoplasm.
23. ____ Segmented neutrophil
    f. Lobulated nucleus, black granules

24. The youngest cell in the granulocytic series of white cells is the:
   a. Progranulocyte
   b. Neutrophilic segmented cell
   c. Neutrophilic band cell
   d. Neutrophilic metamyelocyte
   e. Myeloblast

25. Turk cell is an old name for a:
   a. Lymphocyte
   b. Monocyte
   c. Neutrophilic band cell
   d. Neutrophilic metamyelocyte
   e. Proplasmacyte
26. Given the following results of a differential white count: 20 neutrophilic segmented cells; 75 normal lymphocytes; 1 eosinophil; and 4 monocytes, the evaluation would be:

a. This report is abnormal because of the low number of eosinophils.
b. This report is abnormal because there is a high number of lymphocytes in relation to the neutrophils.
c. This report is abnormal because of the low number of monocytes.
d. This report is abnormal because there are no basophils.
e. This report is normal.

The following questions refer to Kodachrome slides:

27. Slide 11: The three cells (from a-c) can be identified as:

a. Lymphocyte, monocyte, granulocyte.
b. Lymphocyte, granulocyte, monocyte.
c. Monocyte, lymphocyte, granulocyte.
d. Monocyte, granulocyte, lymphocyte.
e. Granulocyte, lymphocyte, monocyte.

28. Slide 13: The four cells are examples of:

a. Monocytes
b. Lymphocytes
c. Granulocytes
d. Basophils
e. Eosinophils

29. Slide 10: Identify the elements indicated by the arrows:

a. Precipitated stain
b. Artifacts
c. Leptocytes
d. Megakaryocytes
e. Platelets

30. Slide 1-25: Some of the red cells on this slide are examples of:

a. Target cells
b. Burr cells
c. Ovalocytes
d. Elliptocytes
e. Schistocytes
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th>1. a b c d e</th>
<th>18. a b c d e f</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>a b c d e</td>
<td>19. a b c d e f</td>
</tr>
<tr>
<td>3.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>a b c d e</td>
<td>20. a b c d e f</td>
</tr>
<tr>
<td>4.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>a b c d e</td>
<td>21. a b c d e f</td>
</tr>
<tr>
<td>5.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>a b c d e</td>
<td>22. a b c d e f</td>
</tr>
<tr>
<td>6.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>a b c d e</td>
<td>23. a b c d e f</td>
</tr>
<tr>
<td>7.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>a b c d e</td>
<td>24. a b c d e</td>
</tr>
<tr>
<td>8.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>a b c d e</td>
<td>25. a b c d e</td>
</tr>
<tr>
<td>9.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>a b c d e</td>
<td>26. a b c d e</td>
</tr>
<tr>
<td>10.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>a b c d e</td>
<td>27. a b c d e</td>
</tr>
<tr>
<td>11.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>a b c d e</td>
<td>28. a b c d e</td>
</tr>
<tr>
<td>12.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>a b c d e</td>
<td>29. a b c d e</td>
</tr>
<tr>
<td>13.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>a b c d e</td>
<td>30. a b c d e</td>
</tr>
<tr>
<td>14.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>a b c d e</td>
<td></td>
</tr>
<tr>
<td>15.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>a b c d e</td>
<td></td>
</tr>
<tr>
<td>16.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>a b c d e</td>
<td></td>
</tr>
<tr>
<td>17.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>a b c d e</td>
<td></td>
</tr>
</tbody>
</table>
APPENDIX C

Post Test

Instructions

Answer the following questions on the separate answer sheet. Circle the letter corresponding to your answer. The questions have only one correct answer. You may use the question booklet for calculations and figuring.

1. In a slide blood smear preparation:
   a. Granulocytes and monocytes are found on the periphery and lymphocytes in the center of the smear.
   b. Granulocytes and monocytes are found in the center and lymphocytes on the periphery of the smear.
   c. Lymphocytes and monocytes are found in the center and granulocytes on the periphery of the smear.
   d. Lymphocytes and granulocytes are found on the periphery and monocytes in the center of the smear.
   e. The distribution is random without areas of special cell concentrations.

2. The major advantage of slide blood smear preparations over coverslip preparations is:
   a. Their cost
   b. Their ease of handling
   c. Their distribution of WBC's
   d. Their distribution of RBC's
   e. Their distribution of platelets
3. The blood on a good blood smear will make a gradual transition from a concentrated area to a thin area without extending over the end of the slide. If your smear extends over the end of the slide you:

a. Did not use enough blood to make the smear.
b. Used too much blood to make the smear.
c. Did not push the spreader quickly enough.
d. Pushed the spreader with a jerky motion.
e. Raised the spreader before completing the smear.

4. Wright's stain is a modification of:

a. Koch's acid fast stain.
b. Grunwal's PAS stain.
c. Bulinksky's Prussian blue stain.
d. Romanowsky's polychrome stain.
e. Dameshek's supravital stain.

5. In a good Wright stain the film will appear pink. If the smear is too red:

a. The staining time is too long.
b. The stain is precipitating on the slide.
c. The stain is unevenly distributed.
d. The buffer solution is too basic.
e. The buffer solution is too acid.

6. The smallest WBC found in normal blood is the:

a. Lymphocyte
b. Monocyte
c. Neutrophilic segmented cell
d. Neutrophilic band cell
e. Plasmacyte

7. The normal percentages in a differential count for monocytes are:

a. 0-1
b. 2-6
c. 10-20
d. 20-35
e. 55-75
8. How would you distinguish a neutrophilic myelocyte from a neutrophilic metamyelocyte?
   a. Former has 1 nucleoli; latter has 3 nucleoli.
   b. Former has red granules; latter has purple granules.
   c. Former is small; latter is large.
   d. Former has round or oval nucleus; latter has indented nucleus.
   e. Former has granules; latter has no granules.

9. If a patient has a white cell count of 3,000 and a differential showing 70% lymphocytes, 28% neutrophilic segmented cells and 2% monocytes, his absolute lymphocyte count would be:
   a. 2,100/mm³
   b. 210/mm³
   c. 840/mm³
   d. 8,400/mm³
   e. 600/mm³

10. "Shift to the left" means:
   a. irreversible coagulation.
   b. Increase in immature cells.
   c. Increase in monocytes.
   d. Decrease in erythrocytes.
   e. Terminal leukemia.

11. Abnormal variation in the size of erythrocytes is called:
   a. Hypochromia
   b. Poikilocytosis
   c. Anisocytosis
   d. Ovalocytosis
   e. Spherocytosis

12. On a peripheral blood smear platelets are said to be normal if:
   a. There is an average of 35-40 per oil immersion field.
   b. There is an average of 25-30 per oil immersion field.
   c. There is an average of 20-25 per oil immersion field.
   d. There is an average of 5-10 per oil immersion field.
   e. There is an average of 1-5 per oil immersion field.
13. Variation in the shape of erythrocytes is called:
   a. Poikilocytosis
   b. Anisocytosis
   c. Spherocytosis
   d. Hypochromia
   e. Hyperchromia

15. ____ Cabot rings  b. Nuclear remnants
16. ____ Basophilic stippling  c. Loop-shaped structures
17. ____ Reticulocytes  d. Precipitate of denatured hemoglobin
18. ____ Heinz bodies  e. Coarse dark granules derived from endoplasmic reticulum.
19. ____ Pappenheimer bodies  f. Basophilic reticulum under vital stain.

20. The immediate precursor of the myelocyte is the:
   a. Neutrophilic band cell
   b. Neutrophilic metamyelocyte
   c. Promyelocyte
   d. Myeloblast
   e. Prorubricyte

21. Which of the following is not present in normal peripheral blood?
   a. Neutrophilic segmented cell
   b. Monocyte
   c. Lymphocyte
   d. Plasmacyte
   e. Neutrophilic band cell

22. A hypochromic red blood cell has:
   a. A blue-gray tinge to the cytoplasm.
   b. Blue granules in the cytoplasm
   c. A thin rim of hemoglobin.
   d. Free iron in the cytoplasm.
   e. Cytoplasmic RNA.
23. The youngest cell in the erythrocytic series is:
   a. Metarubricyte
   b. Prorubricyte
   c. Erythrocyte
   d. Rubricyte
   e. Rubriblast

24. Target cells are also known as:
   a. Siderocytes
   b. Leptocytes
   c. Schistocytes
   d. Elliptocytes
   e. Ovalocytes

25. Which cell is not an immature member of the granulocytic series?
   a. Myeloblast
   b. Neutrophilic metamyelocyte
   c. Promyelocyte
   d. Neutrophilic segmented cell
   e. Neutrophilic myelocyte

26. Given the following results of a differential white cell count: 2 band cells, 65 segmented cells, 25 lymphocytes, 2 monocytes, 6 eosinophils, 1 basophil, WBC count 5,000, the evaluation would be:
   a. This report is normal.
   b. This report is abnormal because of abnormally increased eosinophils.
   c. This report is abnormal because of the low number of monocytes.
   d. This report is abnormal because there is a high number of neutrophils in relation to lymphocytes.
   e. This report is abnormal because of the low number of band cells.

27. Identify the cells in this slide (1):
   a. Lymphocytes
   b. Monocytes
   c. Granulocytes
   d. Plasma cells
   e. Band cells
28. Identify the cells on the slide (2):
   a. Lymphocytes
   b. Monocytes
   c. Myelocytes
   d. Plasma cells
   e. Nucleated red blood cells

29. This cell is an example of a (3):
   a. Monocyte
   b. Metamyelocyte
   c. Myelocyte
   d. Band cell
   e. Granulocyte

30. On this slide the red cells could be described as (4):
   a. Normal
   b. Polychromatophilic
   c. Hypochromic
   d. Poikilocytes
   e. Anisocytes
ANSWER SHEET
Post Test

1. a b c d e
2. a b c d e
3. a b c d e
4. a b c d e
5. a b c d e
6. a b c d e
7. a b c d e
8. a b c d e
9. a b c d e
10. a b c d e
11. a b c d e
12. a b c d e
13. a b c d e
14. a b c d e f
15. a b c d e f
16. a b c d e f
17. a b c d e f
18. a b c d e f
19. a b c d e f
20. a b c d e
21. a b c d e
22. a b c d e
23. a b c d e
24. a b c d e
25. a b c d e
26. a b c d e
27. a b c d e
28. a b c d e
29. a b c d e
30. a b c d e
<table>
<thead>
<tr>
<th>Name</th>
<th>Marie Elaine Likins Kotter</th>
</tr>
</thead>
<tbody>
<tr>
<td>Birthplace</td>
<td>Boulder, Colorado</td>
</tr>
<tr>
<td>Birthdate</td>
<td>October 10, 1946</td>
</tr>
<tr>
<td>High School</td>
<td>Lincoln County High School, Panaca, Nevada</td>
</tr>
<tr>
<td></td>
<td>Highland High School, Salt Lake City, Utah</td>
</tr>
<tr>
<td>University</td>
<td>University of Utah</td>
</tr>
<tr>
<td>1964-1968</td>
<td>Salt Lake City, Utah</td>
</tr>
<tr>
<td>Degree</td>
<td>B.S., Medical Technology</td>
</tr>
<tr>
<td>1968</td>
<td>University of Utah</td>
</tr>
<tr>
<td>Certificates</td>
<td>Registered Medical Technologist</td>
</tr>
<tr>
<td>1968</td>
<td>American Society Clinical Pathologists</td>
</tr>
<tr>
<td>Professional Organizations</td>
<td>American Society of Medical Technologists</td>
</tr>
<tr>
<td>Professional Positions</td>
<td>Blood Bank Technologist, Holy Cross Hospital, Salt Lake City, Utah, 1968-71; Educational Coordinator, Holy Cross Hospital, Salt Lake City, Utah, 1971-72; Assistant Professor of Health Occupations, Weber State College, Ogden, Utah, 1973-present.</td>
</tr>
</tbody>
</table>