THE PREPARATION OF COMPETENCY-BASED CHEMISTRY

INSTRUCTIONAL MATERIALS FOR

MEDICAL LABORATORY TECHNICIANS

by

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Dissertation submitted to the Graduate Faculty of the

Virginia Polytechnic Institute and State University

in partial fulfillment of the requirements for the degree of

DOCTOR OF EDUCATION

in

Community College Education

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June 1974

Blacksburg, Virginia

To Bob

ACKNOWLEDGEMENTS

I wish to express my appreciation to Bob, Mom and Dad for their understanding and encouragement throughout the course of this investigation.

Also, I am indebted to Dr. John Crigler for his advice concerning the statistical aspects of the study.

Mrs. Charlotte Cord deserves special praise for the excellent manner in which she typed and proofread the final copy.

Finally, I should like to thank my committee for their help and leadership throughout the period of investigation.

TABLE OF CONTENTS

LIST OF TABLES AND FIGURES

I. INTRODUCTION

Background

The need for health technicians of all kinds has been well documented by state and federal agencies and by professional organizations. Smith (1970, p.311) has stated that at the present time there are approximately 2,800,000 workers in various health occupations; moreover, the projection of the need for health technicians in the years ahead is set at an additional 1,500,000 workers by 1980. This demand for health technicians is a direct result of an increasing population, the enactment of health care legislation, and recognition of the need to provide better health care services.

In anticipation of the growth in the need for more health technicians, the American Association of Community and Junior Colleges (AACJC) compiled a directory in 1970 of all of the health programs being taught in community colleges throughout the country. This inventory was conducted on behalf of the Division of Allied Health Manpower, the Bureau of Health Manpower Education, the National Institutes of Health, and the Department of Health, Education and Welfare.

The directory divides the allied-health programs into fourteen major categories which are further subdivided into approximately fifty-two careers (American Association of Junior Colleges, 1970). A list of these categories and careers is provided in Appendix A. One of the fourteen major categories is that of Laboratory Services in which persons are prepared to participate in a variety of specialties which require knowledge and skill in clinical laboratory procedures. Among the careers under Laboratory Services are those of cytotechnologist, histology/cytology technician, medical laboratory assistant, and medical laboratory technician. The ensuing investigation involved the determination of what competencies were needed by medical laboratory technicians and of the chemistry content which would aid in achieving those competencies.

Because trade schools and on-the-job training programs have not been able to keep up with the demand for more and better health services, an increasing part of the responsibility for training programs in the health care field has fallen to the nation's community colleges. Eventually, it is anticipated by some authorities that these institut-ions will completely take over the task of training the allied-health workers (Taub, 1971).

It is the opinion of both Smith and Taub that the public community college offers the greatest promise for meeting this demand for health technicians and workers. The list of allied-health areas and careers which is included in Appendix A shows that indeed the community colleges of the nation are making an effort to offer programs for the training of health-career students.

A perusal of many catalogues from community colleges located in various parts of the nation reveals the fact that many of the allied-health services or programs require a student to take chemistry as part of his course of study if he is preparing for a career under one of these fourteen major categories.

Some of the careers such as nursing home administration, medical secretary, geriatric assistant, or optician require little, if any, chemistry knowledge. Other careers such as dental assistant, radiological health technician, or registered nurse require a greater knowledge of chemistry in order for the practitioner to fulfill the duties of his particular job. In a few of the allied-health careers, and in particular the career of a medical laboratory technician, a considerable amount of chemistry is a necessity. One indication that medical laboratory technicians do need an excellent background in chemistry is the fact that many persons who hold a baccalaureate degree in chemistry work in a clinical or hospital laboratory as their first job or position. It seems reasonable to assume that some of the skills of the chemistry major are similar to some of the skills needed by a medical laboratory technician if he performs successfully in a clinical or hospital laboratory.

As previously stated, many of the programs for the preparation of students who are pursuing any of the health careers require that the student take some chemistry. Very often the health-career student is forced to enroll in the only chemistry course offered at the community college--the traditional, first-year college chemistry course which everyone from transfer students and pre-medical students to chemistry majors takes because no other alternatives are available (Chapman, 1965). Needless to say, most of the health-career students are not getting the kinds of chemistry appropriate for their chosen careers. Hill (1971) voiced this same opinion based upon a study which he conducted in the Virginia community college system. He observed that the chemistry curricula now being offered in the community colleges were not meeting the needs of the diverse student population enrolled in the beginning chemistry courses. He concluded that there was a dire need for the development of a beginning chemistry curriculum which would be more responsive to students' needs and that would equip them with necessary competencies to perform successfully on the job.

Much research is now being done in the area of improving not only the chemistry curriculum but also other types of curricula found in community colleges. The desirability of making the first year of college chemistry more relevant and current has been well documented (Meek, 1972). According to Lippincott (1969, p. 333), "The student is motivated most when he feels there is something he wants to learn."

One of the most successful approaches used to date is that of first determining or identifying the skills or competencies required of students for a particular job or career; and subsequently, building or constructing the curriculum around these skills or competencies. Hopefully, through this method, the student receives the subject or course content which is directly relevant to his chosen career (Taub, 1971).

Purposes of the Study

The above discussion leads directly into the purposes of this study-- (1) to determine the kinds of competencies in chemistry needed for medical laboratory technicians; and (2) to use these competencies to develop chemistry instructional materials which would assure the achievement or realization of these competencies.

Basic Assumption

The major assumption made in this study was that a chemistry curriculum based directly on the competencies or skills needed by medical laboratory technicians is more appropriate than the traditional chemistry curriculum. Meek (1972, p. 35) has stated that much research is necessary to show positively whether or not competency-based chemistry curricula are superior to the traditional chemistry curricula. It may be an easy matter for the allied-health educator to state clearly in performance terms: "The student will be able to ...". However, as Meek has pointed out, various and important concepts from chemistry are not and can not be based on a specific task-oriented behavior; e.g., chemical bonding. In other words, it is difficult to write certain chemical concepts in performance terms or in the form of a task-oriented behavior. According to Meek (1972, p. 35) "To attempt to write all concepts as a specific task-oriented behavior could destroy the inner logic (concepts) of the material."

Definition of Terms

It is imperative to this study that the title medical laboratory technician be thoroughly understood. Apparently, there exists a number of titles or names for the person who holds the associate in science degree in medical technology. Some authorities refer to the title as simply medical technician; others call it medical technologist. However, most of the national associations for medical technology have agreed that the title is medical laboratory technician.

The American Medical Technologists (AMT) has defined a medical laboratory technician as a person qualified by education and experience to perform clinical laboratory testing requiring a minimal exercise of independent judgment and discretion. According to AMT, a medical laboratory technician ordinarily works under immediate supervision, particularly when performing tests of other than a routine nature. However, he may perform tests and report the results of any routine procedure without close supervision, provided a medical technologist or other person of higher qualification is on duty in the laboratory or on immediate call.

According to the standards set forth by the AMT, an applicant for a career in medical laboratory technology must meet certain requirements. He must be a citizen or resident of the United States and of good moral character. An applicant must be a high school graduate or an acceptable equivalent.

Basically, there are three routes by which one may become a medical laboratory technician:

1. Professional school training--an applicant must be a graduate of a medical laboratory school (offering a 12 or 18 month course in medical laboratory technology) which has been accredited by the Accrediting Bureau of Medical Laboratory Schools. In addition, the applicant must acquire enough approved laboratory experience to make his combined school and laboratory experience program at least two years in length.

2. Armed forces school--an applicant must have completed a course

of at least one year (50 weeks) in a United States Armed Forces school of medical laboratory techniques. The school's courses must be the substantial equivalent of the courses offered in a school accredited by the Accrediting Bureau of Medical Laboratory Schools. In addition, the applicant must complete 12 months of approved laboratory experience.

3. College, university or community college--an applicant must have completed 60 semester hours in an accredited college or community college, including at least 25 semester hours in the sciences. This must include the following specific course requirements or the substantial equivalent: 12 hours in chemistry, bacteriology or parasitology in any combination; 3 hours in mathematics and 8 hours in biology, genetics, embryology, zoology or anatomy in any combination. Or, an applicant must be the holder of an associate of science degree in medical technology (or equivalent) from an accredited community college. In addition, all applicants must complete six months of approved laboratory experience.

Finally, all applicants must take and pass the American Medical Technologist's registry examination for the certification of medical laboratory technicians.

A very prestigious national organization, the American Society of Clinical Pathologists (ASCP), agrees with the American Medical Technologists on the title of medical laboratory technician. According to the ASCP, the newest member of the medical laboratory team, the medical laboratory technician, is an individual who has graduated from a community college program which included supervised clinical experience in an approved laboratory. The medical laboratory technician performs more complicated laboratory procedures than the laboratory assistant and he requires only a limited amount of supervision; but, he does not undertake the supervisory and educational responsibilities of the professional medical technologist.

The present criterion for certification as a medical laboratory technician by the Board of Registry of the ASCP is an associate degree from an accredited community college. Also, the applicant must have had some supervised clinical experience in an approved laboratory. Associate degree level programs for medical laboratory technicians are being developed in many community colleges, utilizing essentials adopted by the American Medical Association. These essentials call for a structured educational curriculum comprised of general education, laboratory science (including clinical laboratory) and related subjects. The clinical laboratory instruction is to include courses in the teaching laboratory and in the clinical laboratory focusing on basic skills, understanding principles, and mastering the procedures involved.

The medical laboratory technician position provides a new intermediate level on the laboratory career ladder opening the way for individuals to move more easily to higher levels--(certified laboratory assistant; medical laboratory technician; medical technologist; laboratory sciences, Ph.D.; pathologist, M.D.). Community colleges are encouraged to provide for upward mobility of students by granting advanced standing on the basis of transfer credits or equivalency examinations and by seeking to ensure transferability of credits earned.

According to the ASCP, medical laboratory technicians probably earn somewhere between the certified laboratory assistant and the medical technologist scale, which would indicate a median salary of $7000-$8000 for 1972. In Federal Civil Service, they enter with a starting salary of $6,544. Employment opportunities can be expected to be widespread in line with general demands for well-trained laboratory personnel.

In conjunction with the definitions and guidelines as set forth by the AMT, the ASCP and the AACJC, this writer also used the term medical laboratory technician. As was previously stated, there are three routes by which one may become a certified medical laboratory technician. However, in this particular study, interest was focused on medical laboratory technicians who receive the associate in science degree from an accredited community college.

Another rather elusive term was allied health. The term allied-health manpower, when used broadly, covers all of the professional, technical, and supportive workers in the field of patient care, public health, and health research who engage in activities that support, complement or supplement the professional functions of physicians, dentists, and registered nurses. The term also refers to personnel engaged in organized environmental health activities who are expected to have expertise in environmental health (Pennell and Hoover, 1970).

In the allied-health-education directory compiled by the AACJC in 1970, the primary source authority in determining whether a reported program was indeed an allied-health program was the Division of Allied-Health Manpower and consultant groups from the Environmental Protection Agency, Division of Nursing, Division of Dental Health, and the National Institute of Mental Health. For example, the National Institute of Mental Health distinguished the psychiatric aide as one who is trained specifically to work in an institutional setting where psychiatric care is rendered in contrast to the mental health worker who works with psychiatrists and psychologists in clinics or offices (AACJC, 1970).

In this study an allied-health career was considered to be any career which required specific health training in an institution as a necessary prerequisite to working on the job.

The last term to be defined is that of competencies. Competencies were considered to be those skills or abilities needed in the field of chemistry in order for a medical laboratory technician to perform adequately on the job.

Summary

The demand for health technicians of all kinds has been increasing steadily over the past decade. The needs for the future are anticipated to be even greater. Many community colleges throughout the country are implementing new allied-health programs into their curricula to aid in the training of more health technicians.

A majority of these new programs require the allied-health student to take chemistry as part of his course work. Most community colleges do not find it economically feasible to offer more than one type of general chemistry; consequently, the allied-health student is being forced to enroll in the only general chemistry course offered at the college--the typical first-year course in which everyone from transfer students, pre-medical students, and engineering students to chemistry majors enrolls. Many educators and practitioners believe that the allied-health student is not getting the chemistry he needs.

II. REVIEW OF RELATED LITERATURE AND RESEARCH

Review of Chemistry Curricula and Teaching Methods

General chemistry is offered by most two-year colleges throughout the United States. In some cases it is the only chemistry course found in the college catalogue. Because more students are enrolled and more faculty time is devoted to the general chemistry course, it has always been a major item for discussion at conferences and professional meetings (Chapman, 1965). Traditionally, most general chemistry courses have been constructed for the major in chemistry and related rigorous disciplines where mathematics was quite likely to be the determining factor for the measurement of achievement (O'Leary, 1965).

With the launching of Sputnik in 1957, a whole new era in the teaching and the content of science courses emerged. The degree of rigor and sophistication in the chemistry programs reached an impressive level. For the good students, and the strongly motivated students, the accelerated and enriched programs proved to be very successful. However, for the average students, these post-Sputnik innovations made unrealistic demands.

About twenty years ago, the general chemistry course was abruptly changed from an introduction of inorganic and descriptive chemistry to a principles-oriented course. More and more of what had been physical chemistry became part of the general chemistry course. Today there is a shift towards the inclusion of descriptive chemistry within the context of chemical principles (Slabaugh, 1971). Many studies have shown that students can understand the principles better if there are more points of contact with the real world in terms of specific chemical pnenomena (Lippincott, 1969). Furthermore, chemistry teachers are aware that students without sufficient mathematical background can not adequately master some of the more advanced and quantitative aspects of chemical principles. As Slabaugh (1971, p. 2) has stated, "Hopefully, a more workable balance between the descriptive and principles-oriented chemistry will be the future make-up of the typical general chemistry course."

The future of the instruction and content of chemistry will depend on internal influences (the science itself) as well as the external influences (culture and society). At the present time, the external influences appear to hold the upper hand (Mortimer, 1971). The student is much more concerned with how chemistry can improve his way of life rather than with the classical aspects of chemistry as a pure science.

In an address at a recent conference on education in chemistry, Dr. Donald F. Hornig (1971, p. 30) stated:

> ...the external factors which have resulted in changes of classical ways of teaching chemistry since 1960 include the following factors: declines in the job market, declines in research subsidies, and declines in the proportion of students entering programs leading to careers in science.

With the above situation in mind, what will be the future trends in general chemistry? It is the expressed opinion of many chemistry educators that general chemistry must, and will, become more human centered. In the past, introductory chemistry has been "turning students off" because they are more concerned about social action and the improvement of human conditions than with cold facts and principles. Perhaps the teaching of chemistry should be less directed toward the importance of chemistry to industry and more centered on the ways in which chemistry helps to meet the more fundamental needs of man (Mortimer, 1971).

According to Mortimer (1971, p. 7),

> ...one way in which chemistry could be more relevant to the students is a reversal of the trend to emphasize theory to the complete neglect of the descriptive chemistry. The descriptive aspects of chemistry are an important part of chemistry; an introductory course is incomplete without some coverage of them. Furthermore, theory itself is of meaning and value only insofar as it interprets descriptive fact.

Several problems exist in the chemistry curricula and instructional processes in the two-year colleges. With the heterogeneity of the student body found in two-year colleges, it is difficult to develop a general chemistry course which is relevant to all the enrolled students. If it is so difficult to develop a single general chemistry course for all the students, would it be feasible or more appropriate to develop separate chemistry courses for the chemistry majors as opposed to the non-chemistry majors? If this were done, the chemistry majors should follow one course of study; whereas, the non-science, non-chemistry major could take a type of chemistry which would be more relevant to his needs. In constructing or developing a chemistry course for the non-science student, how does one decide or determine what is relevant? Assuming one could determine what is relevant, what are the best methods of teaching this non-major's chemistry course? These problems are just a few which have been confronting chemistry educators in two-year colleges all over the nation.

The role of the community colleges in chemistry has been that of providing a firm background in elemental chemistry, especially for the student who was not ready for the more rigorous and accelerated pace of a four-year institution (Maybury, 1968). In the 1960's, emphasis was placed solely upon the chemistry major's problems and how to solve them. Now much interest and energy are being devoted to the lot of the non-science major and his chemistry needs and problems.

Traditionally, community colleges have offered only one general chemistry course. Everyone from chemistry majors to occupationally-oriented students was forced to enroll in the same chemistry course because no other alternatives were available. Typically, this general chemistry course was quite theoretical in nature, with much emphasis placed upon mathematical skills. While this type of course may have been well suited to the needs of the chemistry majors, many educators began to realize that the occupationally-oriented student was being severely shortchanged. As the number of failures continued to increase, many students began changing to programs in which there was no chemistry requirement; or even worse, some dropped out of college altogether (Taub, 1971). Finally, chemistry educators realized it was time to stop talking about the occupationally-oriented student's plight and start doing something to remedy the situation.

According to Lippincott (1969, p. 333) the student is motivated most when he feels there is something he wants and needs to learn. This indicates that there is a dire need to make general chemistry as current and as relevant as possible---not only for the occupationally-oriented student but for the chemistry major as well. Many educators scoff at the term relevancy because they do not understand its meaning.

Nagle (1969, p. 4) has stated:

> ...the educators dismiss the term relevancy because they feel it is simply an expression in the student vernacular meaning to make their course easy and/or entertaining. This misconception is totally wrong. A relevant chemistry course does not mean a "watered-down" one, but rather one in which the student can recognize in the material being taught, information he will need in order to perform well in his chosen occupation.

In a recent conference on science in the two-year college (Conference on Science in the Two-Year College, 1969) it was recommended that the two-year college faculties respond to the diverse needs of their students by offering an appropriate variety of programs in the sciences. Some of these programs should prepare students for upper disvision programs at four-year colleges and universities; others should prepare students for specific occupations. Several recommendations were made for the occupational curricula. One of the most important suggestions was that the science content of occupational programs should be a joint concern of the faculty in science and the faculty in occupational programs. Another suggestion was that those who were concerned with the science content of occupational programs at the two-year colleges should seek the advice from outside specialists who are familiar with both the technical employment and with the existing two-year college occupational programs. One major recommendation was that the teachers who were involved with the actual teaching of the sciences not only should have at least a masters degree in the discipline and also should be familiar with the applications of their discipline to the relevent technical or occupational jobs.

"What is the best way to teach this non-major's occupationally-oriented chemistry?" is a question asked at many professional conferences and meetings. Many authorities believe that the conventional lecture-laboratory course works with a moderate degree of success whenever a class is homogeneous in nature. According to Heider (1969, p. 4), the more diverse the student population, the less effective this classical teaching method becomes since not all students learn at the same rate or through the same instructional mode. It is Heider's belief that some students learn better by the written word, some by hearing, some by films, some by "doing" in the laboratory, etc. Therefore, an effective course should provide a wide diversity of modes to meet each student's particular needs.

Many teaching methods have been tried. One method--the audio-tutorial approach--seems to be working well in many community colleges. The audio-tutorial method permits the students to pace themselves and it utilizes a wide variety of teaching techniques. Most important, it allows for a maximum of personal contact between the instructor and each individual student.

Nordmann (1966, p. 33) developed a new way of doing the laboratory for the non-science major which is still being implemented in many community colleges. He felt that:

> ...the teacher should attempt to interest the non-science student in science by presenting him with a practical problem, explaining how the chemist looks at and solves this problem, then solving it in the laboratory and looking at the underlying principles which are important.

In the past years, there was an awakened interest in the various media of instructional aids. The instructional aids referred to are those of projection systems, television, computer, audio tapes, etc. All of these aids have been tested and tried; however, the results have not been decisive. Slabaugh (1971, p. 1) stated that, "The students have not necessarily been 'turned on' by these various types of media and neither has the chemistry enrollment jumped."

Today, the trend is in the direction of "hands-on chemistry"--the kind of chemistry the student can experience by performing real-life experiments with his own hands or by witnessing a live demonstration in the classroom. These activities seem to offer refreshing alternatives to the above-mentioned instructional devices such as motion pictures or precise computer print-outs of reaction mechanisms, etc. The convenience of canned material versus the labor of preparing lecture demonstrations is definitely against the "hands-on" innovation. However, from the student's standpoint there seems to be a renewed interest in the classical type of lecture demonstration. Slabaugh (1971, pp. 1-2) has suggested that perhaps community college chemistry teachers need to look at a balance between the new and the old.

In recent years, most innovations in instruction have been involved with individualization of instruction, with increased utilization of instrumentation, or with the integration of chemistry in inter-disciplinary programs (Committee on Chemistry in the Two-Year College, 1971). The trend towards individualized instruction involved such developments as the use of behavioral objectives. Behavioral objectives provided for the inclusion of programmed activities that were designed to assist students in achieving the objectives. Many self-pacing instructional programs and independent study programs were also finding a place in the two-year college.

The trend toward the integration of chemistry with other disciplines in inter-disciplinary programs involved natural or integrated science courses, environmental science courses, and experimental science in occupational curricula. Various segments of curricula for the training of occupational students could be carefully coordinated so that concepts and skills learned in one course could be used to a maximum in another course. This coordination could be the joint responsibility of faculty members in chemistry, mathematics, and in all the occupational subjects which the student is required to take (Conference on Science in the Two-Year College, 1969).

Allied-Health Chemistry

According to Taub (1971) the total work force increased 29 percent from 1950 to 1966; during the same years, the number of allied-health workers increased by some 90 percent. From 1966 to 1975, it is predicted that approximately one million more allied-health workers will be needed. How will this tremendous increase affect the community colleges, especially the science departments? The science faculties involved probably will have the responsibility for training and educating increasing numbers of allied-health workers because trade schools and on-the-job training programs will not be able to keep up with the demand for more and better health services.

The question to be discussed is, "How is an allied-health course set up and what chemistry should be included in it?" It is very difficult for an instructor to set up a chemistry course for the allied-health student. One way to find out what chemistry is needed is to consult with the health professions as to what the specific chemistry needs are for each career. Another way to determine the needs for allied-health workers is to find out the tasks which they actually do, and then pull out the chemistry content from those tasks in an effort to derive basic concepts to formulate instructional units.

In summary, Taub (1971) indicated that there were two things which a chemistry department could do to handle the chemistry needs of many allied-health workers:

> ...the first one is to leave things as they are and force the allied-health students to take the existing chemistry courses. As the number of failures continue to increase, as it surely will, one can rationalize that these students should not be in chemistry or ought to change to a non-science major. Many will do just that or drop out of college altogether. The result is that some good allied-health people will be lost. The second, and best approach, is to fit the chemistry concepts to what is relevant and needed by the student so that he can perform. This approach would lay a foundation to whatever further science which the student might take.

The second approach was used as a basis for the UCLA Allied-Health Professions Project described in detail below.

UCLA Allied-Health Professions Project

The Division of Vocational Education of the University of California is an administrative university unit. This unit is concerned with responsibilities for research, teacher education, and public service in the broad area of vocational and technical education. During 1968, this Division entered into an agreement with the United States Office of Education to prepare curricula and instructional materials for a variety of allied-health occupations. For the most part, these materials were related to pre-service and in-service instruction for programs ranging from on-the-job training through the associate degree level (Allied-Health Professions Project, 1972).

A National Advisory Committee, drawn from government, education, professional associations in the health-care field, and the lay public, provided guidance and assistance with the over-all activities of the Allied-Health Professions Project. In addition, a National Technical Advisory Committee of practitioners, educators, and other knowledgeable individuals provided guidance and counsel in the research and curriculum development activities for each of the occupations included in the Allied-Health Professions Project Program. In most cases, these committees worked with the Allied-Health Professions Project staff assigned to the specific occupation to establish a basic task list which, when validated by a national survey, provided the foundation for the curriculum development.

Task inventories were developed by the staff of the Allied-Health Professions Project as the first step in identifying the tasks that people perform in the various allied professions. Before developing a basic inventory, however, the Project staff conducted a search of the literature and gathered job descriptions, existing task inventories, and policy manuals. In many cases, drafts of the inventories were produced with the help of the National Technical Advisory Committee for the given occupation, and/or other consultants

In the course of validation by field survey, each task inventory provided the opportunity for survey respondents to augment the list by adding tasks not represented in the survey instrument. Such tasks then were added to the basic inventory, if appropriate, so that each validated list was considered to represent as broad and authoritative as possible a compendium of tasks performed in health care settings from coast to coast.

Among the fourteen task lists which have been validated by the field survey, the clinical laboratory list was of greatest importance to this study. A National Technical Advisory Committee provided assistance in designing a questionnaire that was used to identify the various individuals currently performing laboratory functions in hospitals and independent laboratories, and to validate a task list appropriate to the clinical laboratory occupations throughout the nation.

The fundamental objectives of the Allied-Health Professions' Project were to develop curricula and instructional materials for those allied-health functions that could be taught at the associate degree level, and to develop in-service and pre-service instructional programs for those health-related occupations for which on-the-job training might be appropriate. The initial steps leading to the development of curricula involved the identification and listing of all possible tasks in a specified functional area, and verification of their performance by personnel in the occupational categories under consideration.

Data on institutional practices in the medical laboratory field were collected by means of a survey form listing those specific tasks which might be performed by individuals who participate in medical laboratory procedures. After a survey of pertinent literature, a tentative list of tasks was constructed. This list was reviewed by the National Technical Advisory Committee for medical laboratory occupations at its July, 1969, meeting. Revisions and additions were made by the Committee, and the list as approved for the survey consisted of 530 tasks.

The main purpose of the survey was to determine the appropriateness of the task list as a foundation for curriculum development. First, the curriculum content (tasks) were determined and then the knowledge and skills required for satisfactory performance of the tasks were evaluated. Three factors which determined curriculum content were task performance, task criticality, and technological change.

One main advantage of using this skills/knowledge process approach was that the occupational requirements for the medical laboratory field could be determined with a high degree of uniformity. The same skills and knowledge are required for a process performed in a 300-bed modern city hospital laboratory as for the same process performed in a 50-bed remote Alaskan hospital.

From the task analysis, the design of the instructional unit was developed. This design included the rationale for the overall teaching strategy, specification of the teaching objectives, and division into modules and units of instruction. The Allied-Health Professions' Project defines a module as a basic self-contained instructional segment. For each module in the unit, a first teaching draft has been developed which will be field tested extensively until all the teaching objectives are met in the final teaching draft.

Unit-Based Chemistry Curriculum

Hill (1974) has recently completed a study designed to produce a viable beginning chemistry curriculum outline for the community college freshman level. He designed the curriculum to meet the career training needs of the wide variety of students enrolled. He conducted his study via a modified Delphi technique and surveyed future employers and educators located in five groups: (1) 25 members of the allied-health professions, (2) 25 members of the occupational-technical fields, (3) 25 members of the chemical industries, (4) 25 professional engineers, and (5) 25 chemical educators. These panelists were asked to indicate what chemical concepts would be needed by prospective workers in their category or area. The writer used the information from this extensive survey to design a more relevant chemistry curriculum from which the enrolled students could obtain the necessary skills to place them in more favorable positions in their chosen careers. The final product of Hill's research was a unit-based chemistry curriculum derived from the convergence of opinions of the panel of experts as to what concepts should be included in a freshman chemistry curriculum.

This investigator was particularly interested in what concepts the 25 experts from the allied-health professions indicated as important. The final results of Hill's study showed that the allied-health respondents considered the concepts of atomic structure, basic measurement, solutions and acidimetry/alkalinitry to be most important for persons pursuing an allied-health career. Organic chemistry and biochemistry were considered as highly important for the allied-health careers.

One significant outcome of Hill's study was the concern registered by the respondents as to the need for more relevant college chemistry curricula. The major recommendation for future work stemming from Hill's investigation was that there was a dire need for more research to determine chemistry concepts needed by each career group.

This investigation--to determine the competencies needed by medical laboratory technicians and then to determine the chemistry topics that would aid in achieving these competencies--is a step in the direction recommended by Hill.

Summary

Much research has gone toward the development of a more relevant chemistry curriculum which will better meet the needs of the allied-health student. Also, much study has been devoted to the teaching methods and techniques that have been used for presenting chemistry to health-career students.

Although conclusive evidence is still lacking, many experts think that a competency-based chemistry curriculum is the superior curriculum for meeting the needs of the allied-health student. No one teaching method has been shown to be more effective than the others for teaching chemistry to allied-health students. In general, the types of students dictate which approach (lecture, individualized instruction, audio-tutorial, etc.) is most effective.

III. PROCEDURE, MATERIALS, AND DESIGN

Procedure

The purposes of this project were to determine the competencies needed by medical laboratory technicians and to develop chemistry instructional materials which would be more relevant to potential medical laboratory technicians and better meet their needs.

In order to accomplish the first purpose, a questionnaire was constructed from items that were found in the UCLA Allied-Health Professions Project's task analysis on clinical laboratory occupations (1971, pp. 6-8). The original UCLA task analysis for clinical laboratory occupations consisted of 530 laboratory and management tasks. The final tabulation of the results from the task analysis survey showed that 50 items out of the total 530 were basic tasks selected by a majority of the 224 respondents in 29 hospitals. These 50 items were then selected to comprise the questionnaire (Appendix B) used for this particular investigation.

Although items from the UCLA task analysis for clinical laboratory occupations were utilized in this investigation, the purposes and intents of the two studies differed in several aspects. The main purpose of the UCLA task analysis was to determine what basic tasks all classifications of laboratory personnel needed to be able to perform. Among the laboratory classifications under investigation were those of microbiologist, medical technologist, clinical laboratory technician, medical laboratory technician, medical health aide, laboratory assistant, cytotechnologist, histologic technician, etc.

The overall purpose of the investigation reported here was to determine what skills were needed by medical laboratory technicians. Because the UCLA task analysis represented all clinical laboratory occupations, the investigator first attempted to ascertain which of these 50 tasks were basic ones for a medical laboratory technician to be able to perform.

Another way in which the two studies differed was in the selection of respondents. In the UCLA task analysis, a representative number of practitioners from the various clinical laboratory occupations were surveyed. However, in this investigation, persons selected from four different specific occupational groups were surveyed.

While the final product of the UCLA investigation dealt with the development of modules for the complete program of study for the various clinical occupations, the final product for this investigation centered around the development of instructional materials just for the chemistry needed by medical laboratory technicians. These instructional materials ultimately could be used as a basis for a course to be taught in community colleges or other institutions offering medical laboratory technician programs.

The fifty items from the UCLA task analysis were grouped into the following categories: (a) processing specimens, (b) maintaining materials and equipment, and (c) using standard laboratory equipment. Each item contained either an activity or skill which a medical laboratory technician might need to perform. The items were written in performance terms and/or in the form of specific task-oriented behaviors.

Each respondent was asked to indicate his reactions concerning each item on the questionnaire by rating the item on a scale of one to four as follows: 1 = disagree; 2 = tend to disagree; 3 = tend to agree; 4 = agree. Also, each respondent was asked to indicate his opinion as to how often each item was performed by a medical laboratory technician according to the following rating scale: 1 = uncertain; 2 = seldom; 3 = occasionally; 4 = frequently.

The questionnaire was sent to persons in the following groups:

1. chemistry teachers in community colleges who were involved with the teaching of health-career students;

2. educators who planned curricula or programs for the training of medical laboratory technicians;

3. medical laboratory technicians who graduated from a two-year college and who had worked a minimum of two years; and

4. supervisors of medical laboratory technicians who were working in a clinical or hospital laboratory.

The chemistry teachers at community colleges were involved directly with the teaching of chemistry to the enrolled students. In order for the chemistry teachers to meet adequately the chemistry needs of their students, it was assumed that they must be aware of their students' occupational goals. As shown in Table I, 97 community colleges located in 33 states had medical laboratory technician programs in operation as of 1970-71. A questionnaire (Appendix B) was mailed to the chemistry department of each of these 97 community colleges (Appendix C).

TABLE I

States With Community Colleges Having

Medical Laboratory Technician Programs in 1970

State	Number of Programs	Total Number of Graduates through 1970
Alabama	2	38
Arizona	1	18
Colorado	1	4
Connecticut	3	17
Delaware	1	15
Florida	3	62
Georgia	2	*
Illinois	8	75
Iowa	2	96
Kentucky	2	14
Maryland	5	48
Massachusetts	2	9
Michigan	4	41
Minnesota	3	67
Mississippi	5	35
Missouri	1	37
New Hampshire	1	*
New Jersey	4	69
New York	19	3338
North Carolina	2	241

TABLE I

(Continued)

State	Number of Programs	Total Number of Graduates through 1970
North Dakota	1	*
Ohio	2	4
Oklahoma	2	18
Oregon	1	33
Pennsylvania	3	129
Rhode Island	1	69
South Carolina	2	22
South Dakota	1	12
Tennessee	2	9
Texas	7	55
Virginia	1	*
Washington	2	41
Wisconsin	1	*

*Data were not available for these programs.

Program designers of medical laboratory technician curricula in community colleges are directly involved in the planning of what courses are needed by medical laboratory technicians in order that they will be well prepared for their future jobs in hospitals or clinical laboratories. It was assumed that these designers were in a position to know the particular skills needed by medical laboratory technicians to perform as effectively and efficiently as possible on the job. A questionnaire was sent to the program directors at each of the 97 community colleges which have medical laboratory technician programs. These colleges are listed in Appendix C.

In most clinical or hospital laboratories, a medical technologist serves as the direct supervisor of the medical laboratory technician. The medical technologist has an academic background that is broader and greater in depth than that of the medical laboratory technician. He has had instruction in all phases of the clinical laboratory and he is able to detect and correct errors. He can set up new procedures, develop quality control programs and supervise and assist both medical laboratory technicians and certified laboratory assistants. In general, he exercises a high degree of independent judgment (Williams, 1971). One hundred questionnaires were sent to medical technologists located in hospitals throughout the nation. The hospitals which received the questionnaires were selected via proportional stratified random sampling. This technique was used in order to insure that each state would have proportional representation according to the number of hospitals located in that state. Table II lists the number of questionnaires sent to each state. A minimum of one questionnaire was sent to a hospital located in each state, including the District of Columbia. The hospitals contacted are listed in Appendix C.

According to the American Medical Technologists (AMT), their registry contained the names of 700 medical laboratory technicians who

TABLE II

Total Number of Hospitals Per State

(1971)* and Number of Questionnaires Mailed Per State

State	Number of Hospitals	Number of Questionnaires
Connecticut	67	1
Maine	56	1
Massachusetts	207	3
New Hampshire	34	1
Rhode Island	25	1
Vermont	25	1
New Jersey	137	2
New York	430	5
Pennsylvania	321	4
Delaware	14	1
District of Columbia	21	1
Florida	196	3
Georgia	166	2
Maryland	84	1
North Carolina	164	2
South Carolina	87	1
Virginia	129	2
West Virginia	88	1

TABLE II

(Continued)

State	Number of Hospitals	Number of Questionnaires
Illinois	312	4
Indiana	135	2
Michigan	246	3
Ohio	244	3
Wisconsin	195	2
Alabama	138	2
Kentucky	131	2
Mississippi	107	1
Tennessee	158	2
Iowa	146	2
Kansas	165	2
Minnesota	205	3
Missouri	144	2
Nebraska	113	1
North Dakota	64	1
South Dakota	66	1
Arkansas	96	1
Louisiana	148	3

TABLE II

(Continued)

State	Number of Hospitals	Number of Questionnaires
Oklahoma	140	2
Texas	556	7
Arizona	80	1
Colorado	94	1
Idaho	53	1
Montana	64	1
Nevada	22	1
New Mexico	56	1
Utah	38	1
Wyoming	31	1
Alaska	26	1
California	644	8
Hawaii	32	1
Oregon	93	1
Washington	130	2

*Information taken from 1971 census data. Total number of hospitals was 7053.

were certified via one of the three routes previously described in chapter one--Armed Forces school, professional training school, or a community college. One hundred questionnaires were sent to hospitals which employ medical laboratory technicians. The hospital administrator of each hospital was asked to have a medical laboratory technician complete the questionnaire. In Appendix C, the names of the hospitals contacted are listed.

After the questionnaires were returned, the items were selected which most of the respondents identified as necessary competencies for a medical laboratory technician. Under each of these items a variety of chemistry topics, subjects, or concepts was listed which might or might not aid in preparing a medical laboratory technician to be able to achieve the particular skill or task identified. The makeup of each chemistry list was determined by interviews, observations in hospital laboratories and a survey of the literature.

The items were then divided into three different lists (Appendix D). Each of the three lists contained a total of ten items. (Certain items were listed in two of the three lists so that all lists would be uniform in size.) Some items represented a composite of several of the items found on the original 50-item questionnaire. For example, all of the items which pertained to the blood were collapsed into one item. Each list was sent to approximately twenty-five persons who were asked to indicate the topics under each item which they thought would aid in the preparation of the particular skill identified in the item. The respondents were selected according to the following criteria:

1. Each respondent must have answered and returned the original 50-item questionnaire;

2. Each respondent must be conscientious and interested in the study. A respondent was considered to possess these two qualities if he:

a. supplied his name and complete mailing address;

b. requested a copy of the results of the investigation; and

c. provided additional remarks, comments, and suggestions concerning items on the original questionnaire.

After a thorough screening process, the results showed that eighty persons qualified for participation in the second part of the investigation. Of the eighty, there were 25 supervisors of medical laboratory technicians, 28 program designers, 19 chemistry teachers and 8 medical laboratory technicians. Therefore, each of the three lists were sent to 8 supervisors, 9 program designers, 6 chemistry teachers, and 3 medical laboratory technicians.

Although this study was basically a descriptive one, a chi-square test was performed on each of the items contained in the original 50-item questionnaire. This statistical procedure is described in detail in the next section.

Statistical Treatment

A chi-square statistical analysis was conducted on the responses for each of the fifty items to determine whether there were significant differences in the importance the four groups of respondents assigned to each item. The same test was conducted on the frequency of each item.

In order to perform this test, a four-by-four (Group versus Response) chi-square contingency table was constructed for each item as shown in Figure I.

		GROUPS			
		1	2	3	4
RESPONSES	1	p_{11}	p_{12}	p_{13}	p_{14}
	2	p_{21}	p_{22}	p_{23}	p_{24}
	3	p_{31}	p_{32}	p_{33}	p_{34}
	4	p_{41}	p_{42}	p_{43}	p_{44}

Figure 1 - Chi-Square Contingency Table for Each of the Fifty Items.

The p_{ij}'s in Figure 1 represent the probability that an individual selected at random from the population under consideration was a member of the cell in the ith row and jth column of the contingency table.

The null hypothesis (H_o) to be tested was

$$H_o: \quad \begin{aligned} p_{11} &= p_{12} = p_{13} = p_{14} \\ p_{21} &= p_{22} = p_{23} = p_{24} \\ p_{31} &= p_{32} = p_{33} = p_{34} \\ p_{41} &= p_{42} = p_{43} = p_{44} \end{aligned} \quad ,$$

versus the alternative hypothesis (H_A) that the above is not the case, at a particular level of significance alpha (.05 for this investigation).

This test was one of homogeneity (as opposed to independence) since a person's group status is not determined by chance.

In order to conduct the test, the chi-square test statistic was computed utilizing the formula

$$\chi^2 = \sum_{i=1}^{4} \sum_{j=1}^{4} \frac{(f_{ij} - e_{ij})^2}{e_{ij}}$$

where f_{ij} is the observed cell frequency and e_{ij} the expected cell frequency. The expected cell frequencies were given by

$$e_{ij} = \frac{(\text{Row } i \text{ total}) \times (\text{Column } j \text{ total})}{n}$$

where n was the total number of observations.

If $\chi^2 \geq \chi^2_{(r-1)(c-1),\alpha}$, then the null hypothesis was rejected. $\chi^2_{(r-1)(c-1),\alpha}$ was the chi-square critical value (or, percentage point) dependent upon the number of degrees of freedom in the table $[(r-1)(c-1)]$ and the level of significance, alpha (α), at which the test of hypothesis was being conducted. These critical values are available in many texts. For example, Owen (1962, p. 51) reports the critical value for a four-by-four contingency table at the .05 significance level as 16.919.

Thus, whenever the computed chi-square value is less than 16.919, the null hypothesis is not rejected and one can conclude that the four groups all come from the same population at the 5 percent level of significance. Another way of stating the same conclusion is that there was no difference in the way the groups thought with regard to the importance or frequency of the particular item being tested.

Whenever H_0 was rejected, a further study was made to determine which group or groups caused the incompatibility on the item. In order to accomplish this, it was necessary to run six more chi-square analyses, comparing the responses of only two groups at a time. The contingency table became a collapsed four-by-two contingency table containing three degrees of freedom. In this latter case, it was not correct to use an alpha level of .05 as was used in the overall test of hypothesis because joint or simultaneous conclusions were being drawn about six different two-group comparisons. If each of these six tests were run at $\alpha = .05$ (assuming the tests are independent), then

$$P_r \text{ [correctly accepting all 6]} = (.95)^6$$

and

$$\begin{aligned} P_r \text{ [correctly rejecting } H_0\text{]} &= 1 - (.95)^6 \\ &= 1 - .74 \\ &= .26 \end{aligned}$$

Thus, the alpha for the overall hypothesis would be .26, which is much too large. To control the overall alpha, it was necessary to run each of the six tests at an $\alpha = .0085$ so that the overall $\alpha = 1 - (.9915)^6 = .05$. The necessary chi-square critical value is not tabulated in textbooks; however, it was obtained by means of numerical integration on a CDC 6700 computer at the Naval Weapons Laboratory. This critical value was 11.6977.

Summary

A 50-item questionnaire was sent to persons located in four groups; chemistry teachers, program designers, practicing medical laboratory technicians, and supervisors of medical laboratory technicians. These persons were asked to indicate their professional judgment about the appropriateness of each item for a medical laboratory technician's curriculum by checking either disagree, tend to disagree, tend to agree, or agree. These same respondents were asked to respond to the frequency of use of the skills specified in each item by checking either uncertain, seldom, occasionally, or frequently. A chi-square statistical analysis was conducted on the responses for each item to determine if the respondents were in agreement as to the necessity and frequency of use by a medical laboratory technician of the skill contained in the various items.

After the questionnaires were returned, the items which were agreed upon by the majority of the respondents were selected. Under each of these items, various chemistry topics were listed. These items were then sent to approximately 25 respondents who were deemed to be very conscientious and interested in the investigation. The respondents were asked to select the chemistry topics which they thought would accomplish the task listed by the item.

The final product of this investigation was the preparation of competency-based chemistry instructional materials.

IV. RESULTS

Phase I Data

In phase I of this investigation, a 50-item questionnaire was sent to persons located in four different occupational groups. The questionnaire consisted of two parts and it concerned chemistry competencies needed by medical laboratory technicians. On part I the respondents were asked to rate the importance of each skill contained in the various items; on part II they indicated how often a medical laboratory technician would perform each of these same skills.

Of the 394 questionnaires mailed, 97 copies were sent to chemistry teachers at two-year colleges which had medical laboratory technician programs in operation as of 1970. Also, 97 questionnaires were sent to designers of medical laboratory programs at these same two-year colleges. One hundred copies were sent to supervisors of medical laboratory technicians working in hospitals or clinical laboratories. One hundred copies were sent to people identified as belonging to the fourth group--practicing medical laboratory technicians.

The percentage of return was approximately 70 percent; 272 questionnaires out of the original 394 were returned. A breakdown of the total percentage according to the four groups is presented in Table III. Twenty-one of the questionnaires could not be used in the treatment of the data from the returns because the respondents failed to indicate the occupational group to which they belonged.

TABLE III

Number and Percentage Return for the "Chemistry Needed for Medical Laboratory Technicians Questionnaire" by Occupational Groups and for the Entire Sample

Group	Total Number Sent	Total Number Returned	Percent Return
MLT'S	100	49	49
Chemistry teachers	97	51	53
Program designers	97	72	74
Supervisors	100	79	79
Other*		21	
Total	394	272	69

*Other represents the total number of questionnaires returned which could not be utilized in the investigation because the respondent did not indicate to which of the four groups he belonged.

Part I

A composite summary of the four groups' responses to part I of the questionnaire is provided in Table IV. The figures indicate how many of the total respondents selected each of the four possible responses: 1 = disagree; 2 = tend to disagree; 3 = tend to agree; and 4 = agree.

For all of the items, the four groups gave a majority of their responses to either a rating of three (tend to agree) or of four (agree).

The number of responses given either a rating of one (disagree) or of two (tend to disagree) were very small as compared to the total number of three's or four's for each item.

TABLE IV

Composite Summary of the Four Groups' Responses to Part I of the "Chemistry Competencies Needed for Medical Laboratory Technicians Questionnaire"

ITEM	1 Disagree	2 Tend to Disagree	3 Tend to Agree	4 Agree	Total
1	4	7	27	211	249
2	26	41	75	105	247
3	3	3	20	224	250
4	1	2	19	229	251
5	1	14	50	182	247
6	2	5	57	185	249
7	15	26	43	165	249
8	18	20	56	157	251
9	2	5	37	206	250

TABLE IV

(Continued)

ITEM	1 Disagree	2 Tend to Disagree	3 Tend to Agree	4 Agree	Total
10	0	2	8	237	247
11	0	1	2	246	249
12	3	2	8	236	249
13	0	2	4	244	250
14	0	2	15	233	250
15	8	5	21	212	246
16	6	3	20	216	245
17	6	2	16	223	247
18	8	8	26	207	249
19	10	12	45	181	248
20	15	15	47	169	246
21	4	6	13	222	245
22	4	3	13	224	244

TABLE IV

(Continued)

ITEM	1 Disagree	2 Tend to Disagree	3 Tend to Agree	4 Agree	Total
23	3	6	15	219	243
24	5	11	21	204	241
25	5	8	22	206	241
26	4	6	14	220	244
27	6	6	16	217	245
28	3	5	10	230	248
29	2	4	13	227	246
30	3	7	19	222	251
31	5	0	15	226	246
32	3	4	19	222	248
33	4	3	11	231	249
34	2	1	8	235	246
35	6	4	15	218	243
36	4	4	32	207	247

TABLE IV

(Continued)

ITEM	1 Disagree	2 Tend to Disagree	3 Tend to Agree	4 Agree	Total
37	4	1	30	210	245
38	4	9	32	199	244
39	5	10	33	198	246
40	2	8	26	207	243
41	5	4	34	199	242
42	7	6	35	197	245
43	3	2	25	218	248
44	3	0	26	216	245
45	3	1	23	219	246
46	5	3	25	213	246
47	4	4	24	211	243
48	3	3	27	210	243
49	2	0	18	224	244
50	3	2	23	220	248

Among the skills which the majority of the respondents agreed were extremely important ones for a medical laboratory technician to be able to perform were those which involved the operation of certain instruments and/or laboratory equipment. In other words, it was considered very important that a medical laboratory technician know how to operate the centrifuge, spectrophotometer, and the microscope. Other instruments which were not considered as important were the microhematocrit centrifuge and reader, the aerobic incubator, and the analytical balance. The abilities for a medical laboratory technician to set up a constant temperature bath and to use various types of pipettes to both deliver and to contain were rated very high by the respondents.

The respondents rated several chemical tests as very necessary ones for a medical laboratory technician to be able to perform. Among the tests receiving the highest rating were pH, specific gravity, urine, acetone and ketone, glucose, hemoglobin, hematocrit, and erythrocyte sedimentation rate. Other tests not rated as important for the medical laboratory technician to be able to perform were sodium, qualitative urine protein, blood urea nitrogen, potassium, chloride, and bilirubin. The tests which received the lowest ratings were those of identification of morphological variations of red and white blood cells, spinal fluid cell counts, venous whole blood coagulation time, prothrombin time, acid and alkaline phosphatase, amylaze, and serum creatinine tests.

In the category of preparing and processing specimens, the respondents agreed that it was imperative that a medical laboratory technician be able to prepare and process specimens and to clean area and equipment aseptically. However, the respondents did not rate preparing specimens for shipment, preparing reagents, and preparing standards as necessary functions for medical laboratory technicians.

The items which received the lowest ratings of all were those of communicating findings to physicians and being able to inventory and order supplies. The respondents indicated that these two skills were not important for a medical laboratory technician to possess.

Part II

In Table V a summary of the four groups' responses to part II of the questionnaire is displayed. The figures in each cell indicate how many of the total respondents selected each of the four possible responses: 1 = uncertain; 2 = seldom; 3 = occasionally; and 4 = frequently.

As in part I, the four groups again gave a majority of their ratings to either three (occasionally) or four (frequently). Very few ratings of one (uncertain) or two (seldom) occurred for the various items.

The respondents agreed that a medical laboratory technician would operate the following instruments frequently: the spectrophotometer, centrifuge, and the microscope. Also, the technician would need to know how to use various types of pipettes, both to deliver and to contain.

Among the most frequent tests run by a medical laboratory technician were those of white blood counts, hematocrit, hemoglobin, examination of urine specimens, specific gravity, pH, glucose, and blood urea nitrogen tests.

The respondents agreed that a technician would frequently have to

TABLE V

Composite Summary of the Four Groups' Responses to Part II of the "Chemistry Competencies Needed for Medical Laboratory Technicians Questionnaire"

ITEM	1 uncertain	2 seldom	3 occasionally	4 frequently	Total
1	1	10	51	177	239
2	5	12	95	78	190
3	2	8	19	217	246
4	0	6	22	217	245
5	1	23	80	132	236
6	0	8	78	153	239
7	3	10	64	138	215
8	4	14	58	147	223
9	1	10	74	159	244
10	1	0	21	223	245
11	0	1	9	236	246
12	0	3	13	230	246

TABLE V

(Continued)

ITEM	1 uncertain	2 seldom	3 occasionally	4 frequently	Total
13	0	0	6	238	244
14	1	3	22	223	249
15	1	7	22	207	237
16	1	4	26	205	236
17	1	4	18	215	238
18	2	4	41	185	232
19	3	9	62	159	233
20	4	11	49	162	226
21	2	8	13	210	233
22	2	5	14	217	238
23	1	8	20	207	236
24	3	13	18	193	228
25	2	8	26	196	232
26	2	7	20	209	238

TABLE V

(Continued)

ITEM	1 uncertain	2 seldom	3 occasionally	4 frequently	Total
27	2	9	19	207	237
28	1	3	15	223	242
29	1	3	27	214	245
30	1	6	31	199	237
31	1	4	21	215	241
32	1	5	25	210	241
33	1	5	17	222	245
34	0	2	15	227	244
35	2	4	21	208	235
36	3	6	35	198	242
37	4	4	32	203	243
38	2	4	52	174	232
39	2	6	45	180	233

TABLE V

(Continued)

ITEM	1 uncertain	2 seldom	3 occasionally	4 frequently	Total
40	2	4	37	189	232
41	2	10	39	186	237
42	3	7	40	186	236
43	1	4	30	205	240
44	2	3	29	208	242
45	2	3	29	208	242
46	2	4	29	203	238
47	2	3	27	203	235
48	2	4	33	198	237
49	1	0	16	224	241
50	2	2	19	220	243

collect, process, and prepare specimens. The respondents indicated that the following skills would not be performed as often by a technician: communicate findings to physicians, operate the analytical balance, prepare reagents and standards, prepare specimens for shipment and inventory and order supplies.

When the results of both parts I and II of phase I were studied simultaneously, many items which had received a high rating for importance of the skill contained in each item also received a high rating for the frequency with which the skill was performed by a medical laboratory technician, and vice versa. (Here, a high rating meant that the respondents selected a majority of response four over the other possible choices on both parts of the questionnaire.)

In summary, the skills contained in the items which obtained the highest rating of response four on both parts I and II should result in these skills receiving considerable attention in phase II of the investigation--the determination of what chemistry topics and/or concepts would best aid in achieving the skill contained in each item. Those items obtaining the lowest ratings for both parts should receive less consideration in the determination of these chemistry topics and/or concepts.

Results of the Chi-Square Statistical Analyses For Parts I and II of Phase I

A chi-square statistical analysis was performed on each of the 50 items to determine if there existed differences of opinions in how the four groups thought concerning the importance of each skill in the items. The chi-square critical value for 9 degrees of freedom at the .05 level of significance is 16.919. The null hypothesis (H_O) was that there was no significant difference in the way the four groups thought concerning the importance of any one particular item. The alternative hypothesis (H_A) was that a significant difference did occur as regards the way one or more groups thought on a particular item.

The following items had calculated chi-square values larger than the above critical value of 16.919: item 2 (33.909), item 3 (28.469), item 6 (20.673), item 7 (23.701), item 8 (20.643), item 9 (31.766), item 21 (21.669), item 22 (22.306), item 26 (24.24), item 29 (20.469) and item 36 (28.245). For these items, H_A was accepted because a significant difference occurred in how one or more of the four groups thought concerning that particular item.

In order to determine where this difference existed, a chi-square test was made on all possible combinations of the four groups taken two at a time. These results are shown in Table VI. The chi-square critical value for three degrees of freedom at the .0085 level of significance is 11.6977.

For item 2 (inventory and order supplies), groups one and three, medical laboratory technicians and program designers differed significantly in how they thought concerning the importance of this item.

TABLE VI

Results of Chi-Square Four-By-Two Contingency Tables

For Part I ($\chi^2_{3,\ .05} = 11.6977$)

ITEM	GROUPS*	CALCULATED CHI-SQUARE VALUE	RESULT
2	1,2	7.926	reject H_o; accept H_A
	1,3	21.097	
	1,4	11.518	
	2,3	9.781	
	2,4	3.924	
	3,4	7.365	
3	1,2	10.465	
	1,3	1.665	
	1,4	3.613	
	2,3	10.025	
	2,4	9.723	
	3,4	.448	
6	1,2	1.037	
	1,3	9.955	
	1,4	5.916	
	2,3	8.074	
	2,4	9.523	
	3,4	3.945	
7	1,2	3.167	reject H_o; accept H_A
	1,3	16.609	
	1,4	7.912	
	2,3	8.787	
	2,4	5.219	
	3,4	10.598	
8	1,2	3.709	reject H_o; accept H_A
	1,3	11.079	
	1,4	15.779	
	2,3	4.307	
	2,4	6.564	
	3,4	1.009	

TABLE VI

(Continued)

ITEM	GROUPS*	CALCULATED CHI-SQUARE VALUE	RESULT
9	1,2	3.193	
	1,3	13.220	reject H_o; accept H_A
	1,4	8.925	
	2,3	18.215	reject H_o; accept H_A
	2,4	12.455	reject H_o; accept H_A
	3,4	3.950	
21	1,2	5.402	
	1,3	4.501	
	1,4	1.708	
	2,3	11.402	
	2,4	9.234	
	3,4	2.316	
22	1,2	7.024	
	1,3	4.530	
	1,4	1.889	
	2,3	9.794	
	2,4	9.635	
	3,4	1.381	
26	1,2	6.231	
	1,3	2.344	
	1,4	.647	
	2,3	15.429	reject H_o; accept H_A
	2,4	10.918	
	3,4	2.976	
29	1,2	2.480	
	1,3	7.564	
	1,4	5.975	
	2,3	13.069	reject H_o; accept H_A
	2,4	10.191	
	3,4	2.035	

TABLE VI

(Continued)

ITEM	GROUPS*	CALCULATED CHI-SQUARE VALUE	RESULT
36	1,2	3.178	
	1,3	17.831	reject H_o; accept H_A
	1,4	2.653	
	2,3	22.891	reject H_o; accept H_A
	2,4	5.333	
	3,4	11.052	

*Group 1 = MLT's; Group 2 = Chemistry teachers; Group 3 = Program designers; Group 4 = Supervisors.

For items 3, 6, 21, and 22 it was impossible to ascertain which group or groups differed from one another. Further discussion will be given on this problem at the end of this section.

Again, groups one and three disagreed concerning their opinions as to the importance of item 7. The other groups essentially agreed in their attitudes toward the skill of being able to prepare standards.

For item 8 (communicating findings to physicians) there was a significant difference in how groups one and four, medical laboratory technicians and supervisors of medical laboratory technicians thought. No such difference occurred in the other five possible combinations of the groups.

Three significant differences occurred for item 9--operating the analytical balance. For groups one and three (MLT's and program designers), groups two and three (chemistry teachers and program designers) and groups two and four (chemistry teachers and supervisors), a significant difference occurred at the .0085 level.

Chemistry teachers and program designers (groups two and three) disagreed in their attitudes concerning both items 26 and 29. These items involved operating the microhematocrit centrifuge and performing acetone and ketone tests, respectively.

Two significant differences occurred for item 36. Here, groups one and three (MLT's and program designers) and groups two and three (chemistry teachers and program designers) disagreed as to the importance of a medical laboratory technician's being able to streak plates for a culture set-up.

An interesting problem occurred for items 3, 6, 21 and 22. When the overall test of hypothesis was performed on all four groups taken concurrently, the calculated chi-square value was greater than the chi-square critical value supplied by a mathematical table. This result implied that a significant difference of opinion occurred between how at least one group thought apart from the others concerning the item in question. However, when a chi-square test was performed on the groups taken two at a time, no significant difference appeared for any of the six various combinations. In other words, it was impossible to ascertain any significant difference between the opinions of any of the four groups.

According to Freund (1969, p. 42), it is possible to find situations in which a chi-square test of the overall hypothesis would result in a significant difference and then be unable to determine which factor or factors was/were causing this difference. Another way of stating this result is that the four groups are mutually dependent in the overall test of the hypothesis; however, when any two groups were looked at concurrently, they became mutually independent. Thus, it was impossible to determine which group or groups were causing the significance found in the overall test of the hypothesis without performing further calculations.

In order to determine where the significant difference lay, a chi-square test was run on all possible combinations of the groups taken three at a time. For each item, it was possible to run four separate tests. For six degrees of freedom and an α level of .0127, the critical value is 15.3490. (This number was determined by numerical integration utilizing the CDC 6700 computer at the Naval Weapons Laboratory.)

The chi-square results for the three-by-four contingency tables is shown in Table VII. For item 3, a significant difference occurred for groups one, two, and three; groups one, two, and four; and groups two, three, and four. No significant difference occurred for groups one, three, and four. In this case, group two (chemistry teachers) appeared to differ significantly from the other groups as to the importance of a MLT having the ability to collect blood specimens from patients.

It was impossible to determine which group or groups was/were responsible for the difference of opinion as regards item 6. Apparently, all combinations of the groups for this item, whether they be four-by-two or four-by-three, result in mutually independent groups.

For item 21 (performing hematocrit tests), the calculated chi-square value for groups 1, 2, and 3 and groups 2, 3 and 4 showed that there was a significant difference between how the groups thought. The same was true for item 22 (performing hemoglobin tests).

A chi-square statistical analysis was performed on each of the 50 items to determine if there existed differences of opinion in how the four groups thought concerning how often a medical laboratory technician

TABLE VII

Results of Chi-square Four-By-Three Contingency Tables

for Part I ($\chi^2_{6,\ .0127} = 15.3490$)

ITEM	GROUPS*	CALCULATED CHI-SQUARE VALUE	RESULT
3	1,2,3	18.9366	reject H_o; accept H_A
	1,2,4	19.7425	reject H_o; accept H_A
	1,3,4	3.023	
	2,3,4	19.4138	reject H_o; accept H_A
6	1,2,3	14.724	
	1,2,4	12.161	
	1,3,4	14.291	
	2,3,4	12.6458	
21	1,2,3	16.866	reject H_o; accept H_A
	1,2,4	12.6463	
	1,3,4	4.8165	
	2,3,4	21.615	reject H_o; accept H_A
22	1,2,3	17.516	reject H_o; accept H_A
	1,2,4	13.995	
	1,3,4	5.505	
	2,3,4	16.980	reject H_o; accept H_A

*Group 1 = MLT's; Group 2 = Chemistry teachers; Group 3 = Program designers; Group 4 = Supervisors.

would perform the skills in the items. Here again, the chi-square critical value for 9 degrees of freedom at the .05 level of significance is 16.919. The following items had calculated chi-square values larger than the critical value: item 2 (27.319), item 4 (18.357), item 5 (36.841), item 7 (18.752), item 8 (19.629), item 9 (24.908), item 14 (35.033), item 15 (23.919), item 16 (23.910), item 17 (29.966), item 18 (27.103), item 20 (17.271), item 21 (34.634), item 22 (27.202), item 23 (29.299), item 24 (18.527), item 26 (25.385), item 27 (25.913), item 31 (19.029), item 32 (21.178), item 35 (20.415), item 36 (23.895), item 37 (19.101), item 43 (22.407), item 44 (22.811), item 45 (22.812), item 46 (28.497), item 47 (28.848), item 48 (21.231) and item 50 (31.718). For these items the null hypothesis (H_O) was rejected and the alternative (H_A) was assumed to be correct. The results of the four-by-two chi-square contingency tables are summarized in Table VIII. For item 2, groups one and two and groups one and three differed significantly in their attitudes concerning how frequently a medical laboratory technician would inventory and order supplies.

Groups two and three disagreed concerning items 4, 27, 36, and 37. No significant differences occurred for any of the other groups as to the frequency of preparing and processing specimens, operating the micro-hematocrit reader, streaking of plates for a culture set-up, and using an aerobic incubator, respectively.

For items 23, 32, 44, 45, and 47, the chemistry teachers and the supervisors of medical laboratory technicians differed significantly in their attitudes as regards the frequency of these items. These items

TABLE VIII

Results of Chi-Square Four-By-Two Contingency Tables

For Part II ($\chi^2_{3, .05} = 11.6977$)

ITEM	GROUPS*	CALCULATED CHI-SQUARE VALUE	RESULT
2	1,2	16.390	reject H_o; accept H_A
	1,3	14.637	reject H_o; accept H_A
	1,4	7.521	
	2,3	6.428	
	2,4	3.822	
	3,4	10.497	
4	1,2	7.344	
	1,3	3.322	
	1,4	1.056	
	2,3	12.643	reject H_o; accept H_A
	2,4	4.778	
	3,4	5.050	
5	1,2	11.107	
	1,3	5.356	
	1,4	6.535	
	2,3	2.313	
	2,4	3.184	
	3,4	.619	
7	1,2	4.415	
	1,3	10.250	
	1,4	6.114	
	2,3	1.730	
	2,4	2.364	
	3,4	5.586	
8	1,2	5.061	
	1,3	12.172	reject H_o; accept H_A
	1,4	13.297	reject H_o; accept H_A
	2,3	2.398	
	2,4	3.759	
	3,4	2.218	

TABLE VIII

(Continued)

ITEM	GROUPS*	CALCULATED CHI-SQUARE VALUE	RESULT
9	1,2	.660	
	1,3	17.800	reject H_o; accept H_A
	1,4	7.421	
	2,3	12.105	reject H_o; accept H_A
	2,4	4.160	
	3.4	4.352	
14	1,2	12.725	reject H_o; accept H_A
	1,3	.002	
	1,4	1.243	
	2,3	16.571	reject H_o; accept H_A
	2,4	17.175	reject H_o; accept H_A
	3,4	1.781	
15	1,2	11.733	reject H_o; accept H_A
	1,3	7.862	
	1,4	13.650	reject H_o; accept H_A
	2,3	3.156	
	2,4	3.271	
	3,4	2.410	
16	1,2	10.521	
	1,3	14.923	reject H_o; accept H_A
	1,4	6.020	
	2,3	7.346	
	2,4	3.612	
	3,4	7.787	
17	1,2	12.180	reject H_o; accept H_A
	1,3	10.671	
	1,4	9.013	
	2,3	1.091	
	2,4	6.651	
	3,4	3.078	

TABLE VIII

(Continued)

ITEM	GROUPS*	CALCULATED CHI-SQUARE VALUE	RESULT
18	1,2	11.261	
	1,3	8.185	
	1,4	7.547	
	2,3	3.487	
	2,4	6.720	
	3,4	.620	
20	1,2	10.221	
	1,3	2.352	
	1,4	2.274	
	2,3	6.260	
	2,4	9.931	
	3,4	3.901	
21	1,2	13.285	reject H_o; accept H_A
	1,3	6.372	
	1,4	2.270	
	2,3	15.312	reject H_o; accept H_A
	2,4	16.081	reject H_o; accept H_A
	3,4	2.092	
22	1,2	11.170	
	1,3	7.765	
	1,4	3.529	
	2,3	6.941	
	2,4	11.100	
	3,4	2.619	
23	1,2	10.801	
	1,3	3.754	
	1,4	2.325	
	2,3	6.859	
	2,4	18.614	reject H_o; accept H_A
	3,4	8.172	

TABLE VIII

(Continued)

ITEM	GROUPS*	CALCULATED CHI-SQUARE VALUE	RESULT
24	1,2	9.923	
	1,3	6.709	
	1,4	6.478	
	2,3	1.571	
	2,4	9.593	
	3,4	5.234	
26	1,2	8.564	
	1,3	1.466	
	1,4	.098	
	2,3	13.902	reject H_o; accept H_A
	2,4	12.813	reject H_o; accept H_A
	3,4	2.129	
27	1,2	10.343	
	1,3	4.345	
	1,4	1.907	
	2,3	14.310	reject H_o; accept H_A
	2,4	10.935	
	3,4	1.724	
31	1,2	4.674	
	1,3	2.271	
	1,4	2.210	
	2,3	6.992	
	2,4	11.262	
	3,4	1.179	
32	1,2	3.337	
	1,3	1.486	
	1,4	3.861	
	2,3	8.242	
	2,4	12.672	reject H_o; accept H_A
	3,4	1.974	

TABLE VIII

(Continued)

ITEM	GROUPS*	CALCULATED CHI-SQUARE VALUE	RESULT
35	1,2	9.352	
	1,3	.059	
	1,4	1.239	
	2,3	10.886	
	2,4	7.835	
	3,4	1.427	
36	1,2	5.962	
	1,3	8.092	
	1,4	4.610	
	2,3	13.628	reject H_o; accept H_A
	2,4	5.698	
	3,4	3.065	
37	1,2	2.986	
	1,3	8.360	
	1,4	3.232	
	2,3	16.113	reject H_o; accept H_A
	2,4	4.039	
	3,4	8.361	
43	1,2	8.862	
	1,3	1.960	
	1,4	1.745	
	2,3	4.745	
	2,4	11.482	
	3,4	6.122	
44	1,2	5.363	
	1,3	1.546	
	1,4	5.641	
	2,3	8.454	
	2,4	16.935	reject H_o; accept H_A
	3,4	5.652	

TABLE VIII

(Continued)

ITEM	GROUPS*	CALCULATED CHI-SQUARE VALUE	RESULT
45	1,2	5.363	
	1,3	1.546	
	1,4	5.641	
	2,3	8.454	
	2,4	16.935	reject H_o; accept H_A
	3,4	5.652	
46	1,2	9.851	
	1,3	3.737	
	1,4	3.220	
	2,3	12.199	reject H_o; accept H_A
	2,4	19.023	reject H_o; accept H_A
	3,4	1.175	
47	1,2	9.847	
	1,3	2.764	
	1,4	1.683	
	2,3	9.354	
	2,4	17.504	reject H_o; accept H_A
	3,4	2.693	
48	1,2	8.212	
	1,3	.710	
	1,4	1.487	
	2,3	8.027	
	2,4	11.136	
	3,4	4.069	
50	1,2	12.132	reject H_o; accept H_A
	1,3	2.356	
	1,4	1.916	
	2,3	11.000	
	2,4	16.802	reject H_o; accept H_A
	3,4	.306	

*Group 1 = MLT's; Group 2 = Chemistry teachers; Group 3 = Program designers; Group 4 = Supervisors.

dealt with performing erythrocyte sedimentation rate, performing qualitative urine protein tests, performing potassium determinations, sodium determinations, and bilirubin tests, in that order.

Groups one and three and groups one and four disagreed in their opinions concerning how often a medical laboratory technician would communicate findings to physicians (item 8).

For item 9 (operation of the analytical balance), the program designers disagreed with both the medical laboratory technicians and the chemistry teachers.

Groups one (MLT's) and three (program designers) were the only two groups to agree in their opinion of how frequently a medical laboratory technician would make use of water baths (item 14). Groups one and two, two and three, and two and four all disagreed.

For item 15 (perform differential cell counts) the medical laboratory technicians disagreed with both the chemistry teachers and the supervisors.

For item 16 (perform red blood count) and item 17 (perform white blood count), the medical laboratory technicians disagreed with the program designers and the chemistry teachers, respectively.

Two group combinations (groups two and three; groups two and four) disagreed significantly in their opinions of items 26 and 46. These two items involved operating the microhematocrit centrifuge and performing bilirubin (direct) tests, respectively.

For item 50 (perform blood urea nitrogen or BUN tests), the chemistry teachers disagreed with the medical laboratory technicians and the supervisors of medical laboratory technicians.

For items 5, 7, 18, 20, 22, 24, 31, 35, 43, and 48, it was not possible to determine which group or groups differed significantly in their opinions regarding these items. Because the various groups for these items became mutually independent whenever they were investigated concurrently, it was necessary to calculate again chi-square values for all possible combinations of the groups taken three at one time. The results of these calculations are given in Table IX. For item 7 (preparation of standards) groups 1, 3 and 4 differed significantly.

For item 18, groups 1, 2, and 3 and groups 1, 2 and 4 exhibited different opinions concerning the frequency of a medical laboratory technician's performing a platelet count. A total of three of the combinations of the groups had significantly different opinions concerning item 22 (performing hemoglobin tests). The combinations were groups one, two, and three; groups one, two, and four; and groups two, three and four.

For items 24 and 31, the calculated chi-square value was greater than the table chi-square for groups one, two, and four. None of the other group combinations showed a significant difference in how often a medical laboratory technician would perform venous whole blood coagulation time tests or perform true glucose tests.

Groups 1, 2, and 3 and groups 2, 3 and 4 disagreed concerning item 35. There was no significant difference of opinion for the other two possible group combinations as to how often a mecial laboratory technician would examine urine specimens microscopically.

TABLE IX

Results of Chi-Square Four-By-Three Contingency Tables for Part II ($\chi^2_{6,\ .0127} = 15.3490$)

ITEM	GROUPS*	CALCULATED CHI-SQUARE VALUE	RESULT
5	1,2,3	12.4617	
	1,2,4	13.587	
	1,3,4	8.1886	
	2,3,4	3.90399	
7	1,2,3	10.9119	
	1,2,4	9.698	
	1,3,4	16.2627	reject H_o; accept H_A
	2,3,4	8.295	
18	1,2,3	18.6758	reject H_o; accept H_A
	1,2,4	21.590	reject H_o; accept H_A
	1,3,4	14.778	
	2,3,4	7.1087	
20	1,2,3	11.8018	
	1,2,4	14.870	
	1,3,4	9.452	
	2,3,4	9.0777	
22	1,2,3	18.0068	reject H_o; accept H_A
	1,2,4	21.8048	reject H_o; accept H_A
	1,3,4	10.2909	
	2,3,4	15.3678	reject H_o; accept H_A
24	1,2,3	10.0331	
	1,2,4	18.436	reject H_o; accept H_A
	1,3,4	12.3437	
	2,3,4	10.4135	

TABLE IX

(Continued)

ITEM	GROUPS*	CALCULATED CHI-SQUARE VALUE	RESULT
31	1,2,3	10.6336	
	1,2,4	15.5686	reject H_o; accept H_A
	1,3,4	4.5359	
	2,3,4	14.9256	
35	1,2,3	16.725	reject H_o; accept H_A
	1,2,4	13.9016	
	1,3,4	2.1066	
	2,3,4	15.7299	reject H_o; accept H_A
43	1,2,3	11.023	
	1,2,4	21.023	reject H_o; accept H_A
	1,3,4	6.710	
	2,3,4	22.032	reject H_o; accept H_A
48	1,2,3	14.470	
	1,2,4	15.688	reject H_o ; accept H_A
	1,3,4	5.401	
	2,3,4	16.3989	reject H_o ; accept H_A

*Group 1 = MLT's; Group 2 = Chemistry teachers; Group 3 = Program designer; Group 4 = Supervisors.

For items 43 (perform chloride tests) and 48 (perform serum creatinine tests), two group combinations varied significantly in their attitudes. These two groups were groups one, two, and four and groups two, three and four.

It was impossible to determine which combinations differed significantly regarding their attitudes towards items 5 and 20. None of the calculated chi-square values were greater than the tabled chi-square value. Apparently, for these two items, the group combinations become mutually independent whenever taken three at one time.

In summary, a significant difference of opinion among the four groups occurred for eleven items on part I; whereas, for part II, a significant difference occurred for thirty items.

Eight of the eleven items for part I (2,7, 8, 9, 21, 22, 26, and 36) in which there was found to be a significant difference of opinions also produced a significant difference of opinion for part II. In all eight of the above cases, the same group or groups that had disagreed significantly on part I also disagreed significantly on part II. For example, for item 2, groups one and three disagreed on both parts of the questionnaire.

For part I, results of the four-by-two and four-by-three contingency tables showed that program designers disagreed significantly 14 times in the various combinations of two and three groups. Next, came the chemistry teachers who disagreed significantly 10 times. Medical laboratory technicians disagreed significantly a total of 9 times from the other groups. The least number of times (4) appeared for the supervisors of medical laboratory technicians. Consequently, group three disagreed more often than the other groups as to the importance of the skills contained in items 2, 3, 6, 7, 8, 9, 21, 22, 26, 29, and 35.

Several program designers who participated in this investigation indicated that they had had experience working in a hospital or clinical laboratory in the capacity of both a practicing medical technologist and as a supervisor of medical laboratory technicians and certified laboratory assistants. Because of this diversified background in the field of medical technology, these program designers should be in a good position to know what is important and what is not important for a medical laboratory technician to be able to perform. In fact, many community colleges have hired such persons to set up medical laboratory technician programs.

Examination of the data collected for each group showed that the program designers had the tendency to select one rating more often than they would split their choices between two or more of the possible ratings. For example, in item 8 (communicate findings to physicians) the program designers almost unanimously selected a rating of four (agree). Members of the other three groups divided their ratings for this item. It appeared that many program designers thought that it was very important for the medical laboratory technician to be able to communicate results to the physician if he were asked to do so. One or two program designers thought that any competent medical laboratory technician should be able to make note of any irregularities in the routine tests which he might perform and be able to provide this type of information to the physician.

The other three groups did not unanimously select a rating of four for this item. Many indicated that they thought the medical laboratory technician should run the test and give the results to his immediate supervisor. The supervisor would then have the responsibility to communicate the findings to the physician or pathologist. Perhaps some of the persons located in the other three groups thought that "communicating the findings to the physician" (item 8) meant that the medical laboratory technician would in some way attempt to explain or interpret his findings. Only a pathologist is qualified to interpret and draw final conclusions from the information supplied.

The results of part I data showed that the hematocrit test was one of the most important necessary for a medical laboratory technician to perform. This test involves the determination of the relative amounts of plasma and corpuscles in the blood. The best way to conduct this test is with the use of some form of centrifugal apparatus, i.e. the microhematocrit centrifuge. Contrary to what would be expected, the results of part I indicated that one of the least important instruments for a medical laboratory technician to know how to operate was the microhematocrit centrifuge. These two pieces of data seem to contradict one another. Results of the chi-square analyses for these two items indicated that differences of opinions occurred among the four groups as to the importance of the items. Significant differences also occurred for how frequently a medical laboratory technician would perform the skills contained in these two items. However, the medical laboratory technicians and supervisors agreed in all the chi-aquare analyses conducted on these two items.

The chemistry teachers tended to disagree more often with various combinations of the other groups. The individual data collected from the medical laboratory technicians and supervisors indicated that both groups thought that it was highly important for a medical laboratory technician to be able to run the hematocrit test and to operate the microhematocrit centrifuge. A lack of knowledge on the part of the chemistry teachers and program designers may have been the reason for the apparent contradiction, i.e. one of the most important tests for a medical laboratory technician to be able to perform was the hematocrit test; but one of the least important instruments for them to be able to operate was the microhematocrit centrifuge.

Results of the part I data showed that the respondents thought that it was extremely important for a medical laboratory technician to be able to operate the centrifuge, spectrophotometer and microscope, set up water baths, and be able to use pipettes. The chi-square analyses conducted on the above showed that there were no significant differences of opinions. In other words, all four groups were in agreement concerning those items.

Among the instruments which were considered least important for a medical laboratory technician to be able to use were the microhematocrit centrifuge, microhematocrit reader, the analytical balance, and the incubator. Analyses of the data showed that the groups were in agreement in their opinions concerning the microhematocrit reader and the incubator; but they disagreed on the other two. The medical laboratory technicians and the supervisors were in agreement on the microhematocrit centrifuge and the analytical balance. Both groups agreed that the microhematocrit centrifuge was a very important instrument for the medical laboratory technician to know how to operate; however, they both agreed that it was not important for the medical laboratory technician to be able to use an analytical balance.

Some of the tests considered very important for a medical laboratory technician to know how to run were those of pH, specific gravity, urine, acetone and ketone, glucose, hemoglobin, hematocrit and erythrocyte sedimentation rate tests. The four groups were in agreement concerning their thoughts about all of the above tests except for the acetone and ketone, hemoglobin and hematocrit ones. Here again, medical laboratory technicians and supervisors were in agreement on these three items.

Various other tests were rated as of less importance for the medical laboratory technician to be able to perform. These tests have already been listed elsewhere. All of the groups were in agreement in their thoughts concerning these tests.

The part I data showed that the groups thought that it was highly important for the medical laboratory technician to be able to prepare and process specimens and to clean area and equipment aseptically. No significant differences of opinions were found for these two items. The ability of a medical laboratory technician to prepare specimens for shipment, to prepare reagents and prepare standards were not rated as highly as the previous two items. The results indicated that there were significant differences of opinions regarding the preparation of reagents and standards; however, it was impossible to determine which groups disagreed.

The part II results of the four-by-two and the four-by-three contingency tables showed that chemistry teachers ranked far ahead of the other three groups. A total of 38 two's occurred in the various combinations of groups which disagreed significantly on 30 different items. The other three groups were very close together with group four disagreeing significantly 23 times, group one 22 times and group three 21 times. The chemistry teachers disagreed more often from the other three groups in respect to the frequency of the skills contained in items 2, 4, 5, 7, 8, 9, 14, 15, 16, 17, 18, 20, 21, 22, 23, 24, 26, 27, 31, 32, 35, 36, 37, 43, 44, 45, 46, 47, 48, and 50.

Results of part II indicated that among the instruments that a medical laboratory technician would use the most often were the spectrophotometer, the centrifuge, the microscope and pipettes. The chi-square statistical tests showed that all of the groups agreed in their opinions concerning the frequency of use of these instruments. Part II results indicated that the medical laboratory technician would not need to operate the analytical balance very frequently. However, results of the chi-square test on this item showed that only the medical laboratory technicians and supervisors were in agreement.

Among the tests which the groups selected as those which would be most frequently performed by the medical laboratory technician were white blood counts, hematocrit, hemoglobin, urine specimens, specific gravity, pH, glucose, and blood urea nitrogen tests. The analyses performed on the responses to these items showed that significant differences of opinion occurred for the white blood count, hematocrit, hemoglobin, urine, glucose and blood urea nitrigen tests. The groups essentially were in agreement on the other tests.

Results of part II data indicated that the groups thought a medical laboratory technician would frequently have to collect blood specimens from patients and process and prepare such specimens. Also, they thought that the medical laboratory technician would less frequently prepare reagents and standards and prepare specimens for shipment. The chi-square statistical analyses on these items showed that no significant differences of opinion occurred for collecting blood specimens from patients and preparing reagents. However, significant differences did occur on the other items above.

Phase II Data

The purpose of phase II of the investigation was to determine the chemistry concepts and/or topics which would aid in the attainment of the skills contained in the various questionnaire items. Originally, only those items for which the majority of the respondents agreed were to be considered for this phase of the study. Since most of the respondents selected a majority of three responses and four responses combined for all of the 50 items, it was decided not to delete any of the items from phase II of the investigation.

For some of the items, it was difficult to list chemistry topics and/or concepts. For instance, item 14 (use water bath) received almost unanimous agreement as being highly important by all four groups; however it was difficult to list chemistry topics which would aid in the achievement of this skill. This same problem was also inherent in item 12 (use of microscope), items 26 and 27 (operate microhematocrit centrifuge and microhematocrit reader), item 36 (streak plates for a culture set-up) and item 37 (use incubator).

Although it was impossible to list chemistry topics for the above six competencies, this fact does not imply that these items should not be given any consideration in the preparation of chemistry instructional materials for medical laboratory technicians. Many of these competencies are closely associated with other items on the questionnaire for which it was possible to make a list of chemistry topics. For example, a medical laboratory technician may need to know how to streak a plate for a culture set-up and to use the microscope in order to perform various blood tests.

Certain items which were somewhat related were combined into one item. For example, items 28 and 35 (examine urine specimens macroscopically and microscopically) were similar as far as the chemistry topics to be listed under each. It seemed more practical to simply combine the two items and place the list of chemistry concepts and/or topics under both.

Items 6 and 7 (prepare reagents and prepare standards) were also combined into one item. Item 31 (perform true glucose tests) and item 49 (perform glucose tests) were combined because the chemistry topics to be listed under each separate item were very similar.

Because items 38, 39, and 40 (perform acid phosphatase test, perform alkaline phosphatase test, and perform amylase test, respectively) were very similar in scope, they were combined into one.

Several items referring to the blood system were combined into one large item. These items were as follows: item 15 (perform differential cell counts); item 16 (perform red blood counts); item 17 (perform white blood count); item 18 (perform platelet count), item 20 (identify morphological variations of red and white blood cells); item 22 (perform hemoglobin tests); item 23 (perform erythrocyte sedimentation rate); item 24 (perform venous whole blood coagulation time tests); and item 25 (perform prothrombin time test).

As was described in chapter three, the items were then divided into three separate categories (Appendix D) or parts, each part consisting of ten items. A list of chemistry concepts and/or topics was placed under each individual item. These lists were constructed from information obtained through various interviews, from personal observations in several laboratories, and from the literature. Each of the three parts were then sent to 26 or 27 respondents selected according to the guidelines as described in chapter three. These persons were asked to mark those chemistry topics under each item which they believed would aid in the achievement of the skill contained in that item. The respondents were encouraged to make any additions to the various lists which they thought were warranted.

A total of 26 copies of group I items (Appendix D) were mailed to selected respondents. Twenty, or 76.92 percent were returned. For group II items (Appendix D), 27 copies were mailed. Twenty four copies were answered for a percentage return of 88.88 percent. Also, twenty seven copies of group III items (Appendix D) were mailed; twenty one were returned (77.77 percent).

In order to present the data for phase II, each item will be given, followed by its list of chemistry topics and/or concepts. A number will be included beside of each entry in the list. This number indicates the percentage of the total respondents who thought this particular entry would be valuable in achieving the skill contained in the item.

1. <u>clean area and equipment aseptically</u>:

   a. chromic acid (90%)
   b. distilled water (85%)
   c. 30% sodium hydorxide solution (65%)
   d. dessicator (65%)
   e. furnace (55%)
   f. incubator (75%)
   *g. autoclave
   organic solvents
   discarding and disposable techniques

2. <u>inventory and order supplies</u>:

   a. chemical formulas (75%)
   b. nomenclature (95%)
   c. knowledge of chemical standards of purity (85%)
   d. chemical equations (45%)
   e. chemical calculations (50%)
   f. metric system (50%)
   *g. record keeping
   knowledge of chemical supply companies
   cost analysis

3. <u>collect blood specimens from patients</u>:

   a. anticoagulants, coagulants (96%)
   b. chelates (71%)
   c. ionization (50%)
   d. protein-free filtrate (54%)
   e. nomenclature of necessary compounds (79%)
   f. chemical formulas of necessary compounds (42%)
   *g. metric system
   preservation methods

*The starred topics represent the additions to the lists made by some of the respondents.

4. <u>prepare and process specimens:</u>

   a. nomenclature of necessary compounds (85%)
   b. chemical formulas of necessary compounds (70%)
   c. chemical properties of necessary compounds (75%)
   d. physical properties of necessary compounds (70%)
   e. chemical calculations (90%)
   f. metric system (100%)
   g. preparation of solutions for tests (80%)
   h. coagulation, anticoagulation (90%)
   i. solubility, insolubility (85%)
   j. temperature effects (85%)
   k. preservatives (100%)
   l. aliquot (95%)
   m. amalgamate (25%)
   n. centrifugal force (80%)
   o. filtrate (90%)
   p. sediment (90%)
   q. supernatant liquid (90%)
   r. centrifugation techniques (95%)
   s. filtration techniques (95%)
   t. pipette techniques (95%)
   u. cleaning equipment aseptically (93%)
   v. incubation techniques (90%)
   *w. proper labeling
   record keeping
   automation techniques
   sources of error

5. <u>prepare specimens for shipment:</u>

   a. dry ice (89%)
   b. fusion (13%)
   c. paraffin (29%)
   d. preservatives (87%)
   e. titer (24%)
   f. vaspar (9%)
   g. polyvinyl alcohol (33%)
   h. formalin (49%)
   i. polystyrene (31%)
   j. pressure effects (27%)
   k. chemical properties of materials to be shipped (78%)
   l. temperature effects on materials to be shipped (93%)
   *m. proper labeling
   stability of test compounds in body fluids

6. prepare reagents and standards:

a. properties of solutions (88%)
b. saturated solution (88%)
c. percent solution (96%)
d. molar solution (96%)
e. molal solution (79%)
f. normal solution (92%)
g. equivalent weight (96%)
h. milli-equivalent weight (88%)
i. molecular weight (92%)
j. chemical calculations (92%)
k. chemical formulas (88%)
l. nomenclature (79%)
m. metric system (96%)
n. chemical equations (71%)
o. electrolysis (50%)
p. oxidation numbers (54%)
q. alkalies (71%)
r. distilled water (92%)
s. deionized water (83%)
t. buffers (83%)
u. pH (88%)
v. chemical equilibrium (58%)
w. standardization techniques (83%)
x. operation of analytical balance (92%)
y. titration (92%)
z. indicators (88%)
aa. endpoint determination (79%)
bb. monobasic, dibasic, polybasic acids (71%)
cc. primary and secondary standards
dd. stoichiometry (54%)
ee. temperature effects (67%)
*ff. quantative transfer
pipetting techniques
chemical storage
safety
contamination
cork boring, etc.

7. communicate findings to physicians:

a. nomenclature (95%)
b. chemical formulas (46%)
c. chemical calculations (71%)
d. metric system (83%)
*e. accepted normal results for the performed test
communication techniques

8. <u>operate analytical balance</u>:

    a. metric system (96%)
    b. gravimetric analysis techniques (63%)
    c. volumetric analysis techniques (58%)
    d. air buoyancy effects (38%)
    e. temperature effects (67%)
    f. oxidation effects (46%)
    g. humidity effects (63%)
    h. static charge effects (29%)
    *i. correct technique of operation
    quantitative transfer

9. <u>operate spectrophotometer</u>:

    a. electromagnetism (33%)
    b. absorption (92%)
    c. infrared spectrum (66%)
    d. ultraviolet spectrum (75%)
    e. visible spectrum (88%)
    f. turbidimetry (67%)
    g. nephelometry (29%)
    h. X-rays (17%)
    i. wavelength (88%)
    j. fluorimetry (46%)
    k. chemical calculations (83%)
    l. metric system (88%)
    m. photoelectric cells (83%)
    n. atomic structures of molecules (46%)
    *o. absorption curve
    Beer's law
    energy
    monochronometer
    calibration techniques

10. <u>use centrifuge</u>:

    a. dehydration (41%)
    b. filtrate (85%)
    c. supernatant liquid (100%)
    d. centrifugal force (85%)
    e. metric system (66%)
    f. chemical calculations (58%)
    g. solids (76%)
    h. liquids (76%)
    i. sedimentation (85%)
    j. amalgamate (12%)
    *k. safety
    precipitate

11. use pipette (automatic, manual, macro, micro, to deliver and to contain):

- a. temperature effects (62%)
- b. calibration techniques (95%)
- c. proper cleansing techniques (83%)
- *d. proper selection of specific pipette for use in various situations
  - surface tension
  - calibration techniques

12. perform blood tests (red blood count, white blood count, platelet count, differential cell count, identification of morphological variations of red and white blood cell, hematocrit tests, erythrocyte sedimentation rate, venous whole blood coagulation time tests, prothrombin time tests):

- a. nomenclature of necessary compounds (90%)
- b. chemical formulas of necessary compounds (50%)
- c. chemical properties of necessary compounds (55%)
- d. physical properties of necessary compounds (65%)
- e. preparation of solutions for tests (95%)
- f. chemical calculations (70%)
- g. metric system (90%)
- h. pH (80%)
- i. coagulation, anticoagulation (95%)
- j. specific gravity (75%)
- k. oxidation-reduction (30%)
- l. molecular structures (30%)
- m. metallic ions (35%)
- n. capillary action (85%)
- o. protein-free filtrate (55%)
- p. preservatives (95%)
- q. temperature effects on blood specimens (90%)
- r. electroneutrality (30%)
- s. partial pressure (30%)
- t. buffers (75%)
- u. electrolytes (70%)
- v. microscope techniques (90%)
- w. spectrophotometry techniques (95%)
- x. centrifugation techniques (95%)
- y. filtration (60%)
- z. aliquot (65%)
- aa. pipetting techniques (95%)
- bb. gas chromatography techniques (40%)
- cc. dilution (95%)
- *dd. operation of appropriate machinery
  - quality control

13. perform spinal fluid cell counts:

a. specific gravity (62%)
b. pH (48%)
c. buffers (38%)
d. pressure effects (38%)
e. coagulation (62%)
f. turbidity (95%)
g. supernatant liquid (71%)
h. sediment (86%)
i. chemical calculations (57%)
j. metric system (62%)
k. electrophoresis (38%)
l. nomenclature of necessary compounds (62%)
m. chemical formulas for necessary compounds (38%)
n. preparation of solutions for tests (86%)
o. microscope techniques (95%)
p. culture set-ups (75%)
q. centrifugation techniques (67%)
r. incubation techniques (52%)
s. pipetting techniques (100%)
*t. contaminated sample handling techniques

14. perform acetone or ketone tests:

a. nomenclature of necessary compounds (95%)
b. chemical formulas of necessary compounds (55%)
c. physical properties of necessary compounds (55%)
d. chemical properties of necessary compounds (55%)
e. preparation of solutions for tests (90%)
f. chemical calculations (85%)
g. metric system (80%)
h. oxidation-reduction (50%)
i. catabolism (40%)
j. buffers (55%)
k. structures of ketones (65%)
l. acidic solution (40%)
m. alkaline solution (40%)
n. water bath set-up (65%)
*o. quality control

15. perform specific gravity tests:

a. specific gravity (88%)
b. osmolality (50%)
c. freezing point depression (50%)
d. dilution (79%)
e. concentration (88%)
f. refractometry techniques (83%)
g. urinometer techniques (88%)

h. preparation of solutions for tests (86%)
*i. calibration of instruments
temperature effects

16. <u>examine urine specimens macroscopically and microscopically</u>:

a. nomenclature of necessary compounds (90%)
b. chemical formulas of necessary compounds (43%)
c. chemical properties of necessary compounds (62%)
d. physical properties of necessary compounds (57%)
e. preparation of solutions for tests (86%)
f. chemical calculations (52%)
g. metric system (62%)
h. specific gravity (86%)
i. dialysis (43%)
j. colloids (43%)
k. diffusion (33%)
l. precipitate (76%)
m. solids (67%)
n. liquids (52%)
o. urinalysis (62%)
p. pH (90%)
q. oxidation-reduction (52%)
r. ketones (90%)
s. electrophoresis (43%)
t. indicators (76%)
u. electrolytes (52%)
v. chemical equilibrium (43%)
w. hydrolysis (29%)
x. buffers (38%)
y. chromatography techniques (43%)
z. pipetting techniques (67%)
aa. titration techniques (38%)
bb. water bath set-up (38%)
cc. filtration (43%)
dd. centrifugation techniques (81%)
ee. microscope techniques (90%)
ff. spectrophotometry techniques (38%)

17. <u>perform bile, SGOT, LDH, and bilirubin tests</u>:

a. nomenclature of necessary compounds (90%)
b. chemical formulas of necessary compounds (65%)
c. physical properties of necessary compounds (65%)
d. chemical properties of necessary compounds (75%)
e. preparation of solutions for tests (90%)
f. chemical calculations (95%)
g. metric system (85%)
h. amino acids (45%)
i. transamination (70%)

j. deamination (60%)
k. heterocyclic hydrocarbon compounds (50%)
l. surface tension (40%)
m. emulsification of fats (40%)
n. quantitative analysis techniques (90%)
o. qualitative analysis techniques (95%)
p. oxidation-reduction (35%)
q. colorimetry techniques (95%)
r. pipetting techniques (100%)
*s. operation of instruments
quality control
electrophoresis
automation methods

18. <u>perform glucose tests:</u>

a. nomenclature of necessary compounds (88%)
b. chemical formulas of necessary compounds (58%)
c. molecular weights of necessary compounds (50%)
d. chemical properties of necessary compounds (71%)
e. physical properties of necessary compounds (50%)
f. preparation of solutions for tests (83%)
g. oxidation-reduction (79%)
h. alkaline solution (63%)
i. protein-free filtrate (79%)
j. colorimetry techniques (88%)
k. catalysis, catalysts (63%)
l. metallic ions (54%)
m. oxidation numbers (38%)
n. chemical calculations (79%)
o. metric system (83%)
*p. preservation techniques
interfering substances
chemical reactions

19. <u>perform qualitative urine protein tests:</u>

a. pH (95%)
b. buffers (81%)
c. alkaline solution (67%)
d. nomenclature of necessary compounds (90%)
e. chemical formulas of necessary compounds (33%)
f. preparation of solutions for tests (90%)
g. metric system (81%)
h. chemical calculations (81%)
i. chemical reactions (62%)
j. spectrophotometry techniques (90%)
k. colorimetry techniques (52%)
*l. precipitate
protein error of indicators

20. perform pH tests:

a. nomenclature of necessary compounds (80%)
b. chemical formulas of necessary compounds (55%)
c. physical properties of necessary compounds (55%)
d. chemical properties of necessary compounds (55%)
e. preparation of solutions for tests (95%)
f. metric system (85%)
g. chemical calculations (80%)
h. acid-base balance (90%)
i. acidosis (85%)
j. alkalosis (85%)
k. buffers (95%)
l. colloids (60%)
m. temperature effects (85%)
n. pressure (40%)
o. electrolysis (55%)
p. conductance (50%)
q. colorimetry techniques (55%)
r. potentiometry techniques (70%)
*s. operation of pH meter
quality control
anticoagulant

21. perform acid phosphatase test, alkaline phosphatase test, and amylase test:

a. nomenclature of necessary compounds (95%)
b. chemical formulas for necessary compounds (62%)
c. preparation of solutions for tests (100%)
d. chemical properties of necessary compounds (71%)
e. physical properties of necessary compounds (52%)
f. chemical calculations (90%)
g. metric system (90%)
h. catalysts (76%)
i. reaction order (81%)
j. concentration of enzymes, substrates (86%)
k. pH (95%)
l. temperature effects (100%)
m. light ray effects (67%)
n. reaction rate (86%)
o. hydrolysis (86%)
p. electrolysis (38%)
q. buffers (100%)
r. colloidal dispersion (14%)
s. colorimetry techniques (86%)
t. filtration (57%)

u. incubation techniques (86%)
v. spectrophotometry techniques (95%)

22. perform serum creatinine tests:

a. nomenclature of necessary compounds (85%)
b. chemical formulas of necessary compounds (60%)
c. chemical properties of necessary compounds
d. physical properties of necessary compounds (50%)
e. chemical calculations (90%)
f. metric system (80%)
g. preparation of solutions for tests (95%)
h. alkaline solution (75%)
i. filtrate (90%)
j. acids (60%)
k. bases (60%)
l. spectrophotometry techniques (95%)
m. colorimetry techniques (90%)
n. chemical equilibrium (35%)
o. pipetting techniques (85%)
p. centrifugation techniques (85%)
q. water bath set-up (80%)
*r. operation of instruments
quality control

23. perform hemoglobin tests:

a. nomenclature of necessary compounds (83%)
b. chemical formulas of necessary compounds (46%)
c. chemical properties of necessary compounds (79%)
d. physical properties of necessary compounds (67%)
e. chemical calculations (67%)
f. metric system (75%)
g. preparation of solutions for tests (88%)
h. spectrophotometry tecnniques (79%)
i. electrolytes (38%)
j. pH (33%)
k. chemical dyes (25%)
l. pressure (17%)
m. electrophoresis (54%)
n. polypeptides (33%)
o. amino acids (42%)
*p. chemical reactions

24. perform potassium determinations:

a. nomenclature of necessary compounds (83%)
b. chemical formulas of necessary compounds (46%)
c. chemical properties of necessary compounds (63%)
d. physical properties of necessary compounds (54%)
e. preparation of solutions for tests (88%)

f. chemical calculations (75%)
g. metric system (71%)
h. centrifugation techniques (63%)
i. flame photometry techniques (96%)
j. operation of fuel tanks (75%)
k. pressure (63%)
l. electrolysis (38%)
m. ionization (63%)
*n. specific ion electrodes
• safety
interferences

25. <u>perform sodium determinations</u>:

a. nomenclature of necessary compounds (100%)
b. chemical formulas of necessary compounds (62%)
c. chemical properties of necessary compounds (71%)
d. physical properties of necessary compounds (67%)
e. preparation of solutions for tests (95%)
f. chemical calculations (95%)
g. metric system (100%)
h. electrolytes (100%)
i. atomic structure and theory (67%)
j. flame photometry techniques (100%)
k. use of oxygen-fuel tank (90%)
l. pressure (57%)
m. salts (76%)
n. ionization (86%)
o. electrolysis (38%)

26. <u>perform chloride tests</u>:

a. nomenclature of necessary compounds
b. chemical formulas of necessary compounds (67%)
c. chemical properties of necessary compounds (81%)
d. physical properties of necessary compounds (62%)
e. chemical calculations (100%)
f. metric system (71%)
g. salts (86%)
h. electrolysis, electrolytes (95%)
i. ionization (86%)
j. preparation of solutions for tests (95%)
k. protein-free filtrate (48%)
l. electroneutrality (57%)
m. titration techniques (95%)
n. endpoint determination (90%)
o. indicators (81%)
p. potentiometry techniques (71%)
q. microburette techniques (81%)
r. colorimetry techniques (52%)
s. filtration (33%)

27. <u>perform blood urea nitrogen (BUN) tests</u>:

a. nomenclature of necessary compounds (100%)
b. chemical formulas of necessary compounds (57%)
c. molecular weights (57%)
d. metric system (90%)
e. chemical properties of necessary compounds (57%)
f. physical properties of necessary compounds (52%)
g. protein-free filtrate (100%)
h. buffer solution (90%)
i. pH (86%)
j. colloids (24%)
k. alkaline solution (62%)
l. colorimetry (100%)
m. deamination of amino acids (48%)
n. double salts (29%)
o. Krebs ornithine cycle (5%)
p. titration (71%)
q. standard acid solution (76%)
r. chemical calculations (100%)
s. mixtures (52%)
t. solutions (86%)
u. catalysts (52%)
v. substrates (62%)
w. chromatography (19%)
x. preparation of solutions for tests (100%)
*y. enzyme action
Beer's law
standard curve
Berthelot reaction
autoanalyzer techniques

The chemistry topics given above which received the highest percentages should be given top priority in the preparation of chemistry instructional materials for medical laboratory technicians. Those topics getting a moderately high percentage should be included after the top priority topics have been adequately covered. Finally, the topics receiving the lowest percentages should be included only if time permits; but not at the expense of the higher percentage topics.

For this investigation, top priority topics were considered to be those which received percentages of 80 percent or over. Chemistry topics receiving percentages between 50-79 percent would be next in line for inclusion. Chemistry topics falling below 50 percent would receive the least consideration.

In conclusion, chemistry instructional materials constructed from topics designed to aid in the achievement of competencies of medical laboratory technicians should be much more relevant and pertinent to the student. The preparation of such competency-based chemistry instructional materials was the major product of this investigation (Appendix E)

V. DISCUSSION AND CONCLUSIONS

General Conclusions

The major conclusion of the investigation was that using a questionnaire to survey the opinions of selected groups as to what competencies were needed by medical laboratory technicians and what chemistry concepts and/or topics were needed to achieve these competencies was successful.

The percent return of the questionnaire for both phases of the study was excellent in comparison to other studies of this type. A percentage return of approximately 70 percent was achieved for phase I; while over 81 percent return was realized for phase II. According to Shannon (1948), a 65 percent return is considered "reputable" for questionnaire studies for theses, dissertations and professional articles. Clearly, the percentage returns for both phases of this investigation were in excess of this normally acceptable value of 65 percent.

The supervisors of medical laboratory technicians working in clinical or hospital laboratories were found to be the most cooperative of all the groups surveyed. Following close behind the supervisors, were the designers of medical laboratory technician programs at community colleges. This result was not unexpected since most program designers were at one time supervisors of medical laboratory technicians.

Not only were the respondents from these two groups prompt in answering and returning the questionnaires; but also, they provided many useful and valuable suggestions and comments concerning the study. The interest which they exhibited in the investigation was commendable. Perhaps one reason for their answering the questionnaire could be attributed to the fact that much investigation is constantly occurring in the medical fields. They are called upon frequently to participate in many types of investigations; thus, they probably are much more aware of the importance of providing any information which they can to the study.

The chemistry teachers, as a group, provided the least cooperation for any of the groups surveyed. While this statement was not true in all cases, it was enough so to warrant mentioning. Many chemistry teachers indicated they had no idea what competencies or skills were needed by medical laboratory technicians or how often these skills would be performed. Consequently, they were somewhat reluctant to participate in the investigation.

Among chemistry teachers, there seems to exist two viewpoints concerning chemistry curricula--the competency-based viewpoint and the non-competency-based one. Those who advocate a non-competency-based curriculum would hold that the teacher should decide what content is to be taught in the course. A course built around this concept is usually one which is more general in nature and less concerned with practical applications as opposed to the competency-based curriculum. This non-competency-based curriculum seemed to be the attitude of many of the chemistry teachers who participated in this investigation.

A low percentage of return also occurred for the medical laboratory technicians surveyed. However, this was not due to their lack of interest.

The problem here, and this problem was the major limitation of the study, was that the investigator had much difficulty in reaching medical laboratory technicians who fit the necessary requirements for the study--graduation from a two-year college medical laboratory technician program and having worked a minimum of two years on the job. The problem would have been only a minor one had the American Medical Technologist Association (AMT) provided its registry of medical laboratory technicians who met the above requirements. A formal request was made to the AMT for this invaluable registry. Full explanation was given relative to the purpose for which it was needed and how it would be used in the study. The AMT promised to take the request to their board and to give it careful consideration (letter, Dziekonski, Executive Secretary of AMT, August 4, 1973). However, no information was received from this organization.

Many of the medical laboratory technicians commented that they were ecstatic that an attempt was being made to determine what chemistry content should be taught to medical laboratory technicians. A few stated that they had almost changed their minds about becoming a MLT because of the irrelevancy of many of their courses, including chemistry.

Restatement of the Problem

Basically, there were two purposes for this investigation. The first purpose was that of determining the competencies needed by medical laboratory technicians in the performance of their jobs. The second purpose was to determine the chemistry content which would aid in the achievement of the competencies determined in purpose one. The information gained from these two purposes was used to construct competency-based chemistry instructional materials which would be more relevant to the needs of a potential MLT (Appendix E). Hopefully, through this approach, only pertinent chemistry content and information would be included in a chemistry course for future medical laboratory technicians. Because the opinions of the four sampled groups--practicing medical laboratory technicians, chemistry teachers, program designers, and supervisors--were reflected in the final product, chemistry teachers for medical laboratory technician students should be more confident that the chemistry course with content structured from the information provided in Appendix E would better meet the chemistry needs of future medical laboratory technicians. Also, they should be much more enthusiastic about sanctioning and utilizing it in two-year college medical laboratory technician programs.

Major Findings

The major findings of this investigation included the following:

(1) the use of the survey technique to determine the necessary competencies for the career of medical laboratory technician and the needed chemistry material to achieve these competencies was successful;

(2) many of the professional persons in the medical technology field were relatively unaware of the new category in medical technology known as medical laboratory technician;

(3) persons (supervisors of medical laboratory technicians and program designers) with medical backgrounds were more prompt in answering the questionnaire and the percentage return was greater for these same

persons;

(4) the chi-square statistical analyses indicated that the chemistry teachers disagreed more often as to the frequency of application of the skills on the questionnaire than did any of the other groups;

(5) the chi-square statistical data showed that the supervisors and medical laboratory technicians agreed most often as to the importance and frequency of each skill on the questionnaire;

(6) for several items, the overall test of the hypothesis showed that the four groups were mutually dependent; however, multiple chi-square tests failed to reveal which groups were causing the difference of opinion;

(7) the chemistry teachers, as a whole, had somewhat negative attitudes concerning the investigation and its intended use; and

(8) medical laboratory technicians were happy that the study was being conducted.

Implications

The Americam Medical Technologist Association and/or the American Society of Clinical Pathologists need to provide some means by which all persons currently involved in the field of medical technology could be made aware of new changes occurring in the field. Far too many people mistakenly assumed that this investigation was for the career of medical technologist (minimum of four years of college education) instead of medical laboratory technician (minimum of two years of college education).

Another important implication was that the chemistry teacher will need much help from supervisors of medical laboratory technicians and designers of programs for medical laboratory technicians in order to keep abreast of newer methods and techniques with which a medical laboratory technician would need to have some knowledge. It would be virtually impossible for the chemistry teacher to keep up with all the constantly occurring changes in not only the medical laboratory technician career but in all the allied-health field careers as well. Much cooperation will be needed by all of these groups in order to provide the best possible education for a potential medical laboratory technician.

Perhaps the most important implication is that unless many of the chemistry teachers' attitudes are changed concerning a competency-based chemistry course, the plight of many medical laboratory technicians and other allied-health career aspirants will not be improved. As was pointed out in chapter two, many potential allied-health students will change majors or drop out of school altogether because of the irrelevancy of some of the required courses. The chemistry teachers must be convinced to at least use the competency-based chemistry course on a trial basis. This particular investigation will be of no meaning unless chemistry teachers use a competency-based course on an experimental, trial basis.

Recommendations for Future Studies

The major recommendation for the future is for the units of a competency-based chemistry course to be written from the information provided in Appendix E. Once these units have been written, the next logical step would be to implement the course in the two-year college chemistry curriculum. A long-range study would then need to be made to determine whether or not medical laboratory technicians were better prepared to meet the expected duties of their careers through the competency-based approach.

Finally, if the competency-based chemistry course does indeed prove to be the superior approach, then it is recommended that a similar investigation such as this one be done for all of the other allied-health careers listed in Appendix A.

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APPENDICES

APPENDIX A

THE AAJC DIRECTORY OF THE FOURTEEN MAJOR CATEGORIES OF ALLIED-HEALTH PROGRAMS AND FIFTY-TWO CAREERS

I. Administrative Services---persons are trained in the supportive, managerial and administrative service areas in institutions where health care is rendered.

a. Health administrative assistant such as ward clerks, hospital unit managers, etc.

b. Nursing home administrator.

II. Biomedical Engineering and Instrumentation Services--persons service, maintain, operate and/or repair medical equipment and instruments that are designed to supplement or support body functions; and, which are used in diagnostic and/or therapeutic procedures.

a. Biomedical engineering technician.

b. Electroencephalography technician.

c. Electroencephalography-electrocardiology technician.

III. Dental Services--persons do routine, backup work for dentists so that they may devote full time to the more intricate, delicate dental operations and procedures.

a. Dental assistant.

b. Dental equipment repairman.

c. Dental hygienist.

d. Dental laboratory technician.

IV. Environmental Control Services--persons participate in activities which range from pollution control and surveillance of food, water, and air resources to monitoring environments and activities in which ionizing radiation is in use.

a. Environmental science aide such as solid waste management.

b. Environmental science technician such as air and water control technician.

c. Radiological health technician.

V. Emergency Services--persons are equipped to administer medical emergency care such as how to transport the sick and injured and how to assist professionals in emergency and intensive care units of hospitals.

a. Medical emergency aide such as an ambulance attendant.

b. Medical emergency technicians.

VI. Laboratory Services--persons participate in a variety of specialties which require knowledge and skill in clinical laboratory procedures.

a. Cytotechnologist.

b. Histology/cytology technician.

c. Medical laboratory assistant.

d. Medical laboratory technician.

VII. Medical Records and Office Services--persons provide secretarial services under the direct jurisdiction of physicians and dentists. Their activities include those of analyzing, coding, filing, and transcribing medical records in health institutions.

a. Medical office assistant.

b. Medical records technician.

c. Medical secretary.

VIII. Mental Health and Psychiatric Services--persons may assist professional personnel in the care of patients with mental or psychiatric disorders.

a. Mental health assistant.

b. Mental retardation specialist.

c. Psychiatric aide.

IX. Medical Care Assistants--persons are prepared to provide assistance to clinical specialists such as orthopedists, pediatricians, surgeons, etc.

a. Cardiovascular technician.

b. Dialysis technician.

c. Inhalation therapist.

d. Intravenous technician.

e. Orthopedic assistant.

f. Physician's assistant.

g. Podiatric assistant.

X. Miscellaneous Services--persons are prepared to function as assistants in a variety of supportive services such as dietary, institutional pharmacy, geriatric, biomedical photography and veterinary services.

a. Dietary technician.

b. Geriatric assistant.

c. Medical photographer.

d. Pharmacy technician.

e. Veterinary technician.

XI. Nursing Services--persons participate in professional nursing and supportive services.

a. Home health aide.

b. Licensed practical nurse.

c. Nursing aide.

d. Registered nurse.

e. Surgical technician.

XII. Optical and Visual Care Services--persons assist opthalmologists and/or optometrists; also, they may assist with corrective eye exercises, fill prescriptions for corrective lenses, etc.

a. Optician.

b. Vision care technician.

XIII. Radiological Services--persons are trained to expose, develop, and critique diagnostic X-ray films and also to assist in therapeutic procedures requiring radio-isotopes or radiation.

a. Nuclear medicine technician.

b. Radiation therapy technician.

c. Radiologic technician.

XIV. Rehabilitation Services--persons assist professionals in the administration of therapeutic and rehabilitative procedures designed to restore patients to optimum activity levels.

a. Occupational therapy assistant.

b. Physical/occupational therapy assistant.

c. Physical therapy assistant.

d. Prosthetic/orthotic technician.

e. Recreational therapy technician.

f. Speech and hearing technician.

APPENDIX B

REPRESENTATIVE EXAMPLE OF A COVER LETTER AND
THE FIFTY-ITEM QUESTIONNAIRE

Dear Chemistry Professor:

I am a graduate student at Virginia Polytechnic Institute and State University located in Blacksburg, Virginia. My research involves determining as closely as possible the degree of competency needed in chemistry for medical laboratory technicians.

Since you are a community college chemistry professor, your responses to the items in the enclosed questionnaire will be invaluable in helping to determine the content of a chemistry course which will be more relevant to the needs of the medical laboratory technician.

Would you be so kind as to complete the enclosed questionnaire and return it to me within 10 days? A pre-addressed and stamped envelope is included for your convenience.

For responding to the questionnaire, I will be happy to send you a copy of the results of the study.

Thank you for your expert assistance in this study.

Sincerely,

Carole Spencer

Carole Spencer
101 Nottingham Court
Oak Manor
Blacksburg, Virginia 24060

QUESTIONNAIRE

CHEMISTRY COMPETENCIES NEEDED FOR MEDICAL LABORATORY TECHNICIANS*

Part I

1. Name________________________________(Optional)

2. In what state do you reside?____________________

3. Please indicate the category under which you could best be classified as a responder to this questionnaire:

   a. Medical laboratory technician

   b. Chemistry teacher in a two-year college

   c. Designer of programs or curriculums for medical laboratory technicians in a two-year college

   d. Supervisor of medical laboratory technicians working in a hospital or clinical laboratory

---

If your answer to question number three is option a, please answer question numbers four and five; otherwise, omit questions four and five and proceed directly to Part II.

---

4. How many years have you worked as a medical laboratory technician?

   a. Less than one year

   b. 1-2 years

   c. More than 2 years

5. Where did you receive your training to become a medical laboratory technician?

   a. Two-year college

   b. Four-year college

   c. Armed-forces school (50 weeks)

   d. Private and vocational school (one year program)

   e. Other

Proceed directly to Part II.

Part II

DIRECTIONS:

Step 1. The following items pertain to activities which a medical laboratory technician might perform. For each item, please indicate your reaction by circling one of the following numbers in the left-hand column.

1 = disagree

2 = tend to disagree

3 = tend to agree

4 = agree

Step 2. For the items which you circled either option 3 or 4 (tend to agree or agree) in Step 1, please indicate your reaction to the frequency of the activity by circling one of the following numbers in the right-hand column.

1 = uncertain

2 = seldom

3 = occasionally

4 = frequently

THE MEDICAL LABORATORY TECHNICIAN SHOULD BE ABLE TO:

	STEP 1	STEP 2
1. clean area and equipment aseptically.	1 2 3 4	1 2 3 4
2. inventory and order supplies.	1 2 3 4	1 2 3 4
3. collect blood specimens from patients.	1 2 3 4	1 2 3 4
4. prepare and process specimens.	1 2 3 4	1 2 3 4
5. prepare specimens for shipment.	1 2 3 4	1 2 3 4
6. prepare reagents.	1 2 3 4	1 2 3 4

7.	prepare standards.	1 2 3 4	1 2 3 4
8.	communicate findings to physicians.	1 2 3 4	1 2 3 4
9.	operate analytical balance.	1 2 3 4	1 2 3 4
10.	operate spectrophotometer.	1 2 3 4	1 2 3 4
11.	use centrifuge.	1 2 3 4	1 2 3 4
12.	use microscope.	1 2 3 4	1 2 3 4
13.	use pipette (automatic, manual, macro, micro, to deliver and to contain.)	1 2 3 4	1 2 3 4
14.	use water baths.	1 2 3 4	1 2 3 4
15.	perform differential cell counts.	1 2 3 4	1 2 3 4
16.	perform red blood count.	1 2 3 4	1 2 3 4
17.	perform white blood count.	1 2 3 4	1 2 3 4
18.	perform platelet count.	1 2 3 4	1 2 3 4
19.	perform spinal fluid cell counts.	1 2 3 4	1 2 3 4
20.	identify morphological variations of red and white blood cells.	1 2 3 4	1 2 3 4
21.	perform hematocrit tests.	1 2 3 4	1 2 3 4
22.	perform hemoglobin tests.	1 2 3 4	1 2 3 4
23.	perform erythrocyte sedimentation rate.	1 2 3 4	1 2 3 4
24.	perform venous whole blood coagulation time tests.	1 2 3 4	1 2 3 4
25.	perform prothrombin time test.	1 2 3 4	1 2 3 4
26.	operate microhematocrit centrifuge.	1 2 3 4	1 2 3 4
27.	operate microhematocrit reader.	1 2 3 4	1 2 3 4
28.	examine urine specimens macroscopically.	1 2 3 4	1 2 3 4
29.	perform acetone or ketone tests.	1 2 3 4	1 2 3 4
30.	perform bile tests.	1 2 3 4	1 2 3 4

31.	perform true glucose tests.	1 2 3 4	1 2 3 4
32.	perform qualitative urine protein tests.	1 2 3 4	1 2 3 4
33.	perform specific gravity tests.	1 2 3 4	1 2 3 4
34.	perform pH tests.	1 2 3 4	1 2 3 4
35.	examine urine specimens microscopically.	1 2 3 4	1 2 3 4
36.	streak plates for a culture set-up.	1 2 3 4	1 2 3 4
37.	use incubator, aerobic.	1 2 3 4	1 2 3 4
38.	perform acid phosphatase test.	1 2 3 4	1 2 3 4
39.	perform alkaline phosphatase test.	1 2 3 4	1 2 3 4
40.	perform amylase test.	1 2 3 4	1 2 3 4
41.	perform serum glutamic oxalacetic transaminase (SGOT) test.	1 2 3 4	1 2 3 4
42.	perform lactic dehydrogenase (LDH) tests.	1 2 3 4	1 2 3 4
43.	perform chlorides test.	1 2 3 4	1 2 3 4
44.	perform potassium determinations.	1 2 3 4	1 2 3 4
45.	perform sodium determinations.	1 2 3 4	1 2 3 4
46.	perform bilirubin (direct) test.	1 2 3 4	1 2 3 4
47.	perform bilirubin (indirect) test.	1 2 3 4	1 2 3 4
48.	perform serum creatinine tests.	1 2 3 4	1 2 3 4
49.	perform glucose tests.	1 2 3 4	1 2 3 4
50.	perform blood urea nitrogen (BUN) tests.	1 2 3 4	1 2 3 4

*The items on this questionnaire were taken from the UCLA Allied Health Professions Project on clinical laboratory occupations.

APPENDIX C

LISTINGS OF COMMUNITY COLLEGES HAVING MLT PROGRAMS THROUGH 1970 AND OF THE HOSPITALS UTILIZED IN PHASE I OF THE INVESTIGATION

COMMUNITY COLLEGES HAVING MLT PROGRAMS THROUGH 1970

Gadsden State Junior College
Gadsden, Alabama 35903

Jefferson State Junior College
Birmingham, Alabama 35215

Maricopa Technical College
Phoenix, Arizona 85004

Manchester Community College
Manchester, Connecticut 06040

Southern Branch
Georgetown, Delaware 19947

Florida Junior College
at Jacksonville
Jacksonville, Florida 33205

Miami-Dade Junior College
Miami, Florida 33156

Tallahassee Community College
Tallahassee, Florida 32304

Valencia Junior College
Orlando, Florida 32809

Dalton Junior College
Dalton, Georgia 30720

Gainesville Junior College
Gainesville, Georgia 30501

Belleville Area College
Belleville, Illinois 62221

College of Lake Country
Grayslake, Illinois 60030

Illinois Central College
East Peoria, Illinois 61611

Moraine Valley Community College
Palos Hills, Illinois 60465

Sauk Valley College
Dixon, Illinois 61021

William Rainey Harper College
Palatine, Illinois 60067

Des Moines Area Community College
Ankeny Campus
Ankeny, Iowa 50021

Scott Community College
Davenport, Iowa 52801

Henderson Community College
Henderson, Kentucky 42420

Somerset Community College
Somerset, Kentucky 42501

Eastern Maine Vocational-
Technical Institute
Bangor, Maine 04401

Catonsville Community College
Baltimore, Maryland 21228

Chesapeake College
Wye Mills, Maryland 21679

Community College of Baltimore
Baltimore, Maryland 21215

Essex Community College
Baltimore, Maryland 21237

Montgomery College
Takoma Park, Maryland 20012

Prince George's Community College
Largo, Maryland 20870

Bristol Community College
Fall River, Massachusetts 02720

Springfield Technical Community College
Springfield, Massachusetts 01105

Worcester Junior College
Worcester, Massachusetts 01608

Highland Park College
Highland Park, Michigan 48203

Kellogg Community College
Battle Creek, Michigan 49016

Lake Michigan College
Benton Harbor, Michigan 49022

Macomb County Community College--
Center Campus
Mt. Clemens, Michigan 48043

Pakland Community College--
Highland Lakes Campus
Union Lake, Michigan 48085

Fergus Falls State Junior College
Fergus Falls, Minnesota 56537

Rochester State Junior College
Rochester, Minnesota 55901

St. Mary's Junior College
Minneapolis, Minnesota 55406

Copiah-Lincoln Junior College
Wesson, Mississippi 39191

Hinds Junior College
Raymond, Mississippi 39154

Mississippi Delta Junior College
Moorhead, Mississippi 38761

Mississippi Gulf Coast Junior
College District--Jackson
County Campus
Gautier, Mississippi 39553

Northwest Mississippi Junior College
Senatobia, Mississippi 38668

Forest Park Community College
St. Louis, Missouri 63110

Colby Junior College for Women
New London, New Hampshire 03257

Atlantic Community College
Mays Landing, New Jersey 08330

Brookdale Community College
Lincroft, New Jersey 07738

Camden County College
Blackwood, New Jersey

County College of Morris
Dover, New Jersey 07801

Adirondack Community College
Glens Falls, New York 12801

Auburn Community College
Auburn, New York 13021

Bronx Community College
Bronx, New York 10468

Broome Technical Community College
Binghamton, New York 13902

Corning Community College
Corning, New York 14830

Erie Community College
Buffalo, New York 14221

Hudson Valley Community College
Troy, New York 12180

Jamestown Community College
Jamestown, New York 14701

Monroe Community College
Rochester, New York 14623

Nassau Community College
Garden City, New York 11530

New York City Community College
New York, New York 11201

Orange County Community College
Middletown, New York 10940

Queensborough Community College
Bayside, New York 11364

Rockland Community College
Suffern, New York 10901

State University of New York
Agriculture and Technical Colleges
Morrisville, New York 13408

Staten Island Community College
Staten Island, New York 10301

Ulster County Community College
Stone Ridge, New York 12484

Westchester Community College
Valhalia, New York 10595

Western Piedmont Community College
Morganton, North Carolina 28655

Columbus Technical Institute
Columbus, Ohio 43215

Jefferson County Technical
Institute
Steubenville, Ohio 43952

Lakeland Community College
Mentor, Ohio 44060

University of Akron Community
and Technical College
Akron, Ohio 44304

Northern Oklahoma College
Tonkawa, Oklahoma 74653

Saint Gregory's College
Shawnee, Oklahoma 74801

Sayre Junior College
Sayre, Oklahoma 73662

Portland Community College
Portland, Oregon 97219

Community College of Allegheny
County--Allegheny Campus
Pittsburgh, Pennsylvania 15212

Harrisburg Area Community College
Harrisburg, Pennsylvania 17110

Mount Aloysius Junior College
Cresson, Pennsylvania 16630

Spring Garden College
Chestnuthill, Pennsylvania 19118

Rhode Island Junior College
Providence, Rhode Island 02908

Technical Education Center--Midlands
Columbia, South Carolina 29205

York County Community College
Rock Hill, South Carolina 29730

Presentation College
Aberdeen, South Dakota 57401

Columbia State Community College
Columbia, Tennessee 38401

Jackson State Community College
Jackson, Tennessee 83801

El Centro College
Dallas, Texas 75202

Paris Junior College
Paris, Texas 75460

Odessa College
Odessa, Texas 79760

San Antonio Junior College District
St. Philip's College
San Antonio, Texas 78203

Tarrant County Junior College District
Northeast/South Campuses
Fort Worth, Texas 76102

Temple Junior College
Temple, Texas 76501

Central Virginia Community College
Lynchburg, Virginia 24502

Wenatchee Valley College
Wenatchee, Washington 98801

Western Wisconsin Technical Institute
La Crosse, Wisconsin 54601

HOSPITALS TO WHICH QUESTIONNAIRES WERE SENT FOR SUPERVISORS OF MEDICAL LABORATORY TECHNICIANS TO COMPLETE

Alabama

Mobile General Hospital
Mobile, Alabama 36617

Veterans Administration Hospital
Montgomery, Alabama 36109

Alaska

U. S. Public Health Service
Alaska Native Medical Center
Anchorage, Alaska 99501

Arizona

St. Joseph's Hospital and
Medical Center
Phoenix, Arizona 85013

Arkansas

University Hospital
Little Rock, Arkansas 72201

California

California Medical Facility
Vacaville, California 95688

Fairmont Hospital
Oakland, California 94578

Long Beach Community Hospital
Long Beach, Califnoria 90801

Orange County Medical Center
Orange, California 92668

Riverside General Hospital
Riverside, California 92503

Santa Barbara General Hospital
Santa Barbara, California 93105

Santa Clara Valley Medical Center
San Jose, California 95128

University Hospital
San Diego, California 92103

Colorado

Fitzsimons General Hospital
Denver, Colorado 80240

Connecticut

Hartford Hospital
Hartford, Connecticut 06115

Delaware

Wilmington Medical Center
Wilmington, Delaware 19899

Washington, D. C.

Georgetown University Hospital
Washington, D. C. 20007

Florida

Baptist Memorial Hospital
Jacksonville, Florida 33207

Broward General Medical Center
Fort Lauderdale, Florida 33316

Veterans Administration Hospital
Gainesville, Florida 32601

Georgia

Medical Center
Columbus, Georgia 31902

Memorial Medical Center
Savannah, Georgia 31405

Hawaii

Queen's Medical Center
Honolulu, Hawaii 96808

Idaho

St. Luke's Hospital
Boise, Idaho 83702

Illinois

Memorial Hospital of Springfield
Springfield, Illinois 62701

Methodist Hospital of
Central Illinois
Peoria, Illinois 61603

Rockford Memorial Hospital
Rockford, Illinois 61101

St. Joseph Hospital
Joliet, Illinois 60435

Indiana

Methodist Hospital of Indiana
Indianapolis, Indiana 46202

Parkville Memorial Hospital
Fort Wayne, Indiana 46805

Iowa

St. Luke's Medical Center
Sioux City, Iowa 51104

University of Iowa
Hospitals and Clinics
Iowa City, Iowa 52240

Kansas

St. Francis Hospital
Wichita, Kansas 67214

Veterans Administration Hospital
Topeka, Kansas 66622

Kentucky

Kentucky Baptist Hospital
Louisville, Kentucky 40204

University Hospital
Lexington, Kentucky 40506

Louisiana

Lafayette General Hospital
Lafayette, Louisiana 71101

Our Lady of the Lake Hospital
Baton Rouge, Louisiana 70802

Rapides General Hospital
Alexandria, Louisiana 71301

Maine

Maine Medical Center
Portland, Maine 04102

Maryland

Baltimore City Hospitals
Baltimore, Maryland 21224

Massachusetts

Cambridge Hospital
Cambridge, Massachusetts

Springfield Hospital Medical Center
Springfield, Massachusetts 01107

St. Elizabeth's Hospital of Boston
Boston, Massachusetts 02135

Michigan

Detroit General Hospital
Detroit, Michigan 48226

Leila Y. Post Montgomery Hospital
Battle Creek, Michigan 49016

University Hospital
Ann Arbor, Michigan 48104

Minnesota

Hibbing General Hospital
Hibbing, Minnesota 55746

St. Cloud Hospital
St. Cloud, Minnesota 56301

St. Joseph's Hospital
Brainerd, Minnesota 56401

Mississippi

Howard Memorial Hospital
Biloxi, Mississippi 39533

Missouri

Boone County Hospital
Columbia, Missouri 65201

St. Mary's Hospital
Jefferson City, Missouri 65101

Montana

St. Patrick Hospital
Missoula, Montana 59801

Nebraska

Nebraska Methodist Hospital
Omaha, Nebraska 68114

Nevada

Sunrise Hospital
Las Vegas, Nevada 89114

New Hampshire

Mary Hitchcock Memorial Hospital
Hanover, New Hampshire 03755

New Jersey

Cooper Hospital
Camden, New Jersey 08103

United Hospitals of Newark
Newark, New Jersey 07107

New Mexico

Presbyterian Hospital Center
Albuquerque, New Mexico 87106

New York

Crouse-Irving Memorial Hospital
Syracuse, New York 13210

Ellis Hospital
Schenectady, New York 12308

Rochester General Hospital
Rochester, New York 14621

Rome Hospital and Murphy Memorial Hospital
Rome, New York 13440

Wyckoff Heights Hospital
Brooklyn, New York 11237

North Carolina

Duke University Medical Center
Durham, North Carolina 27706

Memorial Mission Hospital
Asheville, North Carolina 28801

North Dakota

St. John's Hospital
Fargo, North Dakota 58102

Ohio

Akron City Hospital
Akron, Ohio 44309

Daniel Drake Memorial Hospital
Cincinnati, Ohio

Fairview General Hospital
Cleveland, Ohio 45216

Oklahoma

Baptist Memorial Hospital
Oklahoma City, Oklahoma 73112

Muskogee General Hospital
Muskogee, Oklahoma 74401

Oregon

Salem Hospital
Salem, Oregon 97301

Pennsylvania

Allentown Hospital
Allentown, Pennsylvania 18102

Harrisburg Hospital
Harrisburg, Pennsylvania 17101

St. Joseph Hospital
Hazleton, Pennsylvania 18201

St. Luke's Hospital
Bethlehem, Pennsylvania 18015

Rhode Island

Rhode Island Hospital
Providence, Rhode Island 02902

South Carolina

Midlands Center
Columbia, South Carolina 29203

South Dakota

Sioux Valley Hospital
Sioux Falls, South Dakota 57105

Tennessee

Baptist Hospital
Nashville, Tennessee 37203

Baptist Memorial Hospital
Memphis, Tennessee 38103

Texas

Baptist Hospital of Southeast Texas
Beaumont, Texas 77704

Hendrick Memorial Hospital
Abilene, Texas 79601

Memorial Medical Center
Corpus Christi, Texas 78405

Methodist Hospital of Dallas
Dallas, Texas 75222

Shoal Creek Hospital
Austin, Texas 78703

St. Anthony's Hospital
Amarillo, Texas 79105

Santa Rosa Medical Center
San Antonio, Texas 78207

Utah

Holy Cross Hospital
Salt Lake City, Utah 84102

Vermont

Rutland Hospital
Rutland, Vermont 05701

Virginia

Norfolk General Hospital
Norfolk, Virginia 23507

Richmond Memorial Hospital
Richmond, Virginia 23227

Washington

Sacred Heart Medical Center
Spokane, Washington 99204

Tacoma General Hospital
Tacoma, Washington 98405

West Virginia

Appalachian Regional Hospital
Beckley, West Virginia 25801

Wisconsin

St. Joseph's Hospital
Milwaukee, Wisconsin 53210

St. Vincent Hospital
Green Bay, Wisconsin 54305

Wyoming

Veterans Administration Hospital
Sheridan, Wyoming 82801

HOSPITALS TO WHICH QUESTIONNAIRES WERE SENT TO QUERY MEDICAL LABORATORY TECHNICIANS

Alabama

Baptist Medical Center--Montclair
Birmingham, Alabama 35213

University of Alabama
Hospitals and Clinics
Birmingham, Alabama 35233

Alaska

U. S. Public Health Service
Alaska Native Hospital
Mount Edgecumbe, Alaska 99835

Arizona

Tucson Medical Center
Tucson, Arizona 85716

Arkansas

Veterans Administration Hospital
Little Rock, Arkansas 72206

California

Anaheim Memorial Hospital
Anaheim, California 92803

Daniel Freeman Memorial Hospital
Inglewood, California 90306

Eden Hospital
Castro Valley, California 94546

Greater Bakersfield Memorial Hospital
Bakersfield, California 93302

Herrick Memorial Hospital
Berkeley, California 94704

Inter-Community Hospital
Covina, California 91722

Kaiser Foundation Hospital
Bellflower, California 90706

St. Joseph's Hospital
Burbank, California 91505

Colorado

Boulder Community Hospital
Boulder, Colorado 80302

Connecticut

Yale-New Haven Hospital
New Haven, Connecticut 06504

Delaware

Milford Memorial Hospital
Milford, Delaware 19963

Washington, D. C.

Washington Hospital Center
Washington, D. C. 20010

Florida

Bayfront Medical Center
St. Petersburg, Florida 33701

Jackson Memorial Hospital
Miami, Florida 33136

Sunland Hospital at Orlando
Orlando, Florida 32802

Georgia

Grady Memorial Hospital
Atlanta, Georgia 30303

Veterans Administration Hospital
Augusta, Georgia 30904

Hawaii

Maui Community Hospital
Wailuku, Hawaii 96793

Idaho

Caldwell Memorial Hospital
Caldwell, Idaho 83605

Illinois

Chicago Wesley Memorial Hospital
Chicago, Illinois 60611

Cook County Hospital
Chicago, Illinois 60612

Evanston Hospital
Evanston, Illinois 60201

Lake View Memorial Hospital
Danville, Illinois 61832

Indiana

Memorial Hospital of South Bend
South Bend, Indiana 46601

Union Hospital
Terre Haute, Indiana 47804

Iowa

Iowa Methodist Hospital
Des Moines, Iowa 50308

Mercy Medical Center
Dubuque, Iowa 52001

Kansas

Bethany Hospital
Kansas City, Kansas 66102

Cushing Memorial Hospital
Leavenworth, Kansas 66048

Kentucky

Bowling Green-Warren County Hospital
Bowling Green, Kentucky 42101

Hazelwood Hospital
Louisville, Kentucky 40215

Louisiana

Glenwood Hospital
West Monroe, Louisiana 71291

Schumpert Memorial Hospital .
Shreveport, Louisiana 71101

Southern Baptist Hospital
New Orleans, Louisiana 70115

Maine

Eastern Maine Medical Center
Bangor, Maine 04401

Maryland

Washington County Hospital
Hagerstown, Maryland 21740

Massachusetts

Cooley Dickinson Hospital
Northampton, Massachusetts 01060

St. Luke's Hospital
New Bedford, Massachusetts 02742

Waltham Hospital
Waltham, Massachusetts 02154

Michigan

Butterworth Hospital
Grand Rapids, Michigan 49503

Edward W. Sparrow Hospital
Lansing, Michigan 48912

Hurley Hospital
Flint, Michigan 48502

Minnesota

North Memorial Hospital
Minneapolis, Minnesota 55422

St. Luke's Hospital
Duluth, Minnesota 55805

St. Paul-Ramsey Hospital and
Medical Center
St. Paul, Minnesota 55101

Mississippi

Jeff Anderson Memorial Hospital
Meridian, Mississippi 39301

Missouri

Baptist Memorial Hospital
Kansas City, Missouri 64131

Deaconess Hospital
St. Louis, Missouri 63139

Montana

St. James Community Hospital
Butte, Montana 59701

Nebraska

Lincoln Regional Center
Lincoln, Nebraska 68501

Nevada

Washoe Medical Center
Reno, Nevada 89502

New Hampshire

Elliott Hospital
Manchester, New Hampshire 03103

New Jersey

Mercer Hospital
Trenton, New Jersey 08607

Riverview Hospital
Red Bank, New Jersey 07701

New Mexico

St. Vincent Hospital
Santa Fe, New Mexico 87501

New York

Albany Medical Center Hospital
Albany, New York 12208

Buffalo General Hospital
Buffalo, New York 14203

Glens Falls Hospital
Glens Falls, New York 12801

Long Island College Hospital
Long Island City, New York 11201

Mount Sinai Medical Center
New York, New York 10029

North Carolina

Dorothea Dix Hospital
Raleigh, North Carolina 27602

Forsyth Memorial Hospital
Winston Salem, North Carolina 27103

North Dakota

St. Alexius Hospital
Bismark, North Dakota 58501

Ohio

Miami Valley Hospital
Dayton, Ohio 45409

Riverside Methodist Hospital
Columbus, Ohio 53214

St. Elizabeth Hospital
Youngstown, Ohio 44505

Oklahoma

Hillcrest Medical Center
Tulsa, Oklahoma 74104

Norman Municipal Hospital
Norman, Oklahoma 73069

Oregon

Providence Hospital
Portland, Oregon 97213

Pennsylvania

Allegheny General Hospital
Pittsburgh, Pennsylvania 15212

Mercer Hospital
Scranton, Pennsylvania 18501

Thomas Jefferson University Hospital
Philadelphia, Pennsylvania 19107

Wilkes-Barre General Hospital
Wilkes-Barre, Pennsylvania 18702

Rhode Island

Center General Hospital
Howard, Rhode Island 02834

South Carolina

Greenville General Hospital
Greenville, South Carolina 29601

South Dakota

St. John's McNamara Hospital
Rapid City, South Dakota 57701

Tennessee

Greene Valley Hospital and School
Greeneville, Tennessee 37404

Memorial Hospital
Chattanooga, Tennessee 37404

Texas

Harris Hospital
Fort Worth, Texas 76104

Methodist Hospital
Houston, Texas 77205

Methodist Hospital
Lubbock, Texas 79410

Providence Memorial Hospital
El Paso, Texas 79902

St. Joseph Hospital
Houston, Texas 77002

St. Mary's Hospital
Galveston, Texas 77550

St. Paul Hospital
Dallas, Texas 75235

Utah

McKay-Dee Hospital Center
Ogden, Utah 84402

Vermont

Medical Center Hospital of Vermont
Burlington, Vermont 05401

Virginia

Community Hospital of Roanoke Valley
Roanoke, Virginia 24009

Riverside Hospital
Newport News, Virginia 23601

Washington

St. Elizabeth Hospital
Yakima, Washington 98902

Swedish Hospital Medical Center
Seattle, Washington 98104

West Virginia

Charleston General Hospital
Charleston, West Virginia 25325

Wisconsin

University of Wisconsin Hospitals
Madison, Wisconsin 53706

Waukesha Memorial Hospital
Waukesha, Wisconsin 53186

Wyoming

Memorial Hospital of Natrona County
Casper, Wyoming 82601

APPENDIX D

COVER LETTER AND THE THREE LISTS OF CHEMISTRY TOPICS UTILIZED IN PHASE II OF THE INVESTIGATION

Dear

Thank you for responding to the fifty-item questionnaire concerning "Chemistry Competencies Needed for Medical Laboratory Technicians" which was sent to you in early November, 1973. After receiving a majority of the questionnaires, a tabulation was made to determine which items the over 250 responders felt were important for a MLT to be able to perform.

The second phase of this study involves trying to determine as near as is possible the subject matter in chemistry that is necessary for the attainment of the skills included in the various items. The information gained from this phase will be used to develop a chemistry curriculum which will be based directly upon the expected competencies for a MLT. (Here, the term MLT is defined according to the guidelines set forth by the ASCP for this relatively new category of laboratory personnel.) Hopefully, this approach will eliminate some of the irrelevant chemistry which is now being taught to potential medical laboratory technicians.

Ten of the most frequently selected items are given below. Under each item, a list of chemistry subject matter has been provided. Would you please indicate by a check mark (✓) those chemistry topics which you feel are important in helping a potential MLT to achieve the particular skill contained in each item. Also, if you feel that some important chemistry topics have been omitted, please write these under the appropriate items.

Your help in this second phase of the study will be greatly appreciated. At the conclusion of this study, I will be happy to send you a summary of the complete study, including the results of both questionnaires.

Thank you.

Sincerely,

Carole Spencer

Carole Spencer

GROUP ONE ITEMS

THE MEDICAL LABORATORY TECHNICIAN SHOULD BE ABLE TO:

1. clean area and equipment aseptically.

( ) a. chromic acid
( ) b. distilled water
( ) c. 30% sodium hydroxide solution
( ) d. dessicator
( ) e. furnace
( ) f. incubator
( ) g.

2. use centrifuge.

( ) a. dehydration
( ) b. filtrate
( ) c. supernatant liquid
( ) d. centrifugal force
( ) e. metric system
( ) f. chemical calculations
( ) g. solids
( ) h. liquids
( ) i. sedimentation
( ) j. amalgamate
( ) k.

3. prepare and process specimens

( ) a. nomenclature of necessary compounds
( ) b. chemical formulas of necessary compounds
( ) c. chemical properties of necessary compounds
( ) d. physical properties of necessary compounds
( ) e. chemical calculations
( ) f. metric system
( ) g. preparation of solutions for tests
( ) h. coagulation, anticoagulation
( ) i. solubility, insolubility
( ) j. temperature effects
( ) k. preservatives
( ) l. aliquot
( ) m. amalgamate
( ) n. centrifugal force
( ) o. filtrate
( ) p. sediment

( ) q. supernatant liquid
( ) r. centrifugation techniques
( ) s. filtration techniques
( ) t. pipette techniques
( ) u. cleaning equipment aseptically
( ) v. incubation techniques
( ) w.

4. <u>Perform pH tests</u>.

( ) a. nomenclature of necessary compounds
( ) b. chemical formulas of necessary compounds
( ) c. physical properties of necessary compounds
( ) d. chemical properties of necessary compounds
( ) e. preparation of solutions for tests
( ) f. chemical calculations
( ) g. metric system
( ) h. acid-base balance
( ) i. acidosis
( ) j. alkalosis
( ) k. buffers
( ) l. colloids
( ) m. temperature effects
( ) n. pressure
( ) o. electrolysis
( ) p. conductance
( ) q. colorimetry techniques
( ) r. potentiometry techniques
( ) s.

5. <u>inventory and order supplies</u>.

( ) a. chemical formulas
( ) b. nomenclature
( ) c. knowledge of chemical standards of purity
( ) d. chemical equations
( ) e. chemical calculations
( ) f. metric system
( ) g.

6. <u>perform acetone or ketone tests</u>.

( ) a. nomenclature of necessary compounds
( ) b. chemical formulas of necessary compounds
( ) c. physical properties of necessary compounds
( ) d. chemical properties of necessary compounds
( ) e. preparation of solutions for tests

( ) f. chemical calculations
( ) g. metric system
( ) h. oxidation-reduction
( ) i. catabolism
( ) j. buffers
( ) k. structure of ketones
( ) l. acidic solution
( ) m. alkaline solution
( ) n. water bath setup
( ) o.

7. <u>perform bile, SGOT, LDH, and bilirubin tests</u>.

( ) a. nomenclature of necessary compounds
( ) b. chemical formulas of necessary compounds
( ) c. physical properties of necessary compounds
( ) d. chemical properties of necessary compounds
( ) e. preparation of solutions for tests
( ) f. chemical calculations
( ) g. metric system
( ) h. amino acids
( ) i. transamination
( ) j. deamination
( ) k. heterocyclic hydrocarbon compounds
( ) l. surface tension
( ) m. emulsification of fats
( ) n. quantitative analysis techniques
( ) o. qualitative analysis techniques
( ) p. oxidation-reduction
( ) q. colorimetry techniques
( ) r. pipette techniques
( ) s.

8. <u>communicate findings to physicians</u>.

( ) a. nomenclature
( ) b. chemical formulas
( ) c. chemical calculations
( ) d. metric system
( ) e.

9. <u>perform serum creatinine tests</u>.

( ) a. nomenclature of necessary compounds
( ) b. chemical formulas of necessary compounds
( ) c. chemical properties of necessary compounds
( ) d. physical properties of necessary compounds

( ) e. chemical calculations
( ) f. metric system
( ) g. preparation of solutions for tests
( ) h. alkaline solution
( ) i. filtrate
( ) j. acids
( ) k. bases
( ) l. spectrophotometry techniques
( ) m. colorimetry techniques
( ) n. chemical equilibrium
( ) o. pipette techniques
( ) p. centrifugation techniques
( ) q. water bath setup
( ) r.

10. <u>perform blood tests</u> (red blood count, white blood count, platelet count, differential cell count, identification of morphological variations of red and white blood cells, hematocrit tests, erythrocyte sedimentation rate, venous whole blood coagulation time tests, prothrombin time tests.)

( ) a. nomenclature of necessary compounds
( ) b. chemical formulas of necessary compounds
( ) c. chemical properties of necessary compounds
( ) d. physical properties of necessary compounds
( ) e. preparation of solutions for tests
( ) f. chemical calculations
( ) g. metric system
( ) h. pH
( ) i. coagulation, anticoagulation
( ) j. specific gravity
( ) k. oxidation-reduction
( ) l. molecular structures
( ) m. metallic ions
( ) n. capillary action
( ) o. protein-free filtrate
( ) p. preservatives
( ) q. temperature effects on blood specimens
( ) r. electroneutrality
( ) s. partial pressure
( ) t. buffers
( ) u. electrolytes
( ) v. microscope techniques
( ) w. spectrophotometry techniques
( ) x. centrifugation techniques
( ) y. filtration
( ) z. aliquot

( ) aa. pipette techniques
( ) bb. gas chromatography techniques
( ) cc. dilution
( ) dd.

GROUP TWO ITEMS

THE MEDICAL LABORATORY TECHNICIAN SHOULD BE ABLE TO:

1. operate analytical balance.

( ) a. metric system
( ) b. gravimetric analysis techniques
( ) c. volumetric analysis techniques
( ) d. air buoyancy effects
( ) e. temperature effects
( ) f. oxidation effects
( ) g. humidity effects
( ) h. static charge effects
( ) i.

2. perform hemoglobin tests.

( ) a. nomenclature of necessary compounds
( ) b. chemical formulas of necessary compounds
( ) c. chemical properties of necessary compounds
( ) d. physical properties of necessary compounds
( ) e. chemical calculations
( ) f. metric system
( ) g. preparation of solutions for tests
( ) h. spectrophotometry techniques
( ) i. electrolytes
( ) j. pH
( ) k. chemical dyes
( ) l. pressure
( ) m. electrophoresis
( ) n. polypeptides
( ) o. amino acids
( ) p.

3. use pipette (automatic, manual, macro, micro, to deliver and contain.)

( ) a. temperature effects
( ) b. calibration techniques
( ) c. proper cleansing techniques
( ) d.

4. prepare specimens for shipment.

( ) a. dry ice
( ) b. fusion

( ) c. paraffin
( ) d. preservatives
( ) e. titer
( ) f. vaspar
( ) g. polyvinyl alcohol
( ) h. formalin
( ) i. polystyrene
( ) j. pressure effects
( ) k. chemical properties of materials to be shipped
( ) l. temperature effects of materials to be shipped
( ) m.

5. <u>perform glucose tests</u>.

( ) a. nomenclature of necessary compounds
( ) b. chemical formulas of necessary compounds
( ) c. molecular weights of necessary compounds
( ) d. chemical properties of necessary compounds
( ) e. physical properties of necessary compounds
( ) f. preparation of solutions for tests
( ) g. oxidation-reduction
( ) h. alkaline solutions
( ) i. protein-free filtrate
( ) j. colorimetry techniques
( ) k. catalysis, catalysts
( ) l. metallic ions
( ) m. oxidation numbers
( ) n. chemical calculations
( ) o. metric system
( ) p.

6. <u>perform specific gravity tests</u>.

( ) a. specific gravity
( ) b. osmolality
( ) c. freezing-point depression
( ) d. dilution
( ) e. concentration
( ) f. refractometry techniques
( ) g. urinometer techniques
( ) h. preparation of solutions for tests
( ) i.

7. <u>perform potassium determinations</u>.

( ) a. nomenclature of necessary compounds
( ) b. chemical formulas of necessary compounds
( ) c. chemical properties of necessary compounds
( ) d. physical properties of necessary compounds
( ) e. preparation of solutions for tests
( ) f. chemical calculations
( ) g. metric system
( ) h. centrifugation techniques
( ) i. flame photometry techniques
( ) j. operation of fuel tanks
( ) k. pressure
( ) l. electrolysis
( ) m. ionization
( ) n.

8. <u>collect blood specimens from patients</u>.

( ) a. anticoagulants, coagulants
( ) b. chelates
( ) c. ionization
( ) d. protein-free filtrate
( ) e. nomenclature of necessary compounds
( ) f. chemical formulas of necessary compounds
( ) g.

9. <u>operate spectrophotometer</u>.

( ) a. electromagnetism
( ) b. absorption
( ) c. infrared spectrum
( ) d. ultraviolet spectrum
( ) e. visible spectrum
( ) f. turbidimetry
( ) g. nephelometry
( ) h. X-rays
( ) i. wavelength
( ) j. fluorimetry
( ) k. chemical calculations
( ) l. metric system
( ) m. photoelectric cells
( ) n. atomic structure of molecules
( ) o.

10. prepare reagents and standards.

( ) a. properties of solutions
( ) b. saturated solution
( ) c. percent solutions
( ) d. molar solution
( ) e. molal solution
( ) f. normal solution
( ) g. equivalent weight
( ) h. milliequivalent weight
( ) i. molecular weight
( ) j. chemical calculations
( ) k. chemical formulas
( ) l. nomenclature
( ) m. metric system
( ) n. chemical equations
( ) o. electrolysis
( ) p. oxidation number
( ) q. alkalies
( ) r. distilled water
( ) s. deionized water
( ) t. buffers
( ) u. pH
( ) v. chemical equilibrium
( ) w. standardization techniques
( ) x. operation of analytical balance
( ) y. titration
( ) z. indicators
( ) aa. endpoint determination
( ) bb. monobasic, dibasic, polybasic acids
( ) cc. primary and secondary standards
( ) dd. stoichiometry
( ) ee. temperature effects
( ) ff.

GROUP THREE ITEMS

THE MEDICAL LABORATORY TECHNICIAN SHOULD BE ABLE TO:

1. use centrifuge.

( ) a. dehydration
( ) b. filtrate
( ) c. supernatant liquid
( ) d. centrifugal force
( ) e. metric system
( ) f. chemical calculations
( ) g. solids
( ) h. liquids
( ) i. sedimentation
( ) j. amalgamate
( ) k.

2. perform blood urea nitrogen (BUN) tests.

( ) a. nomenclature of necessary compounds
( ) b. chemical formulas of necessary compounds
( ) c. molecular weights
( ) d. metric system
( ) e. chemical properties of necessary compounds
( ) f. physical properties of necessary compounds
( ) g. protein-free filtrate
( ) h. buffer solution
( ) i. pH
( ) j. colloids
( ) k. alkaline solution
( ) l. colorimetry
( ) m. deamination of amino acids
( ) n. double salts
( ) o. Krebs ornithine cycle
( ) p. titration
( ) q. standard acid solution
( ) r. chemical calculations
( ) s. mixtures
( ) t. solutions
( ) u. catalysts
( ) v. substrates
( ) w. chromatography
( ) x. preparation of necessary solutions for tests
( ) y.

3. communicate findings to physicians.

( ) a. nomenclature
( ) b. chemical formulas
( ) c. chemical calculations
( ) d. metric system
( ) e.

4. perform qualitative urine protein tests.

( ) a. pH
( ) b. buffers
( ) c. alkaline solutions
( ) d. nomenclature of necessary compounds
( ) e. chemical formulas of necessary compounds
( ) f. preparation of solutions for tests
( ) g. metric system
( ) h. chemical calculations
( ) i. chemical reactions
( ) j. spectrophotometry techniques
( ) k. colorimetry techniques
( ) l.

5. perform acid phosphatase test, alkaline phosphatase test, and amylase test.

( ) a. nomenclature of necessary compounds
( ) b. chemical formulas for necessary compounds
( ) c. preparation of solutions for tests
( ) d. chemical properties of necessary compounds
( ) e. physical properties of necessary compounds
( ) f. chemical calculations
( ) g. metric system
( ) h. catalysts
( ) i. reaction order
( ) j. concentration of enzymes, substrates
( ) k. pH
( ) l. temperature effects
( ) m. light ray effects
( ) n. reaction rate
( ) o. hydrolysis
( ) p. electrolysis
( ) q. buffers
( ) r. colloidal dispersion
( ) s. colorimetry techniques
( ) t. filtration
( ) u. incubation techniques
( ) v. spectrophotometry techniques
( ) w.

6. <u>prepare specimens for shipment</u>.

( ) a. dry ice
( ) b. fusion
( ) c. paraffin
( ) d. preservatives
( ) e. titer
( ) f. vaspar
( ) g. polyvinyl alcohol
( ) h. formalin
( ) i. polystyrene
( ) j. pressure effects
( ) k. chemical properties of materials to be shipped
( ) l. temperature effects on materials to be shipped
( ) m.

7. <u>perform spinal fluid cell counts</u>.

( ) a. specific gravity
( ) b. pH
( ) c. buffers
( ) d. pressure effects
( ) e. coagulation
( ) f. turbidity
( ) g. supernatant liquid
( ) h. sediment
( ) i. chemical calculations
( ) j. metric system
( ) k. electrophoresis
( ) l. nomenclature of necessary compounds
( ) m. chemical formulas of necessary compounds
( ) n. preparation of solutions for tests
( ) o. microscope techniques
( ) p. culture setups
( ) q. centrifugation techniques
( ) r. incubation techniques
( ) s. pipette techniques
( ) t.

8. <u>perform sodium determinations</u>.

( ) a. nomenclature of necessary compounds
( ) b. chemical formulas of necessary compounds
( ) c. chemical properties of necessary compounds
( ) d. physical properties of necessary compounds
( ) e. preparation of solutions for tests
( ) f. chemical calculations
( ) g. metric system

( ) h. electrolytes
( ) i. atomic structure and theory
( ) j. flame photometry techniques
( ) k. use of oxygen-fuel tank
( ) l. pressure
( ) m. salts
( ) n. ionization
( ) o. electrolysis
( ) p.

9. <u>perform chloride tests</u>.

( ) a. nomenclature of necessary compounds
( ) b. chemical formulas of necessary compounds
( ) c. chemical properties of necessary compounds
( ) d. physical properties of necessary compounds
( ) e. chemical calculations
( ) f. metric system
( ) g. salts
( ) h. electrolysis, electrolytes
( ) i. ionization
( ) j. preparation of solutions for tests
( ) k. protein-free filtrates
( ) l. electroneutrality
( ) m. titration techniques
( ) n. endpoint determination
( ) o. indicators
( ) p. potentiometry techniques
( ) q. microburette techniques
( ) r. chlorimetry techniques
( ) s. filtration
( ) t.

10. <u>examine urine specimens microscopically and macroscopically</u>.

( ) a. nomenclature of necessary compounds
( ) b. chemical formulas of necessary compounds
( ) c. chemical properties of necessary compounds
( ) d. physical properties of necessary compounds
( ) e. preparation of solutions for tests
( ) f. chemical calculations
( ) g. metric system
( ) h. specific gravity
( ) i. dialysis
( ) j. colloids
( ) k. diffusion
( ) l. precipitate

( ) m. solids
( ) n. liquids
( ) o. urinalysis
( ) p. pH
( ) q. oxidation-reduction
( ) r. ketones
( ) s. electrophoresis
( ) t. indicators
( ) u. electrolytes
( ) v. chemical equilibrium
( ) w. hydrolysis
( ) x. buffers
( ) y. chromatography techniques
( ) z. pipette techniques
( ) aa. titration techniques
( ) bb. water bath setup
( ) cc. filtration
( ) dd. centrifugation techniques
( ) ee. microscope techniques
( ) ff. spectrophotometry techniques
( ) gg.

APPENDIX E

COMPETENCY-BASED CHEMISTRY INSTRUCTIONAL MATERIALS FOR MEDICAL LABORATORY TECHNICIANS

COMPETENCY-BASED CHEMISTRY INSTRUCTIONAL MATERIALS FOR MEDICAL LABORATORY TECHNICIANS

A chemistry course based on the instructional materials which follow should be one of approximately 18 months ($1\frac{1}{2}$ years) consisting of 90 hours devoted to lecture and 270 hours to laboratory. The competency-based chemistry materials are arranged as follows: Each competency (item) is given. The list of chemistry topics and/or concepts for each is divided into three sections:

(1) essential to know;

(2) important to know;

and

(3) least important to know.

In the "essential to know" section, each entry was selected by over 80 percent of the respondents. It is of the utmost importance that this material be included in any competency-based chemistry course derived from these instructional materials.

For the "important to know" section, each topic received a rating between 50 percent to 79 percent. The topics which fall under this section should be given consideration once the "essential to know" topics have been covered.

Topics which received less than 50 percent approval of the responders are placed under the "least important to know" section. These topics should be covered only if time permits but not at the expense of the first two sections.

Wherever pertinent, a list of the most often used methods for the determination of a particular test contained in an item is supplied. Also, references are given for certain of the items. A list of general references which pertain to all of the items is included at the end.

1. clean area and equipment aseptically:

I. a. chromic acid
   b. distilled water
   c. discarding and disposable techniques
   d. organic solvents

II. a. 30% sodium hydroxide solution
   b. dessicator, dessicants
   c. furnace
   d. incubator, incubation, autoclave

2. inventory and order supplies:

I. a. nomenclature
   b. knowledge of chemical standards of purity

II. a. chemical formulas
   b. chemical calculations
   c. metric system

III. a. chemical equations

3. collect blood specimens:

I. a. anticoagulants, coagulants
   b. preservation methods
   c. nomenclature

II. a. chelates
   b. ionization
   c. protein-free filtrate

III. a. chemical formulas of necessary compounds
   b. metric system

Methods of collection:

1. capillary puncture of finger or ear
2. venipuncture

Sample preparation:

1. serum
2. plasma

3. protein-free filtrate
    a. Folin-Wu method
    b. Haden method
    c. Somogyi method

(For sources of information pertaining to this item, see entries 1 and 2 under Specific References.)

4. prepare and process specimens:

I. a. nomenclature of necessary compounds
   b. metric system
   c. chemical calculations
   d. preparation of solutions for tests
   e. coagulation, anticoagulation
   f. solubility, insolubility
   g. temperature effects
   h. preservatives
   i. aliquot
   j. centrifugal force, centrifugation techniques
   k. filtrate, filtration techniques
   l. sediment
   m. supernatant liquid
   n. pipette techniques
   o. cleaning equipment aseptically
   p. incubation techniques

II. a. chemical formulas of necessary compounds
    b. chemical properties of necessary compounds
    c. physical properties of necessary compounds

III. a. amalgamate

5. prepare specimens for shipment:

I. a. dry ice
   b. preservatives
   c. temperature effects on materials to be shipped

II. a. chemical properties of materials to be shipped

III. a. fusion
     b. paraffin
     c. titer
     d. vaspar
     e. polyvinyl alcohol
     f. formalin
     g. polystyrene
     h. pressure effects

6. prepare reagents and standards

I. a. properties of solutions
   b. saturated solution
   c. percent solution
   d. molar solution
   e. normal solution
   f. equivalent weight
   g. milli-equivalent weight
   h. molecular weight
   i. chemical calculations
   j. metric system
   k. chemical formulas
   l. distilled water
   m. deionized water
   n. buffers
   o. pH
   p. standardization techniques
   q. operation of analytical balance
   r. titration techniques
   s. indicators
   t. chemical storage
   u. contamination
   v. pipetting techniques
   w. quality control

II. a. molal solution
   b. nomenclature
   c. chemical equations
   d. electrolysis
   e. oxidation numbers
   f. alkalies
   g. chemical equilibrium
   h. endpoint determination
   i. monobasic, dibasic, polybasic acids
   j. primary and secondary standards
   k. stoichiometry
   l. temperature effects

III. a. cork boring, etc.

(For sources of information pertaining to this item, see entries 3 and 4 under Specific References.)

7. communicate findings to physician:

I. a. nomenclature
   b. metric system

II. a. chemical calculations

III. a. chemical formulas

8. operate analytical balance:

I. a. metric system
b. correct technique of operation

II. a. gravimetric analysis techniques
b. volumetric analysis techniques
c. temperature effects
d. humidity effects

III. a. air buoyancy effects
b. oxidation effects
c. static charge effects

9. operate spectrophotometer:

I. a. absorption
b. visible spectrum
c. wavelength
d. chemical calculations
e. metric system
f. photoelectric cells
g. absorption curve
h. calibration techniques

II. a. infrared spectrum
b. ultraviolet spectrum
c. turbidmetry
d. energy

III. a. electromagnetism
b. nephelometry
c. X-rays
d. fluorimetry
e. atomic structure of molecules
f. Beer's law

(For sources of information pertaining to this item, see entries 5, 6, 7, and 8 under Specific References.)

10. use centrifuge:

    I. a. filtrate
       b. supernatant liquid
       c. centrifugal force
       d. sedimentation
       e. precipitate

    II. a. metric system
        b. chemical calculations
        c. solids
        d. liquids

    III. a. dehydration
         b. amalgamate

11. use pipette (automatic, manual, macro, micro, to deliver, and to contain:

    I. a. calibration techniques
       b. proper cleansing techniques
       c. proper selection of specific pipette for use in various situations

    II. a. temperature effects

12. perform blood tests (red blood count, white blood count, platelet count, differential cell count, identification of red and white blood cells, hematocrit tests, erythrocyte sedimentation rate, venous whole blood coagulation time tests, prothrombin time tests):

    I. a. nomenclature of necessary compounds
       b. preparation of solutions for tests
       c. metric system
       d. pH
       e. coagulation, anticoagulation
       f. capillary action
       g. preservatives
       h. temperature effects on blood specimens
       i. microscope techniques
       j. centrifugation techniques
       k. pipette techniques
       l. dilution

II. a. chemical formulas of necessary compounds
b. chemical properties of necessary compounds
c. physical properties of necessary compounds
d. chemical calculations
e. specific gravity
f. protein-free filtrate
g. buffers
h. electrolytes
i. spectrophotometry techniques
j. filtration techniques
k. aliquot

III. a. oxidation-reduction
b. molecular structures
c. metallic ions
d. electroneutrality
e. partial pressure
f. gas chromatography techniques

Red blood count:

1. use hemacytometer and dilution pipettes
2. sources of error
3. precautions
4. calculations
5. electronic counters

White blood count:

1. using hemacytometer and dilution pipettes
2. sources of error
3. precautions
4. calibration
5. electronic counter

Platelet count:

1. review maturation of platelets
2. indirect and direct methods

Differential cell count:

1. preparation of smear
   a. slide method
   b. cover slip method
2. staining techniques
   a. Wright's stain
   b. Giemsa stain
3. review hematocytopoiesis
4. identification of leukocytes found in normal circulation

5. counting and classifying leukocytes
    a. Schilling
6. study of normal erythrocytes in stained smears
7. identification of platelets in stained smears

Identification of morphological variations of red and white blood cells:

1. review maturation of development of red blood cells and white blood cells
2. study of abnormal red and white blood cells

Hematocrit tests:

1. volume of packed cells
2. definition
3. methods
    a. Wintrobe macrohematocrit
    b. microhematocrit
4. significance of determination

Erythrocyte sedimentation rate:

1. definition
2. factors influencing sedimentation rate
3. methods
    a. Wintrobe
    b. Westergren

Venous whole blood coagulation time tests:

1. definitions, schema of clotting mechanisms, factors involved
2. collection of blood for coagulation studies
3. Tests for vascular function, platelet function, overall clotting ability, fibrinogen, plasma prothrombin, thromboplastin
4. Discussion of hemorrhagic diseases

13. perform spinal fluid cell counts:

I.
    a. turbidity
    b. sediment
    c. preparation of solutions for tests
    d. microscope techniques
    e. pipette techniques
    f. contaminated sample handling

II.
    a. specific gravity
    b. coagulation, anticoagulation
    c. supernatant liquid
    d. chemical calculations
    e. metric system

f. nomenclature of necessary compounds
g. culture setups
h. centrifugation techniques
i. incubation techniques

III. a. pH
b. buffers
c. pressure effects
d. electrophoresis
e. chemistry formulas for necessary compounds

Other information:

1. functions
2. collection of
3. microscopic examination
   a. smear
   b. culture
4. cell count
   a. total cell count
   b. differential cell count
5. chemical examination
   a. protein
   b. globulin
      1. Pandy test
      2. Ross-Jones test
      3. Nonne-Apelt test
   c. total protein
      1. Meolemans method
   d. glucose
   e. chloride

14. perform acetone or ketone tests:

I. a. nomenclature of necessary compounds
b. preparation of solutions for tests
c. chemical calculations
d. metric system
e. quality control

II. a. chemical formulas for necessary compounds
b. physical properties of necessary compounds
c. chemical properties of necessary compounds
d. oxidation-reduction
e. buffers
f. structure of ketones
g. water bath setup

III. a. catabolism
b. acidic solution
c. alkaline solution

Methods:

1. acetest tablets
2. Denco
3. Lange test
4. Rothera test
5. Rantzman test
6. Fromner test
7. Gerhart test

15. examine urine specimens macroscopically and microscopically

I. a. nomenclature of necessary compounds
b. preparation of solutions for tests
c. specific gravity
d. pH
e. ketones
f. centrifugation techniques
g. microscope techniques

II. a. chemical properties of necessary compounds
b. physical properties of necessary compounds
c. chemical calculations
d. metric system
e. precipitates
f. solids
g. liquids
h. urinalysis
i. oxidation-reduction
j. indicators
k. electrolytes
l. pipetting techniques

III. a. chemical formulas of necessary compounds
b. dialysis
c. colloids
d. diffusion
e. electrophoresis
f. chemical equilibrium
g. hydrolysis
h. buffers
i. chromatography techniques
j. titration techniques
k. water bath setup
l. filtration techniques
m. spectrophotometry techniques

Further information:

1. calcium determination
   a. Wang method
2. sulfate determination
   a. Folin methods
3. titratable acidity
   a. Folin method
4. reaction
   a. neutral litmus paper test
   b. nitrazine paper test
   c. pH range paper test
5. carbohydrates
   a. Rubner test
   b. Seliwanoff test
   c. Mucic test
   d. Tauber test
   e. Fermentation test
6. uric acid
   a. Folin method
   b. Brown method
   c. Newton method
7. acetanilide
   a. Yvon method
8. chloral hydrate, iodine, morphine, quinine
   a. Todd-Sanford method
9. glucose in urine
   a. Somogyi-Nelson method

(For sources of information pertaining to this item, see entries 9, 10, 11, 12, 13, and 14 under Specific References.)

16. perform bile, SGOT, LDH, and bilirubin tests:

I. a. nomenclature of necessary compounds
   b. preparation of solutions for tests
   c. chemical calculations
   d. metric system
   e. quantitative analysis techniques
   f. qualitative analysis techniques
   g. colorimetry techniques
   h. pipetting techniques
   i. quality control
   j. spectrophotometry techniques

II. a. chemical formulas of necessary compounds
   b. physical properties of necessary compounds
   c. chemical properties of necessary compounds
   d. transamination
   e. deamination
   f. heterocyclic hydrocarbon compounds

III. a. amino acids
b. surface tension
c. emulsification of fats
d. oxidation-reduction

Methods:

1. Bile pigment
   a. Gmelin test
2. Bilirubin tests
   a. Malley and Evelyn test
      1. direct
      2. indirect
   b. ictotest
3. SGOT
   a. Reitman-Frankel test

(For sources of information pertaining to this item, see entries 15, 16, 17, 18, 19, 20, and 21 under Specific References.)

17. perform glucose tests:

I. a. nomenclature of necessary compounds
b. preparation of solutions for tests
c. colorimetry techniques
d. metric system
e. preservation techniques

II. a. chemical formulas of necessary compounds
b. molecular weight of necessary compounds
c. chemical properties of necessary compounds
d. physical properties of necessary compounds
e. oxidation-reduction
f. alkaline solution
g. protein-free filtrate
h. catalysis, catalysts
i. metallic ions
j. chemical calculations

III. a. oxidation numbers

Methods:

1. Folin-Wu method
2. Benedict method
3. Somogyi-Nelson method
4. Glucose oxidase method

5. glucose tolerance
    a. Janney-Isaacson test
    b. intravenous test
    c. Exton-Rose test

(For sources of information pertaining to this item, see entries 22, 23, and 24 under Specific References.)

18. perform qualitative urine protein tests:

I. a. pH
   b. buffers
   c. nomenclature of necessary compounds
   d. preparation of solutions for tests
   e. metric system
   f. chemical calculations
   g. spectrophotometry techniques
   h. precipitate
   i. protein error of indicators

II. a. alkaline solutions
   b. chemical reactions
   c. colorimetry techniques

III. a. chemical formulas of necessary compounds

Methods:

1. heat and acid test
2. Purdy test
3. Osgood-Haskins test
4. Bence Jones protein
5. sulfosalicylic acid test

19. perform specific gravity tests:

I. a. specific gravity
   b. concentration
   c. refractometry techniques
   d. urinometry techniques
   e. preparation of solutions for tests
   f. calibration of instruments

II. a. osmolality
   b. freezing point depression
   c. dilution
   d. temperature effects

Methods

1. Mosenthal test
2. Fishberg test
3. dilution tests

(For sources of information pertaining to this item, see entry 25 under Specific References.)

20. perform pH tests:

I.
a. nomenclature of necessary compounds
b. preparation of solutions for tests
c. pH
d. chemical calculations
e. metric system
f. acid-base balance
g. acidosis
h. alkalosis
i. buffers
j. temperature effects
k. operation of pH meter
l. quality control

II.
a. chemical formulas of necessary compounds
b. physical properties of necessary compounds
c. chemical properties of necessary compounds
d. colloids
e. electrolysis
f. conductance
g. colorimetry techniques
h. potenticmetry techniques
i. anticoagulant

III.
a. pressure

Methods and further information:

1. bicarbonate buffers
2. phosphate buffers
3. protein buffers
4. Astrup method
5. Beckman pH meter
6. pH-blood gas analyzer

(For sources of information pertaining to this item, see entries 26, 27, and 28 under Specific References.)

21. perform acid phosphatase test, alkaline phosphatase test and amylase test:

I. a. nomenclature of necessary compounds
   b. preparation of necessary solutions
   c. chemical calculations
   d. metric system
   e. reaction order
   f. concentration of enzymes, substrates
   g. pH
   h. temperature effects
   i. reaction rate
   j. hydrolysis
   k. buffers
   l. colorimetry techniques
   m. incubation techniques
   n. spectrophotometry techniques

II. a. chemical formulas for necessary compounds
   b. chemical properties for necessary compounds
   c. physical properties of necessary compounds
   d. catalysts
   e. light ray effects
   f. filtration

III. a. electrolysis
   b. colloidal dispersion

Methods:

1. amylase
   a. Myers-Fine
2. alkaline phosphatase
   a. Bodensky method
   b. King-Armstraóng method
   c. Bessey-Lowry-Brock method
3. acid phosphatase
   a. (same methods as for alkaline phosphatase)

(For sources of information pertaining to this item, see entries 29, 30, and 31 under Specific References.)

22. perform serum creatinine tests:

I. a. nomenclature of necessary compounds
   b. chemical calculations
   c. metric system
   d. preparation of solutions for tests
   e. filtrate
   f. spectrophotometry techniques
   g. colorimetry techniques
   h. pipetting techniques
   i. centrifugation techniques
   j. water bath setup
   k. quality control

II. a. chemical formulas of necessary compounds
   b. chemical properties of necessary compounds
   c. physical properties of necessary compounds
   d. alkaline solution
   e. acids
   f. bases

III. a. chemical equilibrium

Methods:

1. Jaffe' reaction
2. autoanalyzer methods

(For sources of information pertaining to this item, see entries 32, 33, 34, and 35 under Specific References.)

23. perform hemoglobin tests:

I. a. nomenclature of necessary compounds
   b. preparation of solutions for tests

II. a. chemical properties of necessary compounds
   b. physical properties of necessary compounds
   c. cuemical calculations
   d. metric system
   e. spectrophotometry techniques
   f. electrophoresis

III. a. chemical formulas of necessary compounds
   b. electrolytes
   c. pH
   d. chemical dyes
   e. pressure
   f. polypeptides
   g. amino acids

Further information:

1. dissociation curves
2. cellulose acetate electrophoresis
3. starch-gel electrophoresis

(For sources of information pertaining to this item, see entries 32, 33, 34, and 35 under Specific References.)

24. perform potassium determinations:

I. a. nomenclature of necessary compounds
   b. preparation of solutions for tests
   c. flame photometry techniques
   d. specific ion electrodes
   e. interferences

II. a. chemical properties of necessary compounds
   b. physical properties of necessary compounds
   c. chemical calculations
   d. metric system
   e. centrifugation techniques
   f. operation of fuel tanks
   g. pressure
   h. ionization

III. a. chemical formulas of necessary compounds
   b. electrolysis

Methods:

1. Lochhead and Purcell
2. flame photometry

(For sources of information pertaining to this item, see entries 36 and 37 under Specific References.)

25. perform sodium determinations:

I. a. nomenclature of necessary compounds
   b. preparation of solutions for tests
   c. chemical calculations
   d. metric system
   e. electrolytes
   f. flame photometry tests
   g. use of oxygen-fuel tanks
   h. ionization

II. a. chemical formulas of necessary compounds
    b. chemical properties of necessary compounds
    c. physical properties of necessary compounds
    d. atomic structures and theory
    e. salts
    f. pressure

III. a. electrolysis

Methods:

1. colorimetric procedure
2. flame photometry
3. Albanese and Leir

(For sources of information pertaining to this item, see entry 38 under Specific References.)

26. perform chloride tests:

I. a. nomenclature of necessary compounds
   b. chemical properties of necessary compounds
   c. chemical calculations
   d. salts
   e. electrolysis, electrolytes
   f. ionization
   g. preparation of solutions for tests
   h. titration techniques
   i. endpoint determination
   j. indicators
   k. microburette techniques

II. a. chemical formulas for necessary compounds
    b. physical properties of necessary compounds
    c. metric system
    d. electroneutrality
    e. potentiometry techniques
    f. colorimetry techniques

III. a. protein-free filtrate
     b. filtration

Methods:

1. Whitehorn method
2. Schales-Schales method
3. Sandroy method
4. autoanalyzer methods

27. perform blood urea nitrogen (BUN) tests:

I.
- a. nomenclature of necessary compounds
- b. metric system
- c. protein-free filtrate
- d. buffer solution
- e. pH
- f. colorimetry
- g. chemical calculations
- h. solutions
- i. preparation of necessary solutions for tests
- j. enzyme action
- k. standard curve

II.
- a. chemical formulas of necessary compounds
- b. molecular weights
- c. chemical properties of necessary compounds
- d. physical properties of necessary compounds
- e. alkaline solution
- f. titration techniques
- g. mixtures
- h. catalysts
- i. substrates

III.
- a. colloids
- b. deamination of amino acids
- c. double salts
- d. chromatography techniques

Methods:

1. Karr method
2. Van Slyke-Cutter method
3. Gentzkow method
4. Folin-Svedberg method
5. Berthelot reaction
6. urograph method
7. autoanalyzer methods

(For sources of information pertaining to this item, see entries 39 and 40 under Specific References.)

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   535 North Dearborn Street
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3. Modern Talking Picture Service
   1212 Avenue of the Americas
   New York, New York

4. Pfizer Medical Film Library
   267 West 27th Street
   New York, New York

5. Schering Professional Film Library
   Associated Films, Inc.
   561 Hillgrove Avenue
   LaGrange, Illinois

6. Abbott Film Service
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Carole Thomas Spencer

THE PREPARATION OF COMPETENCY-BASED

CHEMISTRY INSTRUCTIONAL MATERIALS

FOR MEDICAL LABORATORY TECHNICIANS

by

Carole Thomas Spencer

(ABSTRACT)

This dissertation dealt with the problem of devising more relevant chemistry instructional materials for potential medical laboratory technicians. The investigation was designed to determine:

(1) competencies needed by medical laboratory technicians in the performance of their jobs; and

(2) the chemistry topics and/or concepts which would aid in the achievement of these needed competencies.

A questionnaire, consisting of fifty items written in performance terms, was developed and sent to approximately 400 persons located in the following four groups:

(1) chemistry teachers at community colleges having medical laboratory technician programs in operation as of 1970;

(2) designers of medical laboratory technician programs at community colleges;

(3) supervisors of medical laboratory technicians working in hospital or clinical laboratories; and

(4) medical laboratory technicians who graduated from a community college and had worked a minimum of two years on the job.

The respondents were asked to indicate the importance and the frequency of application of each skill.

From the literature and through interviews and observations, a list of chemistry topics and/or concepts was developed for each item. The respondents were asked to indicate those chemistry topics which they thought would aid in the achievement of the skill contained in each item.

Several conclusions were drawn as a result of the information collected from the questionnaire. First, many professional persons in the area of medical technology were completely ignorant of the relatively new career in medical technology--that of medical laboratory technician.

Second, the responses of the chemistry teachers indicated that, as a group, they had a negative attitude about the study. Most indicated that they did not know what skills a medical laboratory technician needed to be able to perform or how often the technician would perform these skills.

The medical laboratory technicians who answered the questionnaires were pleased that such an investigation was being conducted. Most agreed that much of the chemistry they had received was irrelevant to their needs.

Results of a chi-square statistical test performed on each item indicated that differences of opinions occurred among the four groups. In general more differences of opinion were found for the frequency of application of the skill rather than its importance. The chemistry teachers disagreed significantly more times on various items than did the other three groups.

This investigation was a successful effort to use questionnaires to determine the competencies needed by medical laboratory technicians and the chemistry content needed to achieve these competencies. The major product of this investigation was an outline of competency-based chemistry instructional materials for the preparation of medical laboratory technicians.