

PREDICTION OF MEDICAL TECHNOLOGISTS' SCORES ON
THE MT(ASCP) CERTIFICATION EXAMINATIONS

by

AHMAD HASAN SULTAN

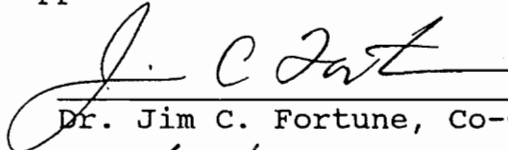
A dissertation submitted to the Graduate Faculty of
the Virginia Polytechnic Institute and State University
in partial fulfillment of the requirements for the degree of

Doctor of Philosophy

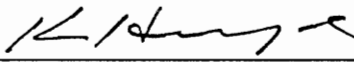
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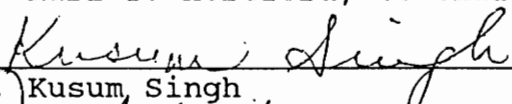
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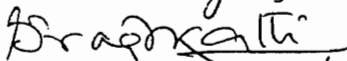
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November, 1992

Blacksburg, Virginia

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Committee Chairmen: Dr. Jim C. Fortune and Dr. Karl Hereford

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(ABSTRACT)

Seventeen students' professional year performance variables were employed to predict their scores on the MT-ASCP certification examination. The purpose of the study was designed to address three principal questions:

1. What is relationship, if any, between students' theory section and combined grades in key subjects (blood bank, hematology, microbiology, and clinical chemistry) and analogous sub-scores on the MT-ASCP examination?

2. What is the relationship, if any, between the seventeen predictor variables and MT-ASCP total scores? and

3. Which of the seventeen predictor variables, individually or in combination, best predict MT-ASCP total scores at the different academic decision points?

The sample consisted of 1985-1987 (N=103) and 1988-1991 (N=147) graduates from the six hospital-based medical technology programs in the commonwealth of Virginia. Data required for analysis were taken from the graduates' academic records at the six institutions.

Descriptive statistics, correlation coefficients, and stepwise regression analyses were used to test eight hypotheses, with results generally as follows:

With the exception of numerical grades in hematology in 1985-1987, there were statistically significant relationships ($p < .05$) between the four major MT courses and MT-ASCP sub-section scores. All seventeen independent variables were statistically ($p < .05$) correlated with 1985-1991 MT-ASCP total scores, regardless of the method of reporting the scores. Four significant ($p < .05$) multiple linear regression equations were computed between the MT-ASCP total scores and the seventeen predictors included in the study at different critical points during professional-year education for 1985-1987 and 1988-1991 graduates. About 50% of the total variance in the 1988-1991 MT-ASCP scaled scores was accounted for by three of the 17 potential professional year predictor variables. The addition of three preprofessional and personal predictors extended the variance explained to 61%.

The research warranted the conclusion that the MT-ASCP examination validly reflects the content and laboratory methods offered in the hospital-based professional training Programs in the sample of Virginia institutions.

ACKNOWLEDGEMENTS

I would like to express my sincere appreciation, thanks, and heartfelt gratitude to my advisor, Dr. Jim Fortune, who has mentored, guided, supported, encouraged, and constructively criticized my work throughout the doctoral program.

To Dr. Karl Hereford, whose encouragement, patience, and assistance helped make this study possible, who always gave just the right amount of advice and guidance to keep me motivated, the author expresses his sincere appreciations.

I also thank Dr. Daniel Vogler, Dr. Kusum Singh, and Dr. Prakash Nagarkatti, who, through their understanding, support, and motivation, have contributed greatly to the completion of the study. I am especially grateful for their patience and moral support.

To medical technology directors at all six hospitals for their assistance and cooperation, I am also grateful.

To my parents, my in laws, my wife Iman, and children Ayman, Waela, Nora, Khalid, and Dana for their unlimited support, understanding, encouragement, and sacrifice, I give my love, gratitude, and appreciation.

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CHAPTER I

INTRODUCTION

Medical technology is one of the many Allied Health Professions (physical therapy, radiology, respiratory therapy, ...,etc) that indirectly contributes to the diagnosis and treatment of various illnesses. Its contribution is necessary to meet the new challenges facing human health (e.g., AIDS) and to make the best use of rapidly changing technology. Medical technology was defined by Fagelson in 1961 as a "branch of medicine concerned with the performance of the laboratory determinations and analyses used in the diagnosis and treatment of disease and the maintenance of health." Laboratory testing is regularly used by physicians to rule-out or confirm their diagnosis and monitor long term medication therapy. Medical laboratory procedures are performed in medical laboratories by medical technologists and under the supervision of a physician, usually a pathologist. Laboratory procedures include various bacteriological, immunological, chemical, hematological, microscopic, and other special tests and analyses.

Medical technologists (MT) are prepared in different programs. They may earn a baccalaureate degree in Medical

Technology after three years of formal academic college education and one year of professional medical technology education (3+1 option). Alternatively, they may earn a baccalaureate degree in addition to a year of internship at an accredited medical technology educational program, referred to as a "4+1 option". A third route includes two years of preprofessional academic education and two years of professional education (American Society of Clinical Pathologists (ASCP), 1985 and Lindberg, Britt, & Fisher, 1984, pp. 30-35).

The year of professional training in MT is similar, whether pre-professional preparation includes two, three, or four years. Typically, the student proceeds from admission to entry into the profession through five points of decision points. These are: (Points 1-3) at each point, all students rotate through a different theory section and each student rotates through a different practicum section, (Point 4) all students complete the four major theory and practica and take the departmental comprehensive examination, and (Point 5) All successful students complete their MT professional education. See Table 1.

TABLE 1

PROFESSIONAL-YEAR OF MT TRAINING: EVENTS FLOW CHART

Point 1

- A. All students completed one theory section.
- B. Each student completed one different practicum.*

Point 2

- A. All students completed two theory sections.
- B. Each student completed two different practica.

Point 3

- A. All students completed three theory sections.
- B. Each student completed three different practica.

Point 4

- A. All students completed four theory sections.
- B. Each student completed all four practicum sections.
- C. Computation of the final (combined theory and practicum) numerical course grade.
- D. Administration of the comprehensive examination.

Point 5

- A. Completion of the remaining short MT theory and practicum courses.
- B. Computation of the overall numerical grade for all theory courses.
- C. Computation of the overall numerical grade for all practicum courses.
- D. Computation of Professional GPA for all MT courses attempted.
- E. Computation of cumulative GPA for all professional and pre-professional courses attempted.
- F. Graduation from MT education program.

* It must be noted that students may take the practicum to one theory course (e.g. hematology) while actually taking microbiology theory. The fact that most students are unable to take their practica in tandem with corresponding theory courses well may influence their scores on later examinations and, therefore, is of major concern in this study.

Regardless of the method of preparation, graduates of MT program enter into practice of their profession only after successfully passing a certification examination, a private sector activity designed primarily to certify qualified personnel. Medical technologists are certified by the Board of Registry (BOR) of the American Society of Clinical Pathologists (ASCP). The organization has been registering laboratory personnel since 1928 (ASCP, 1978; Trotto, 1991; and Lindberg et al, 1984, p. 15) and medical technologists since 1930 (ASCP, 1978 & Board of Registry (BOR), 1992). The certification examinations are designed to verify graduates' mastery of those entry-level competencies that the professional training programs are expected to develop (Castleberry, Lunz, & Tanabe, 1991).

MT-ASCP Certification Examination: Historical Eras

The Board of Registry of the American Society of Clinical Pathology has been using a formal certification examination to certify technologists since 1930. In 1972, the BOR-ASCP made a commitment to change from norm-referenced to criterion-referenced examinations (ASCP, 1978). The first criterion-referenced certification examination was administered in 1980 (Castleberry et al, 1991). A modified Nedlesky standard setting method (Nassif,

1978) was used by the Board to establish a criterion standard for each examination (BOR Newsletter, 1980).

Nedelsky's method

"bases pass-fail cutoff scores on predetermined absolute standards that are directly related to an examinee's demonstration of an acceptable level of performance" (BOR Newsletter, 1980).

A new "cut" score was determined for each MT-ASCP examination, prior to 1985, making comparisons of performance from year to year impractical.

Not until 1985 was a test equating technique, a mathematical procedure used to establish equivalent scores on different MT-ASCP exams administered at different times (Holland & Rubin, 1982), used to ensure that examinees taking the exams at different times were evaluated using the same standards (Lunz & Monsaas, 1986). The Rasch Rating Scale Model (RSM), a method that uses mathematical expression to put both person's ability as well as item difficulty on the same scale (Wright & Stone, 1979), has been used since 1988 for item analysis, test construction, test equating, and for reporting scaled test scores (Lunz & Monsaas, 1986 and Lunz, Stahl & James, 1989). A cut score of 400 on the RSM was used during 1988-1991 to represent minimum competence (Castleberry et al, 1991).

The MT-ASCP certification examinations are pencil and paper exercises designed to test students' cognitive

ability; and examination scores are the only available standardized scores that include all medical technologists. These examinations were used by researchers as a criterion measure of success in medical technology education (Crews, 1980; Floyd, 1987; Lanier & Lambert, 1981; Lehman, Leiken & Firestone, 1984; and Love, Holter & Krall, 1982). In earlier studies of MT certification, researchers used scores on the MT-ASCP examinations administered prior to 1985. That was the period when the MT-ASCP examination scores were not equated, a criterion-referenced minimum passing score was established for each examination, and examination scores were reported in percent. This study differs from those previous studies in that both the older and current MT-ASCP score reporting methods are used to identify and establish predictive models for students' success on the MT-ASCP certification examination. Of these, the MT-ASCP examinations (1988-1991), with cutoff passing scaled score of 400, have not been used as a criterion variable in previous studies. The earlier method of reporting scores was used for the 1985-1987 MT-ASCP exams, when scores were reported in terms of both total raw scores and percent of correct responses.

Test Reliability: Percent scores and scaled scores

MT-ASCP total scores used in the study represent different examinations administered to different groups at different times. Accordingly, it was impossible to compute test reliability for total percent (1985-1987) or total scaled scores (1988-1991). The Board of Registry claims to make every effort to see that the test-retest reliability and measures of internal consistency of MT-ASCP total examinations are higher than .90. Kuder Richardson-20 (KR-20) method was used to compute internal reliability. KR-20 values greater than .90 were reported by Lunz et al (1986) for the MT-ASCP total examination.

This study is one of the first studies to use students' numerical course grades and cumulative grade point averages achieved during professional year training as predictors of success on the MT-ASCP examination. The findings, it is believed, will provide administrators, accreditation agencies, educators, and certification examination developers with useful data about the new score reporting system, and set the stage for future replications with larger samples.

The Research Problem

The question is addressed: what proportion, if any, of the variance in MT-ASCP certification exam scores can be predicted or accounted for by measures of medical technology students' performance in their one year professional training program. Two separate samples of MT-ASCP certification examination scores are used as criterion-measures in this study. One represents the period when total scores were reported in percent (1985-1987), and the second represents the period when scaled scores were used (1988-1991). Specifically, These samples were compared in order to

1. Determine any relationship between students' theory and combined theory and practicum course grades in key subjects (blood bank, hematology, microbiology, clinical chemistry, and microbiology courses) and analogous sub-scores on the MT-ASCP examination;
2. Determine any statistically significant predictors of students' total scores on the MT-ASCP examination from among the seventeen available measures of students' educational performance while in MT training program; and

3. Determine which of these variables, individually or in combination, best predict MT-ASCP total scores at the different academic decision points during the year of professional training, when early intervention might be applied to enhance students' chance of ultimate success on MT-ASCP certification examination.

Hypotheses

This study examined the following null hypotheses at .05 probability level:

Hypothesis 1_a: For 1885-1987 graduates, there is no relationship between numerical grades earned in the theory sections of courses in hematology, clinical chemistry, blood bank, or microbiology and their MT-ASCP sub-scores for the same subject areas.

Hypothesis 1_b: For 1988-1991 graduates, there is no relationship between numerical grades earned in the theory sections of courses in hematology, clinical chemistry, blood bank, or microbiology and their MT-ASCP sub-scores for the same subject areas.

Hypothesis 2_a: For 1885-1987 graduates, there is no relationship between numerical grades earned in the combined theory and practicum sections of courses in hematology,

clinical chemistry, blood bank, or microbiology and their MT-ASCP sub-scores for the same subject areas.

Hypothesis 2_b: For 1988-1991 graduates, there is no relationship between numerical grades earned in the combined theory and practicum sections of courses in hematology, clinical chemistry, blood bank, or microbiology and their MT-ASCP sub-scores for the same subject areas.

Hypothesis 3_a: For the 1985-1987 graduates, there is no statistically significant relationship between any of the predictor variables and total percentage scores on the MT-ASCP examination.

Hypothesis 3_b: For 1988-1991 graduates, there is no statistically significant relationship between any of the predictor variables, individually or in combination and total scaled scores on the MT-ASCP examination.

Hypothesis 4_a: There is no significant multiple-linear regression formula that predicts 1985-1987 graduates' scores on the MT-ASCP examination at the different academic decision points during professional-year training.

Hypothesis 4_b: There is no significant multiple-linear regression formula that predicts 1988-1991 graduates' scores on the MT-ASCP examination at the different academic decision points during professional-year training.

Delimitations

The population of interest in this study includes the 276 students who graduated from the six active Medical technology programs (3+1 or 4+1 options) in Virginia from 1985 through and including 1991 and who took the MT-ASCP board certification examination either in the month of February or August immediately following their graduation. However, data were available only for 250 out of the 276.

The investigation is limited to the following variables:

a. **Predictors (Independent Variables)**

1. numerical grades earned in the **theory** section of courses in hematology (**HEM**), microbiology (**MIC**), clinical chemistry (**CHM**), and blood bank (**BBK**).
2. numerical grades earned in the **practicum** section of courses in **HEM**, **MIC**, **CHM**, and **BBK**.
3. combined (final) numerical course grade across both theory and practicum sections of **HEM**, **MIC**, **CHM**, and **BBK**.
4. average numerical grades for the **theory** section of all professional medical technology courses attempted, including but not limited to those in 1, 2, 3 above.
5. average numerical grades for the **practicum** section of all professional medical technology courses attempted, including but not limited to those in 1, 2, 3 above.
6. scores on the "comprehensive examination".
7. professional year grade point average.

8. cumulative grade point average over all courses attempted for degree including both pre-professional and professional courses.

b. **Criterion (Dependent Variable)**

- students' percent scores on the MT-ASCP exams for 1985 through and including 1987.
- students scaled scores on the MT-ASCP exams for 1988 through and including 1991.

To ensure that all subjects had equal preparation time for the examination without the influence of employment experience, the definition of success used in this study is limited to passing the MT-ASCP certification examination on the first attempt in either February or August immediately after graduation from the medical technology program.

Importance of the Study

The study determines the extent to which MT-ASCP exam total and sub-scores are related to medical technology education programs' curricula. If the content and competencies measured by the MT-ASCP examination differ significantly from that covered in the MT training programs, these relationships could be a strong motivator and guiding force for MT educators and administrators to conduct an objective reexamination of MT curriculums. Student performance could be monitored at different points during MT training using the computed predictive equations. An

earlier program intervention may be implemented to improve the chances of students success on the MT-ASCP certification examination.

Contrariwise, failure of section grades in the several preparation programs to correlate significantly with corresponding sections on the MT-ASCP examination itself may indicate that the examination may lack sufficient content validity to justify its continued use without modification.

Definition of Terms

National Accrediting Agency for Clinical Laboratory Sciences, (NAACLS): an autonomous accrediting body for medical technology educational schools or programs (French & Elkins, 1978).

Final Grade Point Average (FGPA): the numerical average of all completed courses (academic college courses and professional medical technology courses). Letter grades were converted to numbers to compute the quality points. A scale of zero to four points was assigned to determine the quality points for each course, with A=4 points, B=3 points, C=2 points, D=1 point, and F=0 points. Quality points were computed by multiplying the assigned points by the number of credits for each course. The sum of quality points for all courses was then divided by the total number of completed

credits to obtain the FGPA.

Pre-professional Total Grade Point Average (PPTGPA):
the numerical average of all academic college courses that the applicant completed prior to admission to the medical technology program. Computation was the same as that for final grade point average.

Pre-professional Science Grade point Average(PPScGPA):
the numerical average achieved in pre-professional college mathematics and science courses. Computation was the same as that for final grade point average.

Professional Grade Point Average (PGPA): the grade point average achieved in all hospital based professional medical technology courses. Computation was the same as that for final grade point average.

Professional Medical Technology Courses: These were grouped under six major subjects or rotations:

1. **Microbiology.** (virology, bacteriology, serology, parasitology, mycology, and microscopy);
2. **Chemistry.** (routine and special analyses, toxicology, and instrumentation);
3. **Hematology** (routine and special analyses, special stains, hemostasis, microscopy, and white and blood cells morphology);

4. **Immunochemistry (Blood bank).** (Blood immunology and serology);
5. **Body Fluids.** (Urine, spinal, and other body fluids analyses); and
6. **Immunology and Serology.** The duration of each course varies from about twelve weeks each for clinical chemistry, hematology, and microbiology, ten weeks for blood bank, two weeks each for immunology and body fluids.

Professional Year (internship): a full year (50-52 weeks) period spent by the students at an accredited, hospital-based medical technology program.

Medical Technologist (MT): individuals who earned a baccalaureate of science degree in Medical Technology (3+1) or a baccalaureate degree and one year of internship (4+1) at an accredited MT educational program (ASCP, 1985).

Combined Grades: the final numerical course grades. They include grades from both theory and practicum sections.

Comprehensive Examination Scores (C-Exm): those scores received by the student on each of the subsections of the comprehensive examination given after completing the hospital based professional medical technology courses. The examinations were given about one month before the students completed their professional-year education and about two

months before they took the national certification examination. The passing score was set at 60 percent (four programs) and 65 percent (two programs) correct answers. Total score was determined by adding all correct items for each sub-section. Total raw score and the percent of correct answers were reported both for the total examination and for each sub-section.

MT-ASCP Board Certification Examination: a criterion-referenced exam developed, administered, and monitored by the Board of Registry of the American Society of Clinical Pathologists (BOR-ASCP). Eligible candidates are those who have completed the requirements for a bachelors degree of science in medical technology, including a clinical year at an accredited medical technology program. The examination is given twice a year by the Board of Registry of the American Society of Clinical Pathologists (ASCP). Those who pass are certified by the BOR-ASCP and are permitted to add the letters MT(ASCP) after their names. Passing cutoff score for 1985-1987 was 70 percent and a score of 400 scaled points for 1988-1991.

Hospital-Based Medical Technology Program: an accredited hospital based MT educational program where medical technology students can obtain their professional education and clinical training. Upon satisfactory

completion, graduates should be able to perform clinical laboratory procedures with minimum supervision, perform quality assurance procedures and interpret the obtained data, and be capable of handling supervisory duties (National Accrediting Agency for Clinical Laboratory Sciences (NAACLS), 1984).

Summary

This chapter presented an introduction to the study and discussed the research problem, research questions and hypotheses. An overview of literature related to medical technology education is reported in Chapter Two. Chapter Three presents the definition of the sample and utilized procedures. In chapter Four, data analysis and resulting predictive models for students' scores on the MT-ASCP examination at various critical points during professional year training are reported. The prediction of these models and conclusions of the study as well as recommendations are discussed in Chapter Five.

CHAPTER II

LITERATURE REVIEW

This chapter presents an overview of the literature related to the prediction of success in Medical Technology education. Several criteria were used by researchers as measures of students' potential success in MT education programs. These include total and sub-scores on the MT-ASCP certification examination, scores on the departmental comprehensive examination, professional year grade point average, numerical grades on selected professional MT courses, and cumulative (final) grade point average. Most of the studies used only the pre-professional academic and non-academic predictors of ultimate success in MT training programs. These predictive studies were limited in number.

Medical Technology Education: Professional Training Year

During the professional year of medical technology training, students were rotated through different theory and practicum courses, took a comprehensive examination, and prepared for the certification examination. As demonstrated in Chapter 1, Table 1. All students, together, were rotated through each theory section. Each student was rotated through different practicum until all rotations were

completed. After completing all the theory and practicum rotations, they were required to take a departmental comprehensive examination.

A. Pre-professional Academic Predictors of Students' Success in MT Education

1. **Prediction of Student' Success on the MT-ASCP Board Certification Examination.** In the process of selecting the best applicants into the medical technology education programs, different variables have been used to predict students' potential success in MT education. Pre-professional total GPA (PPTGPA) and pre-professional science GPA (PPScGPA) were frequently used with other variables to predict applicants' ultimate success in MT professional training programs (Garza, 1976 and Zufal, 1974). Aptitude tests also were used as predictors (Lanier & Lambert, 1981 and Williams, 1963, 1965).

Williams et al (1967) using step wise regression, identified PPTGPA as the single best predictor of students' T scores on the Registry Examination. They reported a correlation coefficient of .46 ($p < .05$, $n = 87$). Pre-professional total GPA (PPTGPA) was validated by Wise (1983)

as a predictor of students' success in MT education. He found that students' grades in professional clinical chemistry courses were highly predictive of their scores on the chemistry section of the MT-ASCP exam ($r = .489$, $P < .0001$, $n = 247$). With a sample of 52 graduates from a "2 + 2" university-based MT program, Crews (1980) used preprofessional and sophomore year professional performance to predict students' success on the MT-ASCP. He found that there was a moderate relationship between PPTGPA and students' scores on the MT-ASCP ($r = .57$, $p < .005$). Pre-professional GPA (PPTGPA) was the first variable to enter in the reported prediction equation. The second variable to enter was pre-professional science GPA (PPScGPA), which also correlated moderately with scores on the MT-ASCP ($r = .6246$, $F = 31.45$, $P < .005$). In another "2 + 2" MT program, a study of 172 MT graduates, Love et al (1982) found that PPTGPA was a significant ($p < .005$) predictor of students' success on the MT-ASCP exam. They demonstrated that those students ($n = 179$) who were graduated with a GPA less than 2.5 scored less than 70% on the MT-ASCP. Reifken, Maturen, Brace, and Jacobs, (1981) studied the effect of academic and non-academic variables in predicting students' professional GPA, comprehensive examination score, MT-ASCP exam score, practicum total grades in HEM, CHM, MIC, and BBK.

Significant correlations were reported between academic factor predictors and MT-ASCP scores ($r = .38$, $p < .05$, $n = 59$). Pre-professional non-science GPA (PPnscgpa), PPTGPA, and PPScGPA were loaded under an "academic factor predictor." Lanier and Lambert (1981) used PGPA, PPTGPA, PPScGPA and C-Exm scores to predict students' success. They reported significant correlations for MT-ASCP scores with PPTGPA ($r = .41$, $p < .001$, $n = 195$), PPScGPA ($r = .35$, $p < .001$, $n = 189$), PGPA ($r = .72$, $p < .001$, $n = 189$), and (C-Exm) comprehensive exam ($r = .81$, and $p < .001$, $n = 180$). When stepwise regression was used by Lanier and Lambert (1981), Otis Quick-Scoring Mental Ability Test (Gamma, form C) score and pre-professional science GPA were selected as the two best predictors of MT-ASCP scores ($R^2 = .25$, $p < .01$, $n = 112$). Preprofessional GPA and Nelson-Deny Reading test (Form A) scores were not found to be significant ($P < .01$) predictors of MT-ASCP scores. Both PPTGPA and leadership style (measured by the Leadership Behavior Description Questionnaire [LBDQ]) scores were found to be significant predictors of MT-ASCP exam scores (Blagg, Gaspatrick, & Guiles, 1986). The relationship between 10 student personality characteristics and performance on the MT-ASCP exam was studied by Millstead (1992). Three variables (comprehension, judgement, and initiative/originality), when

used together were found to be strong predictors ($R = .67$, $n = 31$, $p < .05$) of MT-ASCP certification exam. No significant differences were found when Floyd (1987) compared graduates' scores from "3 + 1" and "2 + 2" MT programs ($n = 227$) on the MT-ASCP. Similar findings were reported by Downing, Mann, and Tomlinson (1982). The effect of different configurations of selected science courses on students' professional academic success was studied by Huang Lin et al (1987). They concluded that selected science courses had no significant influence on students' performance on both the MT-ASCP examination and in professional courses. On the other hand, a significant interaction was reported between those students who selected physiologic chemistry or organic chemistry plus the biochemistry option and scores on the MT-ASCP certification examination.

After eight years of operation, the medical technology program at the University of Nevada at Reno (UNR) required MT students to pass a comprehensive examination at the end of their practicum. Kiehn and Maehara (1989) compared the performance of 86 students on the MT-ASCP examination before ($n = 86$) and after ($n = 73$) the comprehensive examination was required. They reported an 11.6 percent increase in the number of students passing the MT-ASCP examination on the first try after the C-Exm was required, from 80.2% ($n = 69$) to

91.8% (n=67). A moderate correlation was found ($r = .74$, $p < .001$) between students' C-Exm scores and their scores on the MT-ASCP examination. PPTGPA and the consideration scale of the LBDQ, leadership scale were found to be significant predictors of MT-ASCP scores ($r^2 = .6076$, r^2 change = $.3628$, $P < .05$, $n = 24$) (Blagg et al, 1986).

2. Prediction of Students Professional Grade Point Average (PGPA)

Professional-year grade point average (PGPA) reflects students' overall comprehension of the theoretical, practical and professional aspects of medical laboratory technology. Several studies have used PGPA as a measure of success in MT professional education. Elberfeld and Love (1970) obtained significant correlation coefficients ($p < .05$) between pre-professional GPA (PPTGPA) with professional GPA (PGPA) ($r = .82$). Lanier and Lambert (1981) used stepwise regression to select the best predictors of students' professional GPA. Science GPA and Nelson-Denny Combination Test scores were selected as the two best predictors of Professional GPA ($n = 112$, $r^2 = .25$, $p < .01$). Rifken et al, (1981) used academic, non-academic, and motivation factors to predict academic success of medical technology students. Among other findings, significant ($p < .05$) correlations were

reported for PGPA with the academic factor ($r = .61$, $n = 59$) and the motivation factor ($r = .38$, $n = 59$). Another study by Blagg et al (1986) used personality variables (cognitive style and leadership style) and PPTGPA to predict performance measures of their success in MT educational programs. PPTGPA and three personality variables (Consideration scale of the LBDQ, dogmatism, and integrative complexity) were found as significant predictors of PGPA (cumulative $r^2 = .69$, $P < .05$, $n = 17$).

3. Prediction of Students' Success on the Departmental Comprehensive Examination (C-Exm)

A departmental comprehensive examination is prepared by the faculty at each MT program. It is usually similar to the MT-ASCP Board examination in content and length, and it covers all professional medical technology content. Total and sub-section raw and percentage scores are usually computed for each student. Students take the examination after completing the four major MT professional courses. Several studies have established that these C-Exam scores are good predictors of students' performance on the MT and MLT-ASCP Board Certification Examination.

Pre-professional GPA (PPTGPA) was found by Love et al (1982) to be a significant predictor of students' success on

the comprehensive examination (C-Exm). They also reported that students graduated with a GPA less than 2.5 scored less than 70% on the comprehensive examination. Academic predictors and non-academic predictors were good predictors of C-Exm total scores (Rifken et al, (1981). They reported a correlation coefficient of .38 for C-Exm with the academic factor, and .29 with the non-academic factor. PPScGPA and Otis Quick-Scoring Mental Test scores were identified as the best two predictors ($R^2 = .27$, $p < .05$, $n = 112$) for students' success on the C-Exm (Lanier & Lambert, 1981).

4. Prediction of Students' Success on Professional Courses

Students' success on professional MT courses is dependent on their pre-professional preparation. Researchers have tested different pre-professional achievements and found some to be good predictors of potential success in MT education.

Elberfeld and Love (1970) reported significant ($p < .05$) correlation coefficients between PPTGPA with (T-OAS) overall average of theory sections numerical grades ($r = .75$, $n = 61$), and (P-OAS) overall average of practicum sections numerical grades ($r = .61$). Pre-professional total GPA (PPTGPA) and Consideration scale LBDQ were found by Blagg et al (1986) to

be significant predictors of clinical (practicum courses) GPA ($r^2 = .36$, r^2 change = $.09$, $p < .05$, $n = 24$). In 1987, Huang Lin et al reported no statistical significance ($p < .05$) existed between pre-professional science course configuration and students' success on professional MT courses. Students who completed a quantitative analysis-type course were found by Johnson, Dumff, and Shoemaker (1977) to score better on College Level Examination Program (CLEP) subject examinations in hematology, clinical chemistry, blood bank, and microbiology. Those findings were supported by Lehman et al (1984), who found that students with an Associate of Science Degree (AS) in general science achieved less on practical clinical chemistry courses than those who completed either an Associate in Applied Science Degree (AAS) in medical laboratory technology, or an equivalent two years from a four-year college. Such low performance may have been related to students with an Associate of Science degree not having a quantitative analysis course in their curriculum.

5. Prediction of Students Final GPA (F-GPA)

Heilman (1991) used eleven pre-professional academic variables to predict Medical Laboratory Technician (MLT) students' success on the MLT-ASCP certification examination.

He included the total score on Nelson-Denny Reading test (NDRT) and its three sub-tests Vocabulary (NDRTv), Comprehension (NDRTc), and Reading Rate (NDRT_r), the American College Test (ACT) and its four sub-tests: English (ACT_e), Mathematics (ACT_m), Natural Science (ACT_n), and Social Science (ACT_s), pre-professional overall grade average, and pre-professional science grade average. Significant ($p < .05$) correlation coefficients were reported for students' FGPA with NDRT_t ($r = .48$, $n = 105$), NDRT_v ($r = .46$, $n = 105$), NDRT_c ($r = .42$, $n = 105$), NDRT_r ($r = .25$, $n = 100$), ACT_e ($r = .47$, $n = 42$), ACT_m ($r = .59$, $n = 42$), ACT_s ($r = .44$, $n = 42$), ACT_n ($r = .56$, $n = 42$), ACT_c ($r = .61$, $n = 42$), PPTGPA ($r = .34$, $n = 103$), and PPScGPA ($r = .39$, $n = 103$). Maximum regression (MAXR) procedure was used to produce the best three-variable model, which included NDRT_v, ACT_m, and PGA. The model was significant at ($F = 12.55$, $P < .0001$, $n = 31$) and accounted for 57 percent of the total variance in professional GPA.

B. Professional Academic Predictors of Students' Success in Medical Technology Education

There are very limited number of published studies where researchers used student's performance on professional

MT courses during MT training year as predictors of graduates' success on the MT-ASCP examination.

Crews (1980) reported a correlation coefficient of .72 between students' scores (n=52) on C-Exm and their scores on the MT-ASCP. In 1981, significant correlations ($p < .001$) were reported by Lanier and Lambert for total scores on the MT-ASCP examination with Professional GPA ($r = .72$, $n = 189$), and C-Exm ($r = .81$, $n = 180$). Significant relationships ($p < .05$) were computed by Ahlstrom (1980) between MLT-ASCP examination sub-scores ($n = 63$) and corresponding course scores in clinical chemistry ($r = .54$, $P < .01$), microbiology ($r = .27$, $P < .05$), and hematology course scores ($r = .42$, $p < .01$). Lunz et al (1986) demonstrated significant correlations ($p < .01$) between faculty ratings of overall theory (cognitive) and practical (skills) and total scores on the MT-ASCP examination and MT-ASCP sub-scores with corresponding theory and practical ratings.

Summary

The literature review in this Chapter was devoted to the predictive studies pertaining to students' success in medical technology (MT) education. These studies focussed mainly on the selection of applicants with the best chance of succeeding in professional MT education. Pre-

professional academic and nonacademic variables were used as predictors of students potential success in MT education program. These included: pre-professional total and science grade point averages, aptitude tests (Nelson Denny Reading Test), leadership characteristics, mental ability tests (Otis Quick-scoring Mental Ability test), and demographic and personality characteristics. Measures of success in MT education included MT-ASCP certification examination total and sub-scores, professional and final GPAs, departmental comprehensive examination scores, and numerical grades on selected MT courses.

Preprofessional total GPA (PPTGPA) was determined by most studies as the best single predictor of success in MT education, followed by science GPA (PPScGPA). The other predictors were used less frequently and were better predictors when used in combination with PPTGPA and/or PPScGPA. No studies known to this researcher have focussed on students' performance professional during MT training year as predictors of their ultimate success on the MT-ASCP examination. The research questions remain: to what extent, if any, can prediction of success on the MT-ASCP certification examination be improved by inclusion of students performance during their year of professional studies and to what extent, if any, are there early

indicators of ultimate success in the program at one or more of the key decision points in the program.

CHAPTER III

RESEARCH METHODOLOGY

Target Population and Sample

In this chapter, attention is given to the design of research employed to examine the eight hypotheses identified in Chapter I. The chapter will describe the population and samples of MT graduates where academic performance in MT courses was employed to predict total and sub-section scores on the MT-ASCP certification examination for the years 1985-1991.

There are six active hospital-based MT programs in the State of Virginia. These are: Fairfax Hospital (Falls Church), Danville Memorial Hospital (Danville), Rockingham Memorial Hospital (Harrisonburg), King's Daughters' Hospital (Staunton), University of Virginia Hospital (Charlottesville), and Roanoke Memorial Hospital (Roanoke).

The target population for this study included graduates from these six active MT programs for the years 1985-1991. Five programs had one annual graduating class, typically in July. The sixth program held a commencement both in January and July until 1988 when the January commencement was

discontinued. Altogether, there were 276 graduates of the six programs during this time period. Each took the MT-ASCP examination about one month from the date of graduation. One program did not provide access to data for 25 students. One student from a different program did not take the MT-ASCP examination due to personal reasons.

Accordingly, data were available for a sample of 103 of 128 graduates respectively from the classes of 1985 through 1987, and a corresponding sample of 147 of 148 graduates from the 1988 through 1991 classes. There was no evidence suggesting that the missing 26 cases were unique or sufficiently extremely different from the 103 subjects with available data to distort study results based on the lesser number of graduates.

Data Collection

Permission to collect research data was granted by each of the six MT program directors. Students' personal identities were protected throughout the study. One year prior to data collection, the researcher contacted the six program directors to explain his request after which a list of the variables of interest was mailed to them. Each director was asked to report on the availability of each of the variables required for the study. All six MT program

directors expressed their willingness to cooperate. Three programs made their students' records available to the researcher on the agreed dates for data collection. Two program directors decided to collect and mail data directly to the researcher. The remaining program chose to collect the data and hand it to the researcher.

Each student record was given a unique code number (e.g., 1-86001), where 001= student number, 86= graduation year, and 01= institute code). Available demographic data (age, sex, years in college prior to admissions into MT program, laboratory employment, marital status, pre-professional total grade point average (PPTGPA), and science grade point average (PPScGPA) were encoded from students' admission applications. Marital status was included because of noticeable increase in the number of married students entering the profession. Pre-professional total grade point averages (PPTGPA) and science grade point averages (PPScGPA) were collected from admission processing sheets. The sheets were available for each student, and were usually completed by the MT program director. For some students, the sheets were not completed and the researcher had to compute PPTGPA and PPScGPA from their official transcripts.

Students' academic marks (practicum section, theory section, and the combined numerical course grades) were

taken from their official records, which also contained their professional MT education grade point average (Pr-GPA), or the individual grades needed to compute GPA.

Final grade point averages were obtained either from the official record sheet prepared for each graduate, or computed by the researcher from students' preprofessional and professional quality points and total credits earned.

Students' total scores on the Comprehensive Examination (C-Exm) were copied from students' permanent files or MT director grade files. This examination is prepared by program's faculty to mimic the MT-ASCP examination and administered towards the end of MT training year. One program did not keep records of comprehensive examination scores. Another program did not have scores for the class of 1989, because they were chosen by the BOR-ASCP to participate in a nationwide testing of a pool of new items developed for the MT-ASCP examination.

Total and sub-scores on the MT-ASCP examinations for all graduates were obtained from the Board of Registry Program Performance Reports Part A and E. These reports were released to all program directors with students' permission. Each performance report for 1985 through 1991 contained students' sub-scores for each knowledge area (hematology, chemistry, blood bank, microbiology,

immunology, and body fluids). Total raw and percent correct scores were reported for 1985 through 1987 graduates and a total scaled scores were reported for 1988 through 1991 graduates.

Data Treatment

Once collected, coded, and entered on a spreadsheet, available data were analyzed by personal computer, using the Number Cruncher Statistical System (NCSS), version 5.03 (Hintze, 1991). Computer outputs included: means, standard deviations, "t" values, zero-order correlations, coefficients of determination, multiple correlation coefficients, standard error of estimates, and F and p values for each model. Regression coefficients, standard error of regression coefficients, the proportion of variance accounted for by each individual variable (r^2), and R^2 (proportion of variance accounted for by two or more variable) also were obtained from computer output.

The very limited number of missing values on subjects included in the study were treated by pair wise deletion. This permitted the utilization of the maximum number of subjects and achieved the most accurate and complete results (Witta, 1992).

Measures of Professional-Year Performance

There were seventeen (17) measures of professional year performance for each student. They were:

- Numerical grades in four theory sections, one each in **HEM**, **CHM**, **MIC**, and **BBK**,
- Numerical grades in four practicum sections, one each in **HEM**, **CHM**, **MIC**, and **BBK**,
- Final numerical grades combining practicum and theory sections, one each in **HEM**, **CHM**, **MIC**, and **BBK**,
- Total comprehensive examination scores (C-Exm),
- Overall numerical grade point average on all MT theory sections (T-OAS),
- Overall numerical grade point average on all MT practicum sections (P-OAS),
- Professional MT training year GPA (Pr-GPA), and
- Cumulative (Final) GPA (F-GPA) on all attempted professional and pre-professional courses.

Those measures, except for professional GPA and final GPA are employed at four different decision points during the professional year. As demonstrated in Table 2.1 in

Chapter II, Point 1 represents the end of the first training rotation (end of the first 10 to 12 weeks of training), when all students have completed one theory course and each student has completed one different practicum. After about 24 weeks of training (point 2), two theory courses were completed by all students and two different practicums were completed by each student. At the end of point 3 (end of 30-36 weeks of training), all student completed three theory courses and each student completed three different practica. Point 4 (end of 48 weeks of training) marks the completion of all four major theory and practicum courses (hematology, blood bank, clinical chemistry, and microbiology) and the administration of the comprehensive examination. Upon completion of MT professional education (Point in time 5), all seventeen independent variables (professional predictors) were available for all students. For ease of analysis, decision points 1 to through 3 were combined.

Data Analysis

Descriptive statistics, Pearson product-moment correlation coefficients, multiple and stepwise, and forward inclusion regression analysis were used to analyze data collected for 1985-1987 and 1988-1991 MT graduates from all six hospital based medical technology programs in Virginia.

Analyses were designed to

1. Examine the relationship between (a) student's numerical grades in theory and combined (theory and practicum) sections in all four major professional areas hematology, microbiology, blood bank, or clinical chemistry and (b) their MT-ASCP sub-scores for the same subject.

2. Examine the relationship between (a) each predictor variable and (b) the total score on the MT-ASCP examination for 1985-1987 and 1988-1991 graduates.

3. Determine the linear combination of the seventeen professional performance measures that could be used to predict students' performance on the MT-ASCP certification examination most accurately at each of five decision points in the students' progress during their professional year education.

Summary

In this chapter, all six hospital-based medical technology programs in Virginia included in the study were identified. The study population was divided into two separate samples. One sample (N=103) represented the period (1985-1987) when MT-ASCP examination scores were reported in raw and percentage scores. The second sample, consisting of 1988 to 1991 graduates (n= 147), represents

the present score reporting system of the MT-ASCP examination, in which scaled scores, cutoff passing score, and test score equating were used. The computer program, Number Cruncher Statistical System version 5.03, was used to analyze the data.

CHAPTER IV

RESULTS OF DATA ANALYSES

The results of data analyses are organized and presented here in two principal parts, namely:

A. How the MT students performed during their professional year of preparation, including their performance on the MT-ASCP certification examination: 1985-1991, and

B. How best to account for or explain differences in their performance on the MT-ASCP certification examination.

In part A, attention is given to four principal areas of concern, namely:

1. Characteristics of entering MT students: 1985-1991.
2. MT-student performance on the admission standards set by the MT training programs.
3. MT student performance on key theory and practicum courses during their professional years, and
4. MT student performance on the MT-ASCP examination.

In part B, attention is given to these areas of concerns:

1. The effects, if any, of professional year of training on MT-ASCP certification examination;

2. The added effects, if any, of students pre-professional experience on their MT-ASCP examination scores.
3. The early "indications of performance" on the MT-ASCP examination from each stage of academic progress during the professional year of training.

In all subsequent discussions here, the use of the phrase "effects on" or "accounted for" are limited in meaning to the results of regression analyses. A portion of the total differences observed in student scores on the MT-ASCP examination may be accounted for or explained by differences in one or more of the students' accomplishments in their professional year of training. In no sense, are these "effects" to be interpreted as experimental effects.

PART A: HOW MT STUDENTS PERFORMED DURING PROFESSIONAL YEAR

1. Characteristics of Entering MT Students: 1985-1991

Demographic data were collected on 250 subjects from six hospital-based medical technology (MT) programs in the State of Virginia. Data were available for 103 graduates of the period 1985-1987 and for 122 graduates of the period 1988-1991.

Females constituted 86 to 88 percent of those graduated from 1985 to 1991. Among the six programs, the percent of

females ranged from 78 to 95 percent for the 1985-1987 sample and 79 to 97 for the 1988-1991 sample. A few medical technology programs did not have male students for several years.

The average age of 1985-1987 and 1988-1991 students when they entered the medical technology programs was 22 years. The minimum age for all subjects with available data was 20, the maximum 42 years. Average age per program fell between 22 to 27 years. These findings agree with those reported in 1982 by French and Elkins. Descriptive data for age and gender are presented in Table 4.1.

The percent of married students in the 1988-1991 sample was more than double (25%) that reported for 1985-1987 (9%), as shown in Table 4.2. Such an increase can be attributed in part to the increase in demand for nontraditional students, i.e. those with a college degree or inactive practitioners seeking to up grade their credentials before reentering professional practice.

More specifically, increased demand for MT students may be attributed to three primary factors, namely: (a) high attrition rate of practicing technologists (Hajek, 1982; Irwin, 1983; & Myers, Bronstein, & Vojir (1982), (b) increased demand for laboratory personnel to handle changes in technology (Bamberg, 1992; Barros, 1988; Castleberry et al, 1991; Hallam, 1990; Martin, 1988; Mayer, 1987;

TABLE 4.1
 AGE AND GENDER OF ENTERING MT STUDENTS
 (1985-1991)

Program	Gender					Age		
	N	Female	%	Male	%	Mean	SD	Range
1985-1987	103	88	86	14	14	22.48	2.02	20-32
1988-1991	147	130	88	17	12	23.15	3.04	20-42
1985-1991	250	219	88	31	12	22.83	2.68	20-42

TABLE 4.2
 MARITAL STATUS OF ENTERING MT STUDENTS
 (1985-1991)

Marital Status	<u>1985-1987</u>		<u>1988-1991</u>		<u>1985-1991</u>	
	N	%	N	%	N	%
Single	94	91	104	75	198	82
Married	9	9	35	25	44	18
Total	103	100	139	100	242	100

& Summers, Rudman, Simpson, & Weed, 1990), and (c) a continuing decline among traditional students and the number of medical technologist applicants and graduates (Castleberry, 1989; Cherney & castleberry, 1987, 1989, 1991; French & Elkins, 1982; Karni & Seibert, 1988; Putka, 1989; Myers et al, 1982; Statland, 1992; & Snyder, 1992).

In the mid 1980's, fear of AIDS was found by researchers to be an additional reason for the decline in the number of applicants to health professions generally and particularly a decrease in laboratory personnel (Hallam, 1990; Martin, 1988; & Mayer, 1986): There were 5,996 medical technologist graduates in 1980 and 1981 as compared to 3,969 in 1986-1987 (Martin, 1988).

Medical technology educators and laboratory managers have adopted and implemented different approaches both to the staffing shortage and the decreased applicant pool (Martin, 1988; & Neibauer, 1989). These included: targeting older students who hold a college degree in an appropriate field (Flynn, 1990), and recruiting and retaining laboratory personnel who left the profession (Best, 1990; LeGrys, 1992; Pellerin & Renius, 1988; & Martin, 1988). To attract nontraditional students, educators have provided financial assistance, part-time jobs, and flexible class schedules (Flynn, 1990; & Martin, 1988). Managers also have offered,

among other things, fringe benefits, increased salaries, flexible work schedules, facilities or reimbursement for child care (Martin, 1988), and retraining programs to upgrade skills of under-prepared laboratory personnel now in service (Pellerin & Renius, 1988). As shown in Table 4.3, these incentives may be working, particularly among four year college graduates where the number of students has more than doubled and the percent of college graduates entering MT training program (4+1 option) has increased from one third in 1985-87 to over one-half of all trainees (1988-91).

2. Students' Performance on Admission Criteria

In addition to letters of recommendation, three admission criteria typically are employed by the six MT programs. These are: (a) pre-professional total grade point average (PPTGPA), (b) pre-professional science courses grade point average (PPScGPA), and (c) admission interview score (AIScr).

In over 67% of the programs an admission interview was required, but in only 32% of the programs was a standardized set of interview questions employed (Garza et al, 1976). Admission interviews are used by MT educators to learn more about their prospective students and to closely observe the applicant's interpersonal skills (Crocker, 1979). In 1983, Vojir and Bronstein compared their existing interview form

TABLE 4.3

MT PROGRAM OPTIONS: 1985-1991

Program Option	<u>1985-1987</u>		<u>1988-1991</u>		<u>1985-1991</u>	
	N	%	N	%	N	%
3 + 1	71	67	61	44	132	55
4 + 1	32	33	78	56	110	45

with a standardized and objective form. They reported higher interview scores for the new form (n= 17, Mean= 84.7, SD= 7.3) than those for the old form (n=25, Mean= 78.6, SD= 6.4).

The six programs included in the study used a set of about twenty interview questions focusing heavily on student's personality, interest in a career in medical technology, verbal and written abilities, communication and interaction with others, interest and prior knowledge of the MT profession, and knowledge of basic mathematical computations. One possible explanation for 1985-1987 students outscoring their 1988-1991 counterparts on admission interview, is the fact that "3+1" option students chose medical technology as their primary goal, while the 4 year college graduates were pursuing career objectives before they decided to apply for MT professional education. Those without a college degree devoted more time and effort preparing for admission to reputable MT training programs to avoid further delays and being forced to graduate with a degree not in medical technology.

In the literature, it was reported by Garza et al (1976) that over 93% of MT programs (including the six included in the study) required pre-professional science GPA (PPScGPA) and all programs (100%) required pre-professional

total GPA (PPTGPA) for admission. They found that two thirds of the 82 programs surveyed admitted students with 2.5 GPA or greater and about 29% admitted students with 2.5 or less total GPA. No evidence that students with a PPTGPA or PPScGPA of 2.0 or less were admitted (Garza et al, 1976; Love et al, 1982; & Karni and Siebert, 1988).

However, in this sample, 16.9 % of students were admitted with 2.0 to 2.5 PPTGPA, 12% with 2.0 to 2.5 (PPScGPA). One student was admitted with 2.17 PPTGPA and 2.02 PPScGPA (Table 4.4). Presumably, something in the admissions interview persuaded program administrators to admit those with marginal PPTGPA or PPScGPA.

In this sample, as summarized in Table 4.4, there was a decline in admission interview scores (AIScr), but contrary to reports in the literature, no material change was observed between 1985-1987 and 1988-1991 either in PPTGPA or PPScGPA. Accordingly, the study sample reflects the similar admission standards as those reported by others in the literature.

3. MT Students' Academic Performance During Professional Year Training

Three performance characteristics were examined. These are: (a) performance in the four key professional courses, as measured by numerical grades, (b) scores on the

TABLE 4.4

STUDENTS PERFORMANCE ON ADMISSION CRITERIA: 1985-1991

	<u>Cohort 1</u> 1985-1987	<u>Cohort 2</u> 1988-1991	<u>Total</u> 1985-1991
<u>AIScr</u>			
Mean	84	76	79
SD	9.5	13.4	12.6
Range	55-98	44-98	44-98
N	66	99	165
<u>PPTGPA</u>			
Mean	3.02	2.97	2.99
SD	.5	.4	.4
Range	2.30-4.00	2.17-4.00	2.20-4.00
N	103	122	225
<u>PPScGPA</u>			
Mean	2.91	2.89	2.90
SD	.5	.4	.4
Range	2.02-4.00	2.02-4.00	2.02-4.00
N	103	122	225

AIScr= admission interview score, PPTGPA= pre-professional total GPA, PPScGPA= pre-professional science GPA,.

comprehensive examination administered immediately at conclusion of formal training, and (c) grade point average on professional year courses and on combined professional and pre-professional courses.

a. Performance in Professional Courses

As evident in Table 4.5, students in the 1988-1991 cohort did as well or better than their 1985-1987 counterparts on all theory and practicum courses, except microbiology theory. Two factors may have contributed to these differences, namely: (1) Program changes in curriculum, instruction, and examinations in 1987 at three of the six MT programs. These changes were designed to emphasize a competency based education and training. Students entering these programs after 1987 well may have benefitted from these program improvements. (2) A significantly greater proportion of students entering the professional year of MT-Training after 1987 already had earned a college degree and might reasonably be expected to outperform their younger counterpart. Students with a prior degree in most cases also will have completed at least one college course in microbiology and/or immunology before entering their MT professional year of training. Indeed, statistically significant differences were computed between groups of students with a prior college degree and those

TABLE. 4.5

THEORY, PRACTICA, AND COMBINED NUMERICAL GRADES
IN PROFESSIONAL MT COURSES

Course	1985-1987 (N=103)			1988-1991 (N=147)			<u>Differences</u>	
	Mean	SD	Range	Mean	SD	Range	F	p
<u>Theory</u> (four major theory courses corresponding to areas examined on the MT-ASCP examination)								
T-HEM	86	5.2	71-96	87	6.0	73-100	2.18	.140
T-CHM	88	5.5	70-100	88	5.9	66-100	.07	.787
T-MIC	89	5.0	75-98	87	6.3	70-98	4.54	.033*
T-BBK	87	5.8	70-99	88	6.4	71-100	1.16	.281
<u>Practica</u> (four major practica corresponding to areas examined on the MT-ASCP examination)								
P-HEM	88	5.4	73-99	89	5.0	76-99	2.11	.146
P-CHM	89	5.7	70-100	90	5.1	79-100	2.81	.093
P-MIC	90	5.2	77-99	91	4.8	75-99	6.07	.014*
P-BBK	90	5.2	77-99	92	4.9	75-100	9.04	.003*
<u>Combined</u> (Combination of the selected theory and practicum courses above)								
Cm-HEM	87	5.3	63-97	88	5.1	76-98	2.74	.098
Cm-CHM	88	5.0	74-99	89	4.6	78-99	1.23	.268
Cm-MIC	89	4.5	89-98	89	4.6	76-99	0.00	.993
Cm-BBK	89	5.0	74-98	90	4.6	81-100	5.29	.021*
<u>Overall Average</u> (Includes all theory and practicum courses taken during professional year)								
T-OAS	87	4.9	77-97	88	5.2	76-98	0.22	.640
P-OAS	88	5.0	77-98	91	4.3	77-99	12.49	.000

* p<.05

T= Theory grades, P= practicum grades, Cm= combined theory and practicum grades, HEM= hematology, CHM= clinical chemistry, MIC= microbiology, BBK= blood bank, T-OAS= Theory overall average numerical grades, P-OAS= practicum overall average numerical grades.

admitted after three years of college in microbiology theory ($M_1= 87, M_2= 89, F= 4.66, n= 250, p<.05$) and practicum ($M_1= 89, M_2= 92, F=12.34, n= 250, p<.0005$), and overall numerical average of all MT theory ($M_1= 86, M_2= 89, F= 13.72, n= 250, p<.0005$) and practicum ($M_1= 88, M_2= 91, F= 16.25, n=250, p<.0005$) courses.

b. Performance on Comprehensive Examination

A "mock" comprehensive examination (arguably a model of the MT-ASCP certification examination) was administered in all six MT programs. Mean scores on the comprehensive examination (C-Exm) of 66 percent were computed for both cohorts (column 1, Table 4.6). In each cohort, total scores on the comprehensive examination were higher than the "passing" scores set by the six MT programs. Five MT programs set the passing level at 60 percent and one at 65 percent. These passing scores were comparable to those reported in the literature (Kiehn & Maehara, 1989; and Love et al, 1982). The highest score was 88, recorded for each cohort. But the lowest score recorded in 1985-1987 was 48 and the lowest in 1988-1991 only 33. Low C-Exm scores may be attributed to the fact that five of the six programs did not require students to pass the examination before graduation. Some students may have taken it without adequate preparation. One program required all students to

TABLE 4.6

COMPREHENSIVE EXAMINATION SCORES,
PROFESSIONAL AND FINAL GPAS

Year	Comprehensive Examination total scores	Professional GPA	Final GPA
<u>1985-1987</u>			
N	90	103	103
Mean	66.4	3.03	3.01
SD	9.37	.44	.41
Range	48-88	2.09-3.96	2.25-3.92
<u>1988-1991</u>			
N	108	122	122
Mean	66.3	3.27	3.04
SD	9.94	.42	.37
Range	43-88	2.35-4.00	2.35-3.89
<u>Differences</u>	NS	F= 16.88 P< .0001	NS

pass the examination with 65 percent prior to graduation. Scores were used to adjust the final grade in each corresponding regular course by 10 percent. Another program did the same in the past but discontinued that practice in 1987.

c. Professional and Final Grade Point Averages

The mean grade point average (GPA) over all professional courses in the one year programs in 1988-1991 was 3.03, a fraction (.24) higher than the comparable mean of students in the 1985-1987 group. Difference was significant at the .0001 level ($F= 16.88, P<.0001$). Once again, the 1988-1991 group may have benefitted from the presence of more "4+1" students who, because of their greater academic experience, may have adopted more readily to the professional years of training. The 1988-1991 students also may have benefitted from a newly introduced competency-based curriculum.

4. Performance on the MT-ASCP Certification Examination

MT-ASCP mean sub-scores in hematology, chemistry, blood bank, and microbiology were statistically equivalent for both samples, except, as demonstrated in Table 4.7, in microbiology. This is consistent with theory course grades where the 1985-1987 group outscored their 1988-1991 cohort

TABLE 4.7

TOTAL SCORES AND SUB-SCORES ON THE MT-ASCP EXAMINATION

score	1985-1987 (N=103)			1988-1991 (N=147)			differences	
	Mean	SD	Range	Mean	SD	Range	F	p
HEM	73	12.4	41-92	73	11.3	41-95	.00	.986
CHM	67	10.9	35-87	67	10.7	39-93	.01	.917
MIC	71	9.8	43-93	68	10.7	34-95	5.53	.019
BBK	71	12.5	38-100	70	13.3	33-100	.68	.409
Total	70	8.7	46-90	488	72.3	312-723		

HEM= hematology, CHM= clinical chemistry, MIC= microbiology,
 BBK= blood bank

($M_1 = 71$, $M_2 = 68$, $F = 5.53$, $p < .02$). As shown in Table 4.5. The application, in 1988, of a new method for selecting items and reporting scaled scores (RASCH Rating Scale Model) was another factor that may have contributed to the better performance by the 1988-1991 cohort.

Summary

Although the 1988-1991 cohort at time of their admission interview (Table 4.4) did not appear to be as promising as their 1985-1987 counterparts they consistently equalled or exceeded 1985-1987 groups' performance in both theory course and practica (Table 4.5), total scores on the comprehensive examination (Table 4.6), both professional year GPA and final GPA (Table 4.6), as well as the sub-section scores on the MT-ASCP certification examination (Table 4.7).

The one unexplained exception is that of microbiology theory. The 1985-1987 group consistently outscored the 1988-1991 group on all measures of microbiology, including numerical grades, and on the microbiology sub-section of the MT-ASCP certification examination. This occurred despite changes in curriculum and composition of student body that seemed otherwise to have favored the 1988-1991 group's performance.

Differences in performance, therefore, possibly may be explained, at least in part, by the greater number of 4+1 students in the 1988-1991 group, the introduction of a new curriculum in 1987 in three of the six institutional programs, and the change in score reporting method in 1988.

**PART B. ACCOUNTING FOR DIFFERENCES IN STUDENT PERFORMANCE
ON THE MT-ASCP CERTIFICATION EXAMINATION**

1. Effects of Professional Year of Training on MT-ASCP
Total Scores

The main question to be answered by this study was: which of seventeen student performance variables identified during the MT professional year of training, best accounted for differences in total scores on the MT-ASCP certification examination within each of the two cohorts of students and under study. The stepwise, forward inclusion multiple regression analysis program of the Number Cruncher Statistical System was used to address this question.

The 17 variables were correlated to determine whether results from regression procedure might be confounded by multicollinearity. The correlation matrices for the two cohorts are presented in Appendix C.

When the 17 predictor variables for the 1985-1987 cohort were entered into the regression equation, four of

the 17 performance variables were selected by the procedure as significant predictors of the 1985-1987 total percent scores. These variables were: (P-OAS) overall average for all practicum section grades, (C-Exm) comprehensive examination scores, (F-GPA) final (professional and preprofessional) GPA, and (Pr-GPA) professional year GPA. They combined to account for 45.3 percent of the total variance in the MT-ASCP total percent scores for those years ($F=17.6$, $n= 90$, $p<.0001$) (Table 4.8).

When the same 17 variables for the 1988-1991 cohort were entered into the regression model, a different set of predictors was identified for the 1988-1991 total scores. These were: overall average theory (T-OAS) and practicum (P-OAS) section grades, total comprehensive examination scores (C-Exm), and clinical chemistry practicum (P-CHM) grades. The four variables yielded, collectively, an F-ratio of 27.4 ($p<.0001$) and accounted for 51.87 percent of the total variance in the criterion (Table 4.9).

The last variable entered into the equation (P-CHM) resulted in an increase in error variance. Therefore, an F test was performed to determine if the addition of P-CHM significantly enhanced the regression coefficient.

The calculated F value for the addition of P-CHM was 3.43 (df 4, 107), which demonstrated that the contribution of P-CHM to the regression coefficient was not significant

TABLE 4.8

PREDICTION OF 1985-1987 MT-ASCP PERCENT SCORES

Step Variable	Beta	R	R ²	Increase in R ²	F	df	p
1 P-OAS	.743	.516	.266	NA	31.92	1,88	.0001
2 C-Exm	.341	.615	.378	.112	26.46	2,87	.0001
3 F-GPA	-7.526	.648	.420	.042	20.78	3,86	.0001
4 Pr-GPA	6.461	.673	.453	.032	17.59	4,85	.0001

P-OAS= overall average practicum sections grades, C-Exm= comprehensive exam score, F-GPA= final GPA, and Pr-GPA= professional year GPA.

PREDICTION EQUATION FOR MT-ASCP TOTAL PERCENT SCORE (Y'):

$$Y' = -14.508 + .743 (P-OAS) + .341 (C-Exm) - 7.526 (F-GPA) + 6.461 (Pr-GPA)$$

TABLE 4.9

PREDICTION OF 1988-1991 MT-ASCP SCALED SCORES

Step Variable	b	R	R ²	F	df	p
1 T-OAS	.4370	.589	.3581	58.29	1,106	.0001
2 C-Exm	.3577	.697	.4855	34.68	2,105	.0001
3 P-OAS	.2258	.709	<u>.5025</u>	34.68	3,104	.0001
4 P-CHM	.1586	.720	.5187	27.40	4,103	.0001

T-OAS= overall theory average theory sections grades, C-Exm= comprehensive exam, P-OAS= practicum sections overall average grades, and P-CHM= practical chemistry grades.

PREDICTION EQUATION FOR MT-ASCP TOTAL SCALED SCORE (Y'):

$$Y' = -360.818 + 6.037 (T-OAS) + 4.113 (P-OAS) + 2.521 (C-Exm)$$

($p < .05$). Therefore, the clinical chemistry practicum (P-CHM) variable was dropped from the equation. As shown in Table 4.9, the remaining three variables accounted for 50.25 percent of the total variance in the 1988-1991 MT-ASCP total scaled scores, A greater R^2 value than realized by the 1985-1987 cohort.

2. Added Effects of Pre-professional Experience on MT-ASCP Total Scale Scores

This section addresses the question: Would the inclusion of selected pre-professional performance variables with the three significant predictors among the professional year variables improve upon the 50.2% of total variance expected in the total MT-ASCP scaled scores in 1988-1991, the more efficient of the two cohorts?

Nine pre-professional performance variables were available in the study. They were reduced by stepwise, forward regression to five significant predictors of MT-ASCP total scale scores in the 1988-1991 cohort. These are: preprofessional total GPA (PPTGPA), admission interview scores (AIScr), age, employment during professional year training (Empl), and prior college degree (PrDgr) earned before entering MT professional training program. Table 4.10 demonstrates that these five pre-professional

performance variables, independent of professional year training, explained 38.5% of the total variance in 1988-1991 MT-ASCP total scaled scores ($F= 11.6, n= 99, p<.0001$).

In other words, the students who were most likely to do well on the MT-ASCP certification examination in 1988-1991, all other factors being equal, were older students with a college degree and high grades in undergraduate, pre-professional studies, who also interviewed well during admission, and were employed in the laboratory during their full time professional studies.

When the five pre-professional variables in Table 4.11 were combined with the three significant predictors among professional year performance variables ((T-OAS) overall average theory and practicum (P-OAS) sections' grades, and (C-Exm) comprehensive examination scores), the stepwise, forward inclusion procedure reduced the eight variables to six significant predictors. These were: pre-professional total GPA (PPTGPA), age, admission interview scores (AIScr), prior college degree earned before entering MT professional year training program (PrDgr), and laboratory employment during professional-year training (Empl), as shown in Table 4.11.

As demonstrated in Table 4.11, an additional 10.1% of the total variance in 1988-1991 MT-ASCP scaled scores was

TABLE 4.10

PRE-PROFESSIONAL PERFORMANCE AND PERSONAL VARIABLES
WITH 1988-1991 MT-ASCP TOTAL SCALED SCORES

Step	Variable	b	R	R ²	F	df	p
1	PPTGPA	69.875	.461	.212	26.18	1,97	.0001
2	Age	5.140	.522	.272	17.95	2,96	.0001
3	AIScr	1.616	.553	.306	13.96	3,95	.0001
4	PrDgr	-28.914	.596	.355	12.93	4,94	.0001
5	Empl	32.726	.620	.385	11.64	5,93	.0001

PPTGPA= preprofessional total GPA, AIScr= admission interview scores, PrDgr= no prior college degree earned before entering MT professional training program, Empl= employment during professional-year training

TABLE 4.11

PRE-PROFESSIONAL AND PROFESSIONAL PERFORMANCE
VARIABLES WITH 1988-1991 MT-ASCP TOTAL SCALED SCORES

Step	Variable	b	R	R ²	F	df	P
1	T-OAS	6.543	.652	.4248	42.10	1,58	.0001
2	PrDgr	-26.412	.709	.5029	28.33	2,57	.0001
3	Age	4.886	.730	.5331	20.93	3,56	.0001
4	C-Exm	1.794	.746	.5573	17.00	4,55	.0001
5	P-OAS	4.682	.762	.5806	14.67	5,54	.0001
6	AIScr	-1.199	.782	.6113	13.63	6,53	.0001

T-OAS= overall theory average sections grades, PrDgr= prior college degree earned before entering MT professional training program, C-Exm= comprehensive exam score, P-OAS= overall average practicum sections grades, AIScr= admission interview scores.

explained by the inclusion of selected pre-professional performance variables ($F= 13.19$, $n= 59$, $p<.0001$).

The single most influential variable (i.e. the one entered first in the forward inclusion model) was the (T-OAS), the overall numerical average grade for all theory courses in the professional year of study. It accounted for 42% of the total variance in the total scale scores of the 1988-1991 version of the MT-ASCP examination. Professional practica grades and the comprehensive examination scores from the professional year of study added 4.75% to the 42.5% explained by T-OAS alone, or a total contribution to total variance from the professional predictors of 46.8%. The three significant pre-professional variables contributed 14.3%.

Clearly, the MT-ASCP examination reflects the academic content of the professional year of studies. But it also is sensitive to certain of the personal characteristics of students, particularly those most closely associated with the 4+1 option programs.

3. "Early Indicators" of Total MT-ASCP Examination Scores and Sub-Scores

This section is devoted to a series of secondary theses of interest principally to the faculty and administrators of

the six MT programs. The results here add little to the development of the main thesis in the preceding two sections. They are included, however, for their potential interest to program operators. To determine the extent to which so called "early indicators" can predict students' total and sub-section scores on the MT-ASCP examination, both correlation analysis and stepwise, forward inclusion multiple regression analysis were employed to select the best predictor variables among those available at each decision point.

Students' Numerical Grades on Key Courses and Their Scores on Corresponding Sub-Sections of the MT-ASCP Examination

Correlation analysis was used to evaluate the relationship between students performance in professional course work and scores on the MT-ASCP examinations. The first research question in Chapter 1 asked what is the relationship between students' theory or combined numerical grades in hematology, clinical chemistry, microbiology or blood bank courses, and matching sections of MT-ASCP sub-scores for 1985-1987 and 1988-1991 samples? Four hypotheses (H_{1a} , H_{1b} , H_{2a} , and H_{2a}) were examined in response.

MT-ASCP Sub-scores And Theory or Combined Course Numerical Grades

Hypothesis 1_a states that there is no relationship between hematology, clinical chemistry, microbiology, or blood bank **theory** grades for **1985-1987** graduates and the hematology, blood bank, chemistry, or microbiology sub-scores on the MT-ASCP certification exam.

Correlation results for 1985-1987 MT-ASCP hematology, chemistry, microbiology, chemistry, or blood bank sub-scores with hematology, clinical chemistry, blood bank, and microbiology theory scores are summarized in Table 4.12. Small but statistically significant ($p < .05$) coefficients of correlation were obtained between MT-ASCP examination chemistry sub-scores and clinical chemistry theory grades ($r = .27$), microbiology sub-scores with the theory grades ($r = .24$), and blood bank sub-scores with theory grades ($r = .31$). No significant correlation ($p < .05$) was produced between MT-ASCP examination hematology sub-scores and hematology theory grades. Since three out of the four reported correlations were significant, hypothesis H_{1a} was partially rejected.

Hypothesis 1_b states that there is no relationship between hematology, clinical chemistry, microbiology, or blood bank **theory** grades for **1988-1991** graduates and the

hematology, blood bank, chemistry, or microbiology sub-scores on the MT-ASCP certification examination.

By contrast, MT-ASCP sub-scores for 1988-1991 produced, a moderate as well as statistically significant relationship with theory grades for each and all of the selected courses (Table 4.12). Accordingly, hypothesis 1_b was rejected.

Hypothesis 2_a states that there is no relationship between the numerical grades in the combined theory and practicum courses in hematology, clinical chemistry, microbiology, or blood bank for 1985-1987 graduates and the sub-scores on corresponding sections of the MT-ASCP examination. Four correlation coefficients were computed. Table 4.13 indicates that coefficients of correlation for 1985-1987 were small, but statistically significant ($p < .05$) in all cases except hematology. Therefore, hypothesis 2_a was partially rejected.

Hypothesis 2_b states that there is no relationship between the numerical grades in the combined theory and practicum courses in hematology, clinical chemistry, microbiology, or blood bank for 1988-1991 graduates and the sub-scores for corresponding sections on the MT-ASCP certification examination.

As shown in Table 4.13, a moderately positive and statistically significant coefficients of correlation was

TABLE 4.12

CORRELATION OF MT-ASCP SUB-SCORES WITH THEORY GRADES
FOR 1985-1991

Theory scores	1985-1987 (N=103)		1988-1991 (N=147)	
	r	r ²	r	r ²
<u>Hematology</u>	.1555	.0242*	.4191	.1756
<u>Clinical Chemistry</u>	.2686	.0722	.4749	.2284
<u>Microbiology</u>	.2370	.0562	.2785	.0776
<u>Blood Bank</u>	.3068	.0941	.3932	.1594

* Not significant at p <.05

TABLE 4.13

CORRELATION OF MT-ASCP SUB-SCORES WITH COMBINED THEORY AND PRACTICUM NUMERICAL GRADES FOR 1985-1991

Theory scores	1985-1987 (N=103)		1988-1991 (N=147)	
	r	r ²	r	r ²
<u>Hematology</u>	.1965	.0386*	.3785	.1435
<u>Clinical Chemistry</u>	.2425	.0588	.4470	.1998
<u>Microbiology</u>	.2710	.0735	.4080	.1665
<u>Blood Bank</u>	.3480	.1211	.3776	.1426

* Not significant at p <0.05

computed for each and of the all four 1988-1991 combined grades and the corresponding MT-ASCP examination sub-scores. Accordingly hypothesis 2_b was rejected.

The values for the coefficient of determination (r^2) in columns two and four of tables 4.12 and 4.13 indicate that a very small and statistically significant amount of the total variance in all but the hematology sub-scores of the MT-ASCP examination for 1985-1987 was explained by corresponding course grades. That is to say; there was a relatively poor relationship between the content measured by the MT-ASCP examination in 1985-1987 and the curriculum content for the same years of corresponding theory and practicum courses, even though the similarities in content in all cases except hematology were not chance occurrence. On the other hand, the 1988-1991 sub-scores accounted for more of the variance in numerical grades in each of the corresponding theory and practicum courses. This suggests that the 1988-1991 versions of the certification examination, with their scaled cutoff passing scores, were better measures of course content than the corresponding examinations of 1985-1987. In this sense, the case for content validity would seem to be far stronger for the 1988-1991 examination, as administered, than those administered in 1985-1987. Since course content accounted for a statistically significant

portion of total variance in the sub-scores of all but one corresponding section of the MT-ASCP examination in both 1985-1987 and 1988-1991, a case also might be argued for predictive as well as content validity.

MT-ASCP TOTAL PERCENT AND SCALE SCORES WITH ALL PREDICTORS

To answer the question, what if any relationship existed between the 17 measures of students' performance during the professional year of training and their total scores on the Mt-ASCP certification examination? Two hypotheses were examined to determine these relationships.

Hypothesis H_{3a} stated that there is no statistically significant relationship between any of the student performance variables and total percent score on the MT-ASCP examination for 1985-1987 graduates.

Hypothesis H_{3b} states that there is no statistically significant relationship between any of the student performance variables and total scaled score on the MT-ASCP examination for 1988-1991 graduates.

Separate correlation analyses were performed for 1985-1987 and 1988-1991 and reported in Table 4.14. The Table shows the coefficients of correlation (r) and determination (r^2) for each and all seventeen variables with MT-ASCP total examination scores for 1985-1988 and 1988-1991. All student

TABLE 4.14

CORRELATION OF MT-ASCP EXAMINATION TOTAL SCORES
WITH EACH STUDENT PERFORMANCE VARIABLE

Predictor Variable	<u>1985-1987</u> (N=103)		<u>1988-1991</u> (N=147)	
	r	r ²	r	r ²
<u>Theory grades</u>				
Hematology	.33	.11	.56	.32
Clinical Chemistry	.34	.12	.58	.33
Microbiology	.31	.09	.40	.16
Blood Bank	.37	.13	.46	.21
<u>Practicum grades</u>				
Hematology	.43	.18	.48	.23
Clinical Chemistry	.27	.07	.35	.12
Microbiology	.26	.07	.39	.16
Blood Bank	.29	.08	.33	.11
<u>Combined grades</u>				
Hematology	.37	.14	.57	.33
Clinical Chemistry	.34	.12	.57	.32
Microbiology	.32	.10	.48	.23
Blood Bank	.37	.13	.50	.25
<u>Overall Averages</u>				
Theory Grades	.32	.10	.60	.36
Practicum Grades	.42	.18	.51	.26
<u>Comprehensive Exam*</u>				
	.44	.20	.51	.26
<u>Grade Point Averages</u>				
Professional	.44	.19	.49	.24
Final**	.23	.05	.50	.25

All correlations are significant at $p < .05$

* n = 90 for 1985-1987 and n = 107 for 1988-1991

** n = 122 for 1988-1991

performance variables correlated positively with total MT-ASCP scores and were significant at $P < .0001$ for 1988-1991. For 1985-1987 graduates, a significant ($p < .005$) correlation was found between student performance variables and MT-ASCP examination percent scores with the exception of clinical chemistry practicum, microbiology practicum, and final GPA, which were significant at $p < .05$.

Although statistically significant, the r -values for 1985-1987 were smaller than the moderate values computed for 1988-1991. A better relationship existed between students' performance on selected professional MT courses and the MT-ASCP total scaled scores in 1988-1991 than the with MT-ASCP total percent scores of 1985-1987. Accordingly, hypotheses 3_a and 3_b were rejected.

Predicting Performance on the MT-ASCP Examination at Different Points During MT Professional Year Training

The third question seeks to identify the best equation to predict scores on the MT-ASCP certification examination based on information available at different decision points in students' professional year of preparation. These stages are summarized in Table 4.15.

All students completed one different theory course and each student completed one different practicum at each

Table. 4.15

FLOW CHART OF MT STUDENT PERFORMANCE AT FIVE MAJOR POINTS DURING THE PROFESSIONAL YEAR

POINT (1)	* <u>Theory lecture 1 + Practicum rotation 1</u> 3 Months	.	v
POINT (2)	<u>Theory lecture 2 + Practicum rotation 2</u> 5 1/2 Months	.	v
POINT (3)	<u>Theory lecture 3 + Practicum rotation 3</u> 8 Months	.	v
POINT (4)	<u>Theory course 4 + Practicum course 4</u> <u>+ Comprehensive examination (total)</u> 10 1/2 Months	.	v
POINT (5)	** <u>Cm-Scr + T-OAS + OPScr + Pr-GPA + F-GPA</u> 11 Months	.	v
	<u>Minor professional rotations (Immunology, Body fluids, Education, Independent study, Management, and Education)</u> 12 Months	.	v
	<u>MT-ASCP BOARD CERTIFICATION EXAMINATION</u> 13 Months	.	v
			Graduation

* The four major lectures (didactic), and practicums are: hematology (HEM), chemistry (CHM), microbiology (MIC), & blood bank (BBK).

1. Theory lectures (1, 2, 3, and 4):

- a. One theory lecture is given at each POINT.
- b. The lecture could be in either one of the four subjects HEM, CHM, MIC, or BBK.

2. Practicum rotations (1, 2, 3, & 4):

- a. Students are assigned to different practicum rotation at each point.
- b. In practicum (1), students are rotated through either HEM, CHM, MIC, or BBK.
- c. Practicum (2) includes one other of HEM, CHM, MIC, and BBK, and Practicum rotations continue until all four have been completed by each student.

** Computed by the researcher: T-OAS= theory overall average score, P-OAS= practical overall average score, F-GPA= final grade point average, Pr= professional GPA, Cm-Scr= combined HEM, CHM, MIC, and BBK scores.

point. At the end of point four, all students completed the four major theory and practicum courses included in the study (hematology, clinical chemistry, microbiology, and blood bank) and completed the comprehensive examination as well. Once students completed their minor professional rotations, not included in the study, but contributed to their professional and final grade point averages, all professional MT theory and practicum courses were completed (point 5), combined (theory and practicum) grades, overall numerical average grades for all theory and practicum courses, and professional and final grade point averages were computed.

Two hypotheses (Hypothesis 4_a and Hypothesis 4_b) were examined using stepwise, forward regression analysis. A separate regression equation was examined using data available at each of the five major decision points as independent variables and total scores from the 1985-1987 and the 1988-1991 MT-ASCP examination as criterion variables. The hypotheses were:

Hypothesis 4_a: There is no significant multiple-linear regression equation based on available data from students' professional year of preparation that can predict total percent scores on the MT-ASCP certification examination for the years 1985-1987, and

Hypothesis 4_b: There is no significant multiple-linear regression equation based on available data from students' professional year of preparation that can predict total scaled scores on the MT-ASCP certification examination for the years 1988-1991.

To test these hypotheses, three separate models of the stepwise regression were examined using the total 1985-1987 and 1988-1991 MT-ASCP examination scores as criterion.

In the first model (points 1 through 3), theory and practicum grades for the different rotations in hematology (T-HEM), microbiology (MIC), blood bank (T-BBK), and clinical chemistry (T-CHM) course were entered. The second model contained those independent variables available at point 4. These included the four theory and practicum grades from plus the comprehensive examination scores. In the third model, combined (theory and practicum) grades for the four MT courses and the comprehensive examination scores were entered.

Model 1

Point 1-3: Theory and Practicum Scores and MT-ASCP Total Scores

Theory and practicum numerical grades for each of the four major professional MT courses were regressed with MT-ASCP total scores for each of the two cohorts (Table 4.16). Regression equations for each predictor variable with total MT-ASCP total scores from each cohort are presented in Appendix A. These equations were computed to avoid using 16 possible theory and practicum combinations.

Table 4.17 shows the stepwise regression statistics for points in time 1-3. The Practicum in the hematology was the only statistically significant predictor of 1985-1987 MT-ASCP total percent scores in the regression equation. It produced a significant ($p < .0001$) F-ratio of 22.9 and accounted for 18.5 percent of the total variance in 1985-1987 MT-ASCP total percent scores.

When theory and practical grades from step 1-3 were entered in a regression equation for 1988-1991 MT-ASCP scaled scores, the final step in the forward inclusion, stepwise procedure, produced three predictor variables, namely: clinical chemistry theory, hematology theory, and microbiology practicum. Chemistry theory grades entered the

TABLE 4.16

PREDICTION OF 1985-1991 MT-ASCP TOTAL SCORES
WITH THEORY AND PRACTICUM NUMERICAL GRADES

Predictor Variable	b	r	r ²	F	df	p
(1985-1987)						
<u>Theory grades</u>						
Hematology	.559	.33	.11	12.7	1,102	.0050
Clinical Chemistry	.544	.34	.12	13.4	1,102	.0001
Microbiology	.525	.31	.08	10.4	1,102	.0050
Blood bank	.543	.37	.13	15.7	1,102	.0001
<u>Practicum grades:</u>						
Hematology	.682	.43	.18	22.9	1,102	.0001
Clinical Chemistry	.418	.27	.07	8.2	1,102	.0500
Microbiology	.441	.26	.07	7.5	1,102	.0500
Blood bank	.482	.29	.08	9.3	1,102	.0050
(1988-1991)						
<u>Theory grades:</u>						
Hematology	.559	.57	.32	67.2	1,146	.0001
Clinical chemistry	.544	.58	.33	72.9	1,146	.0001
Microbiology	.525	.40	.16	28.0	1,146	.0001
Blood bank	.543	.46	.21	38.5	1,146	.0001
<u>Practicum grades:</u>						
Hematology	.682	.48	.23	44.2	1,146	.0001
Clinical Chemistry	.418	.35	.12	20.2	1,146	.0001
Microbiology	.441	.39	.16	26.9	1,146	.0001
Blood bank	.482	.33	.11	17.9	1,146	.0001

TABLE 4.17

PREDICTION OF 1985-1987 MT-ASCP EXAMINATION
TOTAL PERCENT SCORES: POINTS 1-3

Step	Variable	b	R	R ²	F	df	p
1	P-HEM	.682	.430	.185	22.92	1,101	.0001

P-HEM= hematology practicum grades.

PREDICTION EQUATION FOR MT-ASCP TOTAL PERCENT SCORE (Y'):

$$Y' = 9.76762 + 0.68158 (P-HEM)$$

equation first, followed by hematology theory and microbiology practicum. The three variables accounted for 41.7 percent of the total variance in MT-ASCP total scaled scores, and a significant ($p < .0001$) F-ratio of 34.11, as shown in Table 4.18.

It is interesting to note that hematology practicum grades for 1985-1987 was better predictor of MT-ASCP percent scores than hematology theory scores. This suggests that 1985-1987 students were better prepared for MT-ASCP exams by their practicum training in hematology than by the theory hematology course. On the other hand, for points in time 1-3, predictive equation for 1988-1991 MT-ASCP scores contained two theory and one practical scores. Moreover, comparison of the R^2 values in Table 4.18 shows that numerical grades in theory courses were better predictors of success in the 1988-1991 MT-ASCP examinations than grades in comparable courses in the 1985-1987 examinations.

Model 2

Point 4: Theory, Practica, and Comprehensive Examination Scores and MT-ASCP Examination Total Scores

After comprehensive examination scores were entered with theory and practicum grades in the second model, three

TABLE 4.18

PREDICTION OF 1988-1991 MT-ASCP EXAMINATION TOTAL
 SCALED SCORES: POINTS 1-3

Step Variable	b	R	R ²	F	df	P
1 T-CHM	4.41	.578	.334	72.89	1,144	.0001
2 T-HEM	2.80	.621	.386	45.33	2,143	.0001
3 P-MIC	2.87	.646	.417	34.11	3,142	.0001

T-CHM= chemistry theory grades, T-HEM= hematology theory grades, and P-MIC= microbiology practicum grades.

PREDICTION EQUATION FOR MT-ASCP TOTAL SCALED SCORE (Y'):

$$Y' = -404.975 + 4.408 (T-CHM) + 2.805 (T-HEM) + 2.870 (P-MIC)$$

predictors of 1985-1987 MT-ASCP total percent scores were selected in the equation. These predictors were: hematology practicum grades, comprehensive examination scores, and microbiology theory grades. Hematology practicum was the first to enter the prediction equation. A significant ($p < .0001$) F-ratio of 17.8 was yielded by the three variables and produced an R^2 value of .383, as shown in Table 4.19).

For 1988-1991 MT-ASCP total scaled scores, a regression equation with four predictors was computed ($p < .0001$). The four variables were: clinical chemistry, hematology, and blood bank theory grades and the comprehensive examination scores. Clinical chemistry was the first variable to enter the equation and produced an R^2 value of .275. A cumulative R^2 value of .496 was computed with all four variables in the equation, as summarized in Table 4.20.

Model 3

Combined Theory and practicum Grades and Comprehensive Examination Scores with MT-ASCP Examination Total Scores

From stage 4 of the professional year, computed combined grades were entered in a regression model in place of individual theory and practicum section grades, along with comprehensive examination scores. A model with three

TABLE 4.19

PREDICTION OF 1985-1987 MT-ASCP PERCENT SCORES: POINT 4

Step Variable	b	R	R ²	F	df	p
1 P-HEM	.642	.494	.244	28.46	1,88	.0001
2 C-Exm	.292	.597	.356	24.08	2,87	.0001
3 T-MIC	.286	.619	.383	17.81	3,86	.0001

P-HEM= hematology practicum grades, C-Exm= comprehensive exam, and T-MIC= microbiology theory grades.

PREDICTION EQUATION FOR MT-ASCP TOTAL PERCENT SCORE (Y'):

$$Y' = -30.828 + .286 (T-MIC) + .643 (P-HEM) + .292 (C-Exm)$$

TABLE 4.20

PREDICTION OF 1988-1991 MT-ASCP SCALED SCORES: POINT 4

Step	Variable	b	R	R ²	F	df	p
1	T-CHM	2.48	.525	.275	39.86	1,105	.0001
2	C-Exm	2.74	.661	.438	40.47	2,104	.0001
3	T-HEM	2.57	.688	.474	30.95	3,103	.0001
4	T-BBK	1.87	.704	.496	25.13	4,102	.0001

T-CHM= clinical chemistry theory grades, C-Exm= comprehensive examination scores, T-HEM= hematology theory grades, and T-BBK= blood bank theory grades.

PREDICTION EQUATION FOR MT-ASCP TOTAL SCALED SCORE (Y'):

$$Y' = 301.403 + 2.483 (T-CHM) + 2.746 (C-Exm) + 2.574 (T-HEM) + 1.875 (T-BBK)$$

variables was selected. Comprehensive examination scores were entered first, followed by combined microbiology and combined hematology grades. The three variables accounted for 32.2 percent of the total variance in MT-ASCP total percent scores. See Table 4.21.

The stage 4 variables accounted for six percent less total variance in MT-ASCP total percent scores than the stage 3 variables. The difference suggests that practicum and theory grades each has a unique relationship with the criterion.

After combined course grades and comprehensive examination scores were entered, three variables were included in the final equation for 1988-1991 scores. These variables were combined blood bank and hematology grades, and comprehensive examination scores. A statistically significant ($p < .0001$) cumulative R^2 value of .450 was computed (Table 4.22).

Again, as with 1985-1987 MT-ASCP scores, a smaller cumulative R^2 value of .454 was computed ($F = 21.2$, $p < .0001$, $n = 103$) when the combined course grades were substituted for theory and practica grades.

TABLE 4.21

PREDICTION OF 1985-1987 MT-ASCP PERCENT SCORES WITH
COMBINED THEORY AND PRACTICUM NUMERICAL GRADES AND
COMPREHENSIVE EXAMINATION SCORES

Step	Variable	b	R	R ²	F	df	p
1	C-Exm	.302	.445	.198	21.77	1,88	.0001
2	Cm-MIC	.450	.534	.285	17.36	2,87	.0001
3	Cm-HEM	.369	.567	.322	13.59	3,86	.0001

C-Exm= comprehensive examination scores, Cm-MIC=
microbiology combined theory and practicum grades , and
Cm-HEM= hematology combined theory and practicum grades.

PREDICTION EQUATION FOR MT-ASCP TOTAL PERCENT SCORE (Y'):

$$Y' = -21.817 + .302 (C-Exm) + .450 (Cm-MIC) + .369 (Cm-HEM)$$

TABLE 4.22

PREDICTION OF 1988-1991 MT-ASCP PERCENT SCORES WITH
COMBINED THEORY AND PRACTICUM NUMERICAL GRADES AND
COMPREHENSIVE EXAMINATION SCORES

Step Variable	b	R	R ²	F	df	P
1 Cm-HEM	4.936	.551	.304	45.81	1,105	.0001
2 C-Exm	2.14	.641	.410	36.22	2,104	.0001
3 Cm-BBK	3.59	.671	.450	28.09	3,103	.0001

Cm-HEM= combined hematology theory and practicum grades,
C-Exm= comprehensive examination scores, and Cm-BBK=
combined blood bank theory and practicum grades.

PREDICTION EQUATION FOR MT-ASCP TOTAL SCALED SCORE (Y'):

$$Y' = -411.259 + 4.936 (\text{Cm-HEM}) + 2.136 (\text{C-Exm}) \\ + 3.594 (\text{Cm-BBK})$$

Summary

The best combination of professional year predictors among the seventeen variables included in the study, explained only 50.2 percent of the total variance in MT-ASCP total scaled scores. This compares very favorably with results of earlier studies in the literature (Crews, 1980; Lunz, 1986; Rifken et al, 1981; & Wise, 1983). But it leaves about 50% of the of the total variance unexplained.

When comparing the results of the four stepwise regression analyses for 1985-1987 MT-ASCP total percent scores with those for 1988-1991 total scaled, larger R^2 values were computed for 1988-1991 MT-ASCP total scaled scores at all points in time: STEPS 1-5. This clearly and strongly suggest that 1988-1991 MT-ASCP certification examinations were more content valid than those given in 1985-1987.

As noted in chapter 2, pre-professional achievement and demographic variables have been identified as good predictors of MT-ASCP total percent scores (Lanier and Lambert, 1981; Lehman and Leiken, 1984; Love and Holter, 1982; & Rifken et al, 1981).

Although no hypotheses were advanced in this regard, further exploratory analyses were performed in search of unexplained variance. Specifically, demographic data for

the 250 MT students were used to determine the relationship, if any, between students pre-professional variables and MT-ASCP total scaled scores. These included:

1. The combined contribution of selected pre-professional demographic and performance variables to the prediction of 1988-1991 MT-ASCP total scaled scores.

2. The combined contribution of both professional year performance variables and preprofessional demographic and performance variables to the prediction of MT-ASCP scaled scores for 1988-1991 graduates.

The question of concern, however, was: would the inclusion of selected pre-professional variables to those significant predictors among the professional year variables improve upon the 50.2% of total variance explained in the total MT-ASCP scaled scores in 1988-1991. The regression of both significant professional performance variables and selected pre-professional variables and MT-ASCP total scaled scores produced an equation with three professional and three preprofessional variables. These were: overall average theory (T-OAS) and practicum (P-OAS) sections' grades, age, employment during professional training (Empl), and admission interview scores (AIScr). The six variables explained 61.13% of the total variance in the MT-ASCP total scaled score, an additional 11% of total variance explained

by the three professional performance variables alone.

CHAPTER V

SUMMARY, CONCLUSION, AND RECOMMENDATIONS

The purpose of this study was three-fold:

1. To determine the relationship between students' theory and combined theory and practicum grades in hematology, clinical chemistry, blood bank, or microbiology and corresponding MT-ASCP sub-scores for 1985-1987 and 1988-1991 graduates.

2. To investigate the relationship between MT-ASCP total percent scores for 1985-1987 and scaled scores for 1988-1991 with each predictor variable, and

3. To identify those predictors, singly or collectively, that best predict students' MT-ASCP scores at different points in time during their professional year.

Seventeen potential professional-year predictors were included in the study, some of which proved to be moderate predictors, of 1988-1991 total scaled scores and small predictors of 1985-1987 total percent scores. Eight research hypotheses were examined at $P < .05$ to answer those questions, and the following results were produced:

1. H_a : There is a significant relationship between clinical chemistry, microbiology, and blood bank theory numerical grades for 1985-1987 graduates and MT-ASCP sub-

scores for the same subject, but no significant relationship between hematology theory score and MT-ASCP hematology sub-score was demonstrated.

H_b : There is a significant relationship between hematology, clinical chemistry, microbiology, and blood bank theory numerical grades for 1988-1991 graduates and MT-ASCP sub-scores for the same subject.

2. H_a : There is a significant relationship between microbiology, clinical chemistry, and blood bank combined theory and practicum numerical grades for 1985-1987 graduates and MT-ASCP sub-scores for the same subject, but no demonstrable relationship existed between hematology combined theory and practicum grades and MT-ASCP hematology sub-score.

H_b : There is a significant relationship between hematology, blood bank, clinical chemistry, and microbiology combined theory and practicum numerical grades for 1988-1991 graduates and MT-ASCP sub-scores for the same subject.

3. H_a : There is a statistically significant relationship between each of the 17 student performance variables and total percent scores on the MT-ASCP examination for 1985-1987 graduates.

H_b : There is a statistically significant relationship between each of the 17 student performance

variables and total scaled scores on the MT-ASCP certification examination for 1988-1991 graduates.

4. H_a : There are four significant multiple linear regression equations that predict 1985-1987 graduates' total percent scores on the MT-ASCP examination at corresponding points in time during students' professional year training.

H_1 : There are four significant multiple linear regression equations that predict 1988-1991 graduates' total scaled scores on the MT-ASCP examination at corresponding points in time during professional-year training.

Significant correlation was computed for each of the seventeen predictor variables and total scores on the MT-ASCP certification examinations for 1985-1977 and 1988-1991. As shown in Table 5.1, comprehensive examination scores and professional year GPA produced the largest correlation with 1985-1987 MT-ASCP total scores. On the other hand, overall numerical grade average for all MT theory courses (T-OAS) was the best predictor of 1988-1991 MT-ASCP examination scores. Again, larger correlations were computed for 1988-1991 MT-ASCP total scores with T-OAS and P-OAS (overall numerical grade average for all MT practicum courses) than those for 1985-1987 MT-ASCP total scores.

Four regression equations were computed for 1985-1987 and 1988-1991 grades. Stepwise, forward inclusion multiple

Table 5.1
Summary of Results

	MT-ASCP Examination Scores			
	1985-1987 (n=103)		1988-1991 (n=147)	
	<u>Total</u> r	<u>Sub-</u> <u>section</u> r	<u>Total</u> r	<u>Sub-</u> <u>section</u> r
<u>Theory Grade</u>				
Hematology	<u>.33</u>	<u>.15 *</u>	<u>.56</u>	<u>.42</u>
Clinical Chemistry	<u>.34</u>	<u>.27</u>	<u>.58</u>	<u>.47</u>
Microbiology	<u>.31</u>	<u>.24</u>	<u>.40</u>	<u>.28</u>
Blood bank	<u>.37</u>	<u>.31</u>	<u>.46</u>	<u>.39</u>
<u>Combined (Theory and practicum)</u>				
Hematology	<u>.37</u>	<u>.20 *</u>	<u>.57</u>	<u>.38</u>
Clinical Chemistry	<u>.34</u>	<u>.24</u>	<u>.57</u>	<u>.45</u>
Microbiology	<u>.32</u>	<u>.27</u>	<u>.48</u>	<u>.41</u>
Blood bank	<u>.37</u>	<u>.35</u>	<u>.50</u>	<u>.38</u>
<u>Practicum Grade</u>				
Hematology	<u>.43</u>		<u>.48</u>	
Clinical Chemistry	<u>.27</u>		<u>.35</u>	
Microbiology	<u>.26</u>		<u>.39</u>	
Blood bank	<u>.29</u>		<u>.57</u>	
<u>Comprehensive Exam**</u>	<u>.44</u>		<u>.51</u>	
<u>Overall Numerical Grades Average</u>				
MT Theory Courses	<u>.32</u>		<u>.60</u>	
MT Practicum courses	<u>.42</u>		<u>.51</u>	
<u>Cumulative GPAs***</u>				
Professional year GPA	<u>.44</u>		<u>.49</u>	
Pre-professional and professional GPA	<u>.23</u>		<u>.50</u>	

* not significant at $P < .05$, all other values significant at $p < .05$

** n= 103 (1985-1987) and n= 108 (1988-1991)

*** n= 122 (1985-1987) and n= 147 for 1988-1991

regression analysis was used to examine four different models, each corresponding to a critical academic decision point during the student's professional year of study. Available predictors at each critical point were entered separately during steps 1-3 in order to avoid confounding due to course rotations in the professional program and all seventeen predictors were entered in the last step (point 5). The computed R^2 values suggest that the 1988-1991 models explained more of the total variance in MT-ASCP total exam scores than those computed for 1985-1987. The best predictors were found in the 1988-1991 cohort in which 50.2% of the variance in total scale scores in the MT-ASCP certification examination was accounted for by three summary variables, namely: overall average grade for all theory (T-OAS) and practicum (P-OAS) courses, and comprehensive examination scores (C-Exm).

Nine additional, preprofessional variables were examined in an attempt to increase the amount of total variance in test scores explained by the three professional variables. Three of these were found to function as predictors, when added to the three professional predictors, the percent of total variance in total scale scores on the MT-ASCP certification examination was increased by 11% to a total of 61.1%.

Conclusions

With the exception of numerical grades in hematology and combined (theory and practicum) hematology grades in 1985-1987, numerical grades in key curriculum areas were reliable predictors, both of total scores on the MT-ASCP examination in 1985-1991, regardless of the method of reporting MT-ASCP examination scores, and of corresponding sub-sections of the MT-ASCP examination (Table 5.2).

Of the 17 independent variables examined in the study, the best four predictors of total percent scores on the 1985-1987 versions of the MT-ASCP examination were hematology practicum numerical grades, scores on the comprehensive examination, overall average of numerical grades in all MT practicum courses, and professional MT training year GPA. For 1988-1991, significant predictors were clinical chemistry theory grades, hematology and clinical chemistry combined (theory and practicum) grades, blood bank practicum grades, and overall average of numerical grades in all MT theory courses. The findings agree with those reported by Lunz et al (1986), who found that cognitive ratings were better predictor of MT-ASCP examination total scores than clinical ratings. Similar findings were reported by Richards (1977) and Taylor (1963)

Table 5.2

Summary of Hypotheses

Relationship of MT-ASCP Total and Sub-section Scores by Corresponding MT Professional Subjects	<u>MT-ASCP Examination Scores</u>			
	(1985-1987)		(1988-1991)	
	<u>Total</u>	<u>Sub- Section</u>	<u>Total</u>	<u>Sub- Section</u>
<u>Theory Subjects</u>				
Hematology	<u>*</u>	<u>NS</u>	<u>*</u>	<u>*</u>
Clinical Chemistry	<u>*</u>	<u>*</u>	<u>*</u>	<u>*</u>
Microbiology	<u>*</u>	<u>*</u>	<u>*</u>	<u>*</u>
Blood bank	<u>*</u>	<u>*</u>	<u>*</u>	<u>*</u>
<u>Combined (Theory and practicum)</u>				
Hematology	<u>*</u>	<u>NS</u>	<u>*</u>	<u>*</u>
Clinical Chemistry	<u>*</u>	<u>*</u>	<u>*</u>	<u>*</u>
Microbiology	<u>*</u>	<u>*</u>	<u>*</u>	<u>*</u>
Blood bank	<u>*</u>	<u>*</u>	<u>*</u>	<u>*</u>

* p<.05 NS= not significant

for nursing education and success on the State Board Examination (NCLEX).

Moreover, results of regression analyses demonstrated further that numerical grades, even in the early parts of the MT training program, could be used successfully to predict total and sub-section scores on the MT-ASCP examination, using both 1985-1987 and 1988-1991 scores as criterion.

Differences between results for 1985-1987 and 1988-1991 are interesting because both are statistically significant. However, moderate correlations were computed between students' grades in MT professional courses and 1988-1991 MT-ASCP total examination and sub-section scores as compared the small values for 1985-1991. This suggest that the new system of reporting results is better than that used prior to 1988.

The findings also support the claim that the MT-ASCP examinations measure the same knowledge areas and skills assessed by MT educational programs, but warrant further investigations of the criterion validity of the MT-ASCP examinations administered since 1988.

Four different predictive equations using different combinations of numerical grades and grade point averages on professional MT courses as predictors of students' MT-ASCP

total score were computed. These equations can be used by MT programs to monitor students' progress, predict their success on MT-ASCP examination, and make academic decisions at different critical points during the professional year.

Recommendations

1. This is one of the first studies that used MT-ASCP total scaled scores as a criterion and professional-year as well as personal and pre-professional achievements as predictors. Thus, it should be replicated on a national scale so that generalizations could be extended to all accredited medical technology programs.

2. Although the results of studies of these programs in 1988-1991 suggested that graduates of programs with a greater proportion of 4 +1 option graduates are more likely to do better on the Mt-ASCP examination than 3+1 option graduates, results in part are confounded by initial differences in students' age and employment in the laboratory. Accordingly, future studies should be performed on graduates from hospital based (3+1 and 4+1 options) and university based integrated (2 + 2 option) medical technology programs to clarify differences in graduates' performance.

3. A persistent difference between the 1985-1987 and the 1988-1991 students was their performance in microbiology, both theory and laboratory. In all other professional areas, the graduates after 1987 equalled or outscored earlier graduates, despite the presence of 4+1 option students among the 1988-1991 graduates who may have encountered microbiology and immunology as undergraduates. Since microbiology figures heavily in the laboratory applications and judgments expected of certified medical technologists, this particular difference in the preparation and/or test performance of recent graduates should not be left unaddressed by the profession.

4. In a similar note, the significantly lower certification examination scores in hematology among 1985-1987 graduates warrants a follow-up study on the job to see if their professional practice in any way was impaired by this difference in preparation or testing.

5. Further studies should be conducted on demographic and selection criteria variables to determine the stability of previously identified predictors when used to predict the total scaled scores on the MT-ASCP examination.

6. It is necessary for medical technology professional organizations at the state and national level to establish a data base that includes complete demographic and academic

performance data for every student admitted into the medical technology programs to build a large sample population. Data should be collected in a standardized form, properly coded to ensure confidentiality, computerized, and made available to researchers. Such a data base will open doors for new research, replications, and validation studies will be conducted with higher degree of reliability.

7. Professional year performance variables in this study contributed about 52 percent to the total variance in MT-ASCP total scaled scores, and about 62 percent when professional and pre-professional academic and demographic variables were used. Further studies are warranted to identify additional variables that may account for the remaining 38 percent of the unexplained variance.

8. Although these results may be cited as evidence for content validity of the MT-ASCP examination, particularly the scaled score version introduced in 1988. Additional study will be needed to establish criterion validity, i.e. correlation of MT-ASCP total and sub-section test scores with performance on the job among certified medical technologists.

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APPENDIX A

REGRESSION PREDICTION EQUATIONS FOR **1985-1991** MT-ASCP TOTAL
SCORES WITH ALL SEVENTEEN (17) PROFESSIONAL
ACHIEVEMENT VARIABLES AS SINGLE PREDICTORS

TABLE A.1

REGRESSION PREDICTION EQUATIONS OF 1985-1987 MT-ASCP TOTAL
PERCENT SCORES WITH ALL SEVENTEEN (17) PROFESSIONAL
ACHIEVEMENT VARIABLES AS SINGLE PREDICTORS

Predictor variable	Intercept	Parameter Estimate (b)
<u>Theory Scores:</u>		
Hematology	21.7928	.5586
Clinical chemistry	23.1714	.5442
Microbiology	23.3387	.5246
Blood bank	22.7086	.5430
<u>Practical Scores:</u>		
Hematology	09.7676	.6816
Clinical Chemistry	32.6964	.4180
Microbiology	30.4095	.4411
Blood bank	26.4738	.4825
<u>Combined Scores:</u>		
Hematology	17.2920	.6040
Clinical Chemistry	17.4719	.5941
Microbiology	14.0243	.6268
Blood bank	13.2731	.6401
<u>Overall Average Scores:</u>		
Theory	20.7221	.5642
Practical	05.9523	.7239
Total Comprehensive <u>Examination scores:</u>	43.3087	.3987
<u>Grade Point Averages:</u>		
Professional	44.0335	8.5373
Final	55.3353	4.8564

TABLE A.2

REGRESSION PREDICTION EQUATIONS FOR 1988-1991 MT-ASCP TOTAL
 SCALED SCORES WITH ALL SEVENTEEN (17) PROFESSIONAL
 ACHIEVEMENT VARIABLES AS SINGLE PREDICTORS

Predictor variable	Intercept	Parameter Estimate (b)
<u>Theory Scores:</u>		
Hematology	- 99.2874	6.7300
Clinical chemistry	- 131.3289	7.0610
Microbiology	84.1065	4.6326
Blood bank	37.2977	5.1338
<u>Practical Scores:</u>		
Hematology	- 128.5509	6.9099
Clinical Chemistry	38.5622	4.9828
Microbiology	- 48.3455	5.8850
Blood bank	36.5296	4.9083
<u>Combined Scores:</u>		
Hematology	- 226.0724	8.0926
Clinical Chemistry	- 299.5537	8.8518
Microbiology	- 185.4664	7.5525
Blood bank	- 224.8390	7.9294
<u>Overall Average Scores:</u>		
Theory	- 232.4352	8.2331
Practical	- 294.3232	8.6484
Total Comprehensive <u>Examination scores:</u>	240.9014	3.6286
<u>Grade Point Averages:</u>		
Professional	209.5782	86.0695
Final	187.7770	99.8478

APPENDIX B

Medical Technology Education and The MT-ASCP Certification examination

This section addresses the development of the MT-ASCP examination, methods used for scoring 1985-1987 and 1988-1991 MT-ASCP certification examinations, and scoring methods used on certification and licensure examinations for other profession.

Board of Registry and The MT-ASCP Exam: BRIEF Background

A desperate need for medical laboratory technologists after World War I triggered an interest in the training and identification of qualified laboratory workers. This great need encouraged the American Society of Clinical Pathologists (ASCP) to establish the Registry of Medical Technologists in 1926 (Wiler, 1978), since 1936 called the "Board of Registry" (Fiorella, 1977). This committee was the foundation of the present Board of Registry. Its role involved, among other things, establishing a definition of a "laboratory technician is", identifying, if possible, the different classes of technicians, and eventually publicizing the existence of the board to encourage qualified laboratory personnel to apply for certification (Stembridge, 1978).

In 1928, the registration of laboratory personnel began. Special laboratory technician applicants who met the basic requirements in training and education, set by the registration committee, were annually elected and granted certification without an examination. The first certificate was issued in 1930 (Stembridge, 1978).

Since 1933, all applicants for certification were required to take a written and practical examination. The examinations were prepared and administered by the Board of registry of Registry of the American Society of Clinical Pathologists. Those examinations originally consisted of a written essay, a practical laboratory test, and an evaluation of personal and psychological attributes. Not until 1937 was a new version of the certification examination developed. It included equally weighted written and practical sections (NIH, 1971).

This form of examination continued up to 1944, when it was decided to drop the practicum portion of the certification examination (U.S. Department of Health, Education and Welfare [USDHEW], 1969; and Stembridge, 1978). Three major factors contributed to dropping the practicum portion. First, examination results from 1937 to 1944 revealed that only two percent of those who passed the written section failed the practicum part. Second, there

had been a tremendous increase in the number of applicants. Finally, applicants could not travel for testing due to existing war restrictions.

Essay type questions were used until 1946, when a few true-false items were included in the examination (Directory of Medical Specialists, 1969 & National Institute of Health [NIH], 1971). New, norm-referenced examinations, consisted of multiple choice and true-false items were used in 1948. In 1949, true false items were dropped and the examinations were made up of 200 multiple choice questions. In norm-referenced examination, examinee's performance is compared with the performance of other examinees who took the same examination. The minimum passing (pass/fail) score was established for each examination at one standard deviation below the mean of the reference group score. The reference group score is the average of all first-time examinees who graduated from CAHEA (Committee on Allied Health Education and Accreditation of the American Medical Association) approved programs only. These examinations covered more topic areas, were convenient to grade mechanically and permitted statistical analyses of the results (Stembridge, 1978).

The administration of norm-referenced examinations continued until 1980. The first criterion-referenced MT-

ASCP examination was and administered (Castleberry et al, 1991).

Criterion-referenced MT-ASCP Examination

For over thirty years, norm-referenced examinations were in accepted use for the certification of medical technologists. By the late 1960's and early 1970's, specialists and educators had a better understanding of criterion-referenced testing and measurement. According to Popham (1981), Gloser in 1963 wrote his classical article that "popularizes the notion of criterion-referenced tests." The article awakened many measurement specialists and educators. From 1963 on, the literature is continuously enriched with many articles, books, and chapters completely or partially devoted to criterion-referenced measurement (Popham, 1971, 1978; & Berk, 1980), instructions (Popham, 1973), testing, and measurement (Hambleton, 1978), and compared criterion and norm-referenced measurement systems (Mehrens & Lehman, 1975).

Traditional testing practice for medical technologists prior to 1980 was dominated by norm-referenced measurement examinations. After years of analyzing data on MT-ASCP examinations, and receiving feedback from medical technology schools concerning their graduates' performance, it became

evident that norm-referenced exams are not appropriate (Stembridge, 1978). Such exams measure an individual's performance as compared with the other examinees, but do not document that a student has mastered a specific skill (Gonder, 1978). They "provided very little information about what a potential professional was actually able to do" (Wiler, 1978).

In 1972, the Board of Registry made a serious commitment to change from norm referenced to criterion-referenced examinations. Criterion-referenced tests measure an examinee's performance in terms of absolute standards (Crocker & Algina, 1986). They are used by educators and evaluators to make decisions about both examinees and instructional programs (Ford & Morgan, 1976). In 1980 the BOR-ASCP administered the first criterion-referenced exams for all categories of medical technology generalist and specialist examinations (Stembridge, 1978 & Betre, 1991). Modified Nedelsky method of standard setting was used by selected professional, educators, and experts in the field to determine the minimum passing (pass/fail) score for each examination. This process produced different standards (pass/fail score) for different examinations administered at different times. Test scores were reported in total raw and percent correct.

In 1985, test equating was applied for the first time. This mathematical technique places test scores from different exams on the same scale (Holand & Rubin, 1982 and Hambleton et al, 1991). It is used to insure that the same standards for passing the different MT-ASCP examinations taken by examinees at different times.

Rasch Rating Scale Model (Wright & Stone, 1979) was applied in 1988 for item analysis, item selection, and to provide a measurement scale for reporting cutoff passing scaled scores. The model puts examinee's ability and item difficulty on the same scale. This scale allows for both item and test calibrations. Determining the fit of the difficulty parameter is referred to as item calibration. On the other hand, test calibration "requires the evaluation of the fit of the persons to the Rasch Model and the estimation of the ability parameter corresponding to each test score" (Isaac & Michael, 1990). A scaled score of 400 points was chosen as the Minimum Passing Score (MPS). Thus, "an individual who achieves the level of performance represented by the minimum pass score passes the examination" (Castleberry et al,1991).

Certification Process for Medical Technologists

The U.S Department of Health, Education and welfare (1971) defined certification as " the process by which a

nongovernmental agency or association grants recognition to an individual who has met certain predetermined qualifications specified by the agency or association. Such qualifications may include graduation from an accredited or approved training program, acceptable performance on a qualifying examination, and or completion of some specified amount or type of work experience."

In 1978, Spence gave a simplified definition:

" a selective mechanism by which the educational qualifications and technical competencies of individuals are formally recognized by their respective health professions".

Unlike licensure, it is not unlawful to work without certification, but uncertified professionals usually have a harder time finding employment. The main purpose of the certification is to " indicate to the public that an

individual has demonstrated an acceptable level of competence at career entry, following successful completion of an educational program related to one of the established categories of medical laboratory personnel" (ASCP/CMLP Newsletter 2(2), 1974).

Graduates who are certified develop a sense of professional achievement, confidence, and personal satisfaction (Trotto, 1991). There are several agencies and organizations that certify laboratory personnel. In addition to the BOR-ASCP, there are the National Certification Agency (NCA) for Medical Laboratory Personnel (MLP) and the International Society for Clinical Laboratory Technology (ISCLT) .

Most professional medical technologists are certified by BOR-ASCP, which remains the dominant organization in certification and registration of generalist and specialist medical laboratory personnel. It is considered by many to be the "gold standard for measuring excellence" (Trotto, 1991). As of August 1991, 307,394 laboratory personnel were certified by BOR-ASCP since 1928, including a total of 187,027 certified medical technologists.

The MT-ASCP Certification Examination

The examination is developed, administered, and scored by the Board of Registry of the American Society of Clinical Pathologists (BOR-ASCP), which also is responsible for on-going research to monitor and improve test quality and related methodologies (Castleberry et al, 1991).

MT-ASCP Examinations' Scoring

From 1980 to 1988, raw total scores and percentages were reported for the total exam and for each sub-section. Passing cutoff scores varied from 1980 through year to 1985. In 1985 Test Equating technique was used to equate the standard for all examinees taking different exams at different times. The Rasch scaling model was used in 1988 to determine the scaled cutoff score, 400 scaled points,

scaled scores were used for the first time to report examination results.

Scoring on Other Health Professions' Certification and Licensure Examinations

Criterion-referenced examinations have been used for over twenty years in medical and dental licensing. In the mid 1970's, other health professions began the process of changing from norm- to criterion-referenced examinations for licensure or certification. Developing a criterion-referenced examination requires sincere commitment, time, and money. BOR-ASCP, for example, took about eight years to develop. They administered the first criterion-referenced MT-ASCP exam in 1980.

Scoring methods for eight examinations in the health professions were examined. Two of these are certification exams, the (OTR) Registered Occupational Therapist Examination (American Occupational Therapy Certification Board Inc, 1992) and (CRTT) Certification Examination for Respiratory Therapy Practitioners (National Board for Respiratory Care, 1991). The remaining six licensure examinations are the (NPTE) National Physical Therapist Examination (American Physical Therapy Association, 1992), (SRDE) Southern Region Dentistry Examination (Southern

Regional Testing Agency, Inc. (1992), (NCLEX-RN) National Council Licensure Examination for Registered Nurses (Dvorak, 1991; Dvorak & Yocom, 1988; & Smith, 1992), the (FLEX) Federation Licensing Examination (the Federation of State Medical Boards of the United States, Inc., 1992), (SPEX) Special Purpose Examination (the Federation of State Medical Boards of the United States, Inc., 1992), and the (US-MLE) United States Medical Licensing Examination for medical doctors (The Federation of State Medical Boards of the United States, Inc., and the National Boards of Medical Examiners, 1992).

By 1982, most health professions caught up with medical and dental boards' examinations and began to use criterion-referenced and competency-based certification and licensure examinations. Minimum competency passing (pass/fail) scores were established by the certifying and licensing agencies, associations, and state boards. An arbitrary 400 scaled cutoff score was chosen by BOR-ASCP for MT-ASCP examination. A minimum of 75 percent of the scaled score units must be achieved by those candidates taking CRTT, NPTE, SEDE, FLEX, and SPEX to pass. A scaled score of 450 or better on a 400-600 scale is required to pass the OTR exam. A National passing score on the NCLEX-RN is achieved when candidates score about 75 percent (1600 scaled points), but each state

may set its own passing score. Since 1988, only pass or fail status (not a specific score) on NCLEX-RN is reported to candidates. For USMLE, each licensing authority sets its own passing score, and a standard score of 176 (55-65% correct) for passing step I (Anatomy, behavioral sciences, biochemistry, microbiology, pathology, pharmacology, physiology, and interdisciplinary topics), and 167 (55-65% correct) for step II (internal medicine, obstetrics and gynecology, pediatrics, preventive medicine and public health, psychiatry, and surgery) are recommended by USMLE program. All eight examinations (MT-ASCP, NPTE, OTR, CRTT, NCLEX-RNDESR, FLEX, SPEX, and USLME) used test equating procedure to ensure fairness and equivalent level of performance by all examinees taking different tests at different times.

APPENDIX C

INTERCORRELATION MATRICES OF THE 17 PROFESSIONAL YEAR
PERFORMANCE VARIABLES AND 1985-1991 MT-ASCP TOTAL
EXAMINATION SCORES

TABLE C.A

INTERCORRELATION MATRIX OF THE PREDICTORS AND CRITERION VARIABLES USED IN THE STUDY
1985-1987 (N=103)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	N
1. T-HEM	---	.55	.32	.41	.66	.50	.38	.44	.83	.59	.40	.47	.63	.48	.27	.64	.36	.33	103
2. T-CHM			.43	.53	.58	.60	.39	.40	.59	.89	.50	.52	.75	.59	.18	.69	.44	.34	103
3. T-MIC				.42	.39	.40	.54	.34	.46	.47	.87	.43	.56	.49	.17	.56	.41	.31	103
4. T-BBK					.57	.60	.46	.62	.60	.63	.51	.91	.72	.70	.33	.68	.56	.37	103
5. P-HEM						.62	.59	.46	.83	.67	.56	.57	.61	.81	.24	.67	.40	.43	103
6. P-CHM							.50	.60	.61	.90	.51	.67	.70	.69	.34	.66	.59	.27	103
7. P-MIC								.33	.54	.50	.88	.44	.53	.76	.17	.66	.48	.26	103
8. P-BBK									.53	.56	.38	.89	.56	.50	.52	.48	.53	.29	103
9. Cm-HEM										.67	.57	.63	.68	.70	.30	.73	.46	.37	103
10. Cm-CHM											.55	.67	.81	.72	.29	.76	.57	.34	103
11. Cm-MIC												.50	.62	.72	.19	.70	.51	.32	103
12. Cm-BBK													.72	.68	.48	.65	.60	.37	103
13. T-OAS														.73	.34	.84	.69	.32	103
14. P-OAS															.23	.81	.57	.42	103
15. C-EXM																.37	.39	.44	90
16. Pr-GPA																	.70	.44	103
17. F-GPA																		.23	103
18. ASCP%																		---	103

T-HEM= hematology theory, T-CHM= clinical chemistry theory, T-MIC= microbiology theory, T-BBK= blood bank theory, P-HEM= hematology practicum, P-CHM= clinical chemistry practicum, P-MIC= microbiology practicum, P-BBK= blood bank practicum, Cm-HEM= combined hematology, Cm-CHM= combined clinical chemistry, Cm-MIC= combined microbiology, Cm-BBK= combined blood bank, T-OAS= overall average grade on all theory courses, P-OAS= overall average grade on all practicum courses, C-EXM= comprehensive examination scores, Pr-GPA= professional year GPA, F-GPA= final (cumulative) GPA, ASCP%= MT-ASCP total percent scores.

TABLE C.B

INTERCORRELATION MATRIX OF THE PREDICTORS AND CRITERION VARIABLES USED IN THE STUDY
1988-1991 (N=147)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	N
1. T-HEM	---	.69	.54	.46	.69	.41	.42	.27	.93	.67	.58	.47	.81	.57	.25	.70	.52	.56	147
2. T-CHM			.63	.53	.54	.40	.29	.29	.68	.86	.58	.53	.82	.45	.23	.62	.49	.58	147
3. T-MIC				.50	.49	.38	.36	.24	.56	.61	.87	.48	.72	.40	.22	.52	.35	.40	147
4. T-BBK					.33	.32	.29	.28	.43	.52	.50	.86	.67	.45	.11	.29	.40	.46	147
5. P-HEM						.55	.52	.48	.90	.65	.60	.49	.67	.72	.48	.58	.57	.48	147
6. P-CHM							.53	.57	.52	.81	.53	.53	.56	.71	.42	.37	.47	.35	147
7. P-MIC								.56	.50	.48	.77	.51	.51	.79	.40	.51	.50	.39	147
8. P-BBK									.40	.50	.46	.74	.37	.73	.46	.39	.39	.33	147
9. Cm-HEM										.72	.64	.52	.81	.69	.39	.69	.58	.57	147
10. CM-CHM											.67	.63	.83	.69	.39	.59	.58	.57	147
11. CM-MIC												.60	.76	.69	.36	.62	.50	.48	147
12. CM-BBK													.67	.71	.34	.41	.48	.50	147
13. T-OAS														.65	.30	.67	.70	.60	147
14. P-OAS															.43	.61	.54	.51	147
15. C-Exm																.30	.49	.51	108
16. Pr-GPA																	.55	.49	122
17. P-GPA																		.50	122
18. S-ASCP																		---	147

T-HEM= hematology theory, T-CHM= clinical chemistry theory, T-MIC= microbiology theory, T-BBK= blood bank theory, P-HEM= hematology practicum, P-CHM= clinical chemistry practicum, P-MIC= microbiology practicum, P-BBK= blood bank practicum, Cm-HEM= combined hematology, Cm-CHM= combined clinical chemistry, Cm-MIC= combined microbiology, Cm-BBK= combined blood bank, T-OAS= overall average grade on all theory courses, P-OAS= overall average grade on all practicum courses, C-Exm= comprehensive examination scores, Pr-GPA= professional year GPA, F-GPA= final (cumulative) GPA, S-ASCP= MT-ASCP total scale scores.

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