MATHEMATICAL AND CHEMICAL CONTENT RECOMMENDED FOR A MATHEMATICAL-CHEMICAL TECHNOLOGY CURRICULUM

By

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CHAPTER I

INTRODUCTION

Mathematical-chemical technology is a logical coalescence of the traditional chemical technology and the unperceived mathematical technology. The mathematician, in a traditional sense, can be thought of as a professional supportive consultant to other professionals. Transitionally, a move can be made readily from this capacity to a technological one due to the basic supportive roles entailed in each. Applied mathematics is the link to correlate the mathematical technicians with the chemical technicians for mutual enhancement.

Statement of the Problem

In as much as there is little scientific research and information for a mathematical-chemical technology program, it was felt a questionnaire, with its interpreted results, would begin to gather information needed by technical schools to implement or further develop a mathematical-chemical technology program.

Purpose of the Study

The purpose of this study was to answer the following questions:

1. What chemial course content should be included in a two-year mathematical-chemical technology as recommended by chemical manufacturers and technical schools?

2. What mathematical course content should be included in a two-year mathematical-chemical technology as recommended by chemical manufacturers and technical schools?

Need

As the next chapter will establish, there is a lack of published information concerning mathematical technology and any coalescence involving mathematical technology with other technologies. This very lack of infomration demonstrates the need for this study and dictates the need for investigation at its grass roots level.

Definitions

For the purpose of this study, course content was defined to be fundamental principles and concepts of chemistry and mathematics that would be suitable for a coalescent two-year mathematical-chemical technology program.

Degree in emphasis of acceptability has reference to an interval scale used in this study's questionnaire for respondents to rank chemical and mathematical course content items as to degree of essentiality to a mathematical-chemical technology program (Appendix D). Only those course content items having a range of 3.00 or greater were included in Tables I-VI found in the study.

CHAPTER II

REVIEW OF LITERATURE

The purpose of this study was to answer the following questions:

1. What chemical course content should be included in a two-year mathematical-chemical technology as recommended by chemical manufacturers and technical schools?

2. What mathematical course content should be included in a two-year mathematical-chemical technology as recommended by chemical manufacturers and technical schools?

Through the review of literature, no mention was made of a mathematical-chemical curriculum within the United States. However, it was found that several chemical technologies did exist.

The direction of this review of literature is essentially three-fold. Because no mathematical-chemical curriculum was found to exist, it was felt essential to first identify tasks of technicians implicated to provide a greater functional understanding of their roles. Next, the rationale for the coalescence of the mathematical-chemical technologies was developed through the complementary needs of the two technologies. Last, the results of similar studies were reviewed.

Tasks of Technicians

In general terms, a technician is a person who functions in a liason capacity between the professional and craftsman (1).

The President's Committee on Scientists and Engineers stated the following tasks of technicians:

> The engineering or scientific technician is usually employed in (1) research, design, or development; (2) production, operation, or control; (3) installation, maintenance or sales. When serving in the first of these functional categories, he usually follows a course prescribed by a scientist or engineer but [may or] may not work closely under his direction. When active in the third category, he is frequently performing a task that would otherwise have to be done by an engineer.
>
> In executing his function, the scientific or engineering technician is required to use a high degree of rational thinking and to employ post-secondary-school mathematics and principles of physical and natural science. He thereby assumes the more routine engineering functions necessary in a growing technologically based economy. He must effectively communicate scientific or engineering ideas mathematically, graphically, and linguistically (17, p. 3).

Tasks of Mathematical Technicians

Two great divisions, involving some overlap, occur in mathematics. These include a pure (theoretical) aspect and applied (developmental) aspect. The pure (theoretical) mathematician develops new theories and devises new approaches to the solution of mathematical problems, in all mathematical areas, resulting in important principles which can be used in applied mathematics. The applied mathematician utilizes these principles to solve problems found in areas of practical mathematics. These mathematicians are usually part of a team, working with other professionals, assigned to a given project (3) (8).

Mathematical technicians, the assisting persons to the mathematicians and/or other scientists, are involved in the applied mathematical area for practical work application.

> [Mathematical technicians] may work in research development, design, testing and evaluation of equipment, and in handling computing data. . . . They may document vital information, . . . make computations for studies and designs, . . . conduct analyses, . . . and follow outlined procedures to solve

problems (7, p. 2).

Tasks of Chemical Technicians

Chemical technicians are involved in applied, as opposed to theoretical, work. They assist chemists with experiments, equipment, and procedures; making tests, collecting data, and compiling results. They may convert laboratory techniques into factory production methods, ensure product specifications, oversee operations and training of production operators, concentrate on quality control, work in research and development, and often become specialists in one particular industry (6).

Tasks of Mathematical-Chemical Technicians

A mathematical-chemical technician would be a liason technician able to work both with applied mathematicians and/or mathematical technicians and the applied chemists and/or chemical technicians. The technicians' primary specialization, in this coalescence, would be applied mathematics. The secondary emphasis would be applied chemistry. The individual would usually work in research, design, development, production, operation, and installations as they relate to chemistry.

Rationale for a Coalescent Mathematical-Chemical Technology as Demonstrated Through Needs of Two Technologies

Upon successful completion of a chemical technology program, the graduate will find excellent employability almost anywhere in the United States or abroad (4).

> The outlook for chemical laboratory technicians is excellent. In 1979, more than 650,000 people were employed as engineering

> and science technicians. Forecasts predict that in 1980 the number of people working in the broad classification of technician will be about 760,000. In 1990 this figure is expected to be more than a million (6, p. 3).

> 60,000 to 70,000 chemical technicians . . . are working today. . . . There is only half a technician for each scientist or engineer today, when there should be at least two technicians for each scientist or engineer. With only 600 to 800 graduating per year in the United States, qualified chemical technicians remain in short supply in most areas (4, p.3).

The reasons for the need of chemical technicians include: expansion in industries and continuing technological developments, expansion of chemical companies' research and development departments, upsurge of environmental protection and urban planning, national concern for alternative energy resources, and national security (6).

According to one study involving all the graduates of chemical technician curriculum pilot schools graduating during 1972-1975, 75% were employed as a chemical technician or in a related capacity. Of the remaining graduates, most were either listed as being full-time students or employed in another field. Within three months of graduation, 96% of the graduates found a chemical technological occupation or related occupation, while 79% had a job upon graduation. More than one position was reported available to 68% of the graduates (9).

In fact, chemical industrial manufacturing ranks in the top five United States industries (14).

Of special significance is the realization that,

> in the past, only a few technicians have been available from two-year chemical technology programs. Instead, chemical technicians have been obtained by promoting equipment operators, putting high school graduates through company training programs, and hiring dropouts or graduates from a variety of four-year programs. However, most employers of chemical technicians today prefer the graduates of two-year chemical technology programs for new technicians (4, p. 3).

Apparently a similar situation must exist regarding mathematical technicians. A bulletin from the United States Bureau of Labor Statistics (14) reports that new mathematical technicians were supplied by:

33% Upgrading [Defined as "experience in a technician-related job, often combined with some academic training"]
27% Post-Secondary, Pre-Employment Program
20% Industry Training
10% College & University [Type program unspecified]
8% Manpower Development & Training Act [MDTA] Program
2% Armed Forces Training (p. 37).

The latest available figures from the United States Bureau of Labor Statistics (14), March 1970, reported an estimated 5,300 mathematical technicians were employed in 1966. For 1980 the report predicted a requirement of 10,100 mathematical technicians needed; an increase of 90.6%.

According to several occupational briefs (3) (7) (8), job openings for mathematical technicians will be enhanced through a link, such as chemistry, most particuarly in the private industrial sector where higher mathematics is a principle tool.

Consistent with Charles Schriver (12), chief chemist of GAF Corporation, his company had unsuccessfully looked, one year, for technicians that had a primary emphasis in the area of mathematics and secondary emphasis of chemistry but not necessarily of a four-year program. Their preference was to cater to a graduate of a technology program. Mr. Schriver found not only the mathematical-chemical area to be a helpful association but would also gainfully employ people with a mathematical-organic/physical chemistry technology combination or a mathematical-analytical chemistry technology combination.

Walter J. Brooking (2), Consultant to Technical and Postsecondary Education of the United States Department of Education, revealed to his knowledge, no institution in the United States offered a mathematical technology program nor a mathematical-chemical technology program (for that matter, no hybrid programs existed to his knowledge that would involve a mathematical technology). He enthusiastically welcomed the mathematical-chemical technology concept, indicating an even greater demand would be realized by this particular combination. He further expounded on a need for other coalescent curriculums involving mathematical technology, namely: mathematical-mechanical design technology and mathematical-civil engineering technology.

An obvious reason for linking the mathematical and chemical technologies becomes apparent when one regards how the two complement one another in congruency as they relate to logical, deductive thinking. The one difference between the mathematicians and chemists is the chemist is concerned with mathematical concepts only as they relate to chemistry, but often the main difference in how mathematics is used as a tool is only that of emphasis (7).

An understanding of mathematics is, in fact, needed to understand science (10).

In the words of Francis Bacon:

> Pure mathematics do remedy and cure many defects in the wit and faculties of individuals; for if the wit be dull, they sharpen it; if too wandering, they fix it; if too inherent in the sense they abstract it (cited in 8, p. 11).

Samuel Johnsons stated, "If a man's wit be wandering, let him study the mathematics; for in demonstrations, if his wit be called away ever so little he must begin again" (cited in 8, p. 11).

These quotes, though taken at face value may only appear to be humorous inclusions, point out the direction mathematics leads the mind in a realm analogous to the deductive logic characterized by the chemical scientific realm.

Results of Previous Research

As was attested by the previous summarized conversations with Mr. Schriver (12) and Mr. Brooking (2), and further manifested in the review of literature, no mathematical-chemical technology study existed with which to allow any comparison.

Summary

It was determined from the review of literature that:

1. A coalescence entailing the mathematical-chemical technologies was seen to already be sought by chemical manufacturers and does not presently exist.

2. The combination was perceived as being logical in respect to congruency as the two technologies relate in task performance.

3. The occupational need was seen to be apparent most especially with the enhancement of mathematics through the private industrial sector where even greater employability was realized.

Therefore, the logical combination emerged for a mathematical-chemical technology and the chemical and mathematical course content needed, in a two-year technology program, could be determined by representatives of chemical manufacturers and technical schools in the United States.

CHAPTER III

METHODOLOGY

The purpose of this study was to answer the following questions:

1. What chemical course content should be included in a two-year mathematical-chemical technology as recommended by chemical manufacturers and technical schools?

2. What mathematical course content should be included in a two-year mathematical-chemical technology as recommended by chemical manufacturers and technical schools?

Representatives of technical schools and chemical manufacturers were asked to complete a questionnaire to determine mathematical and chemical course content that could be incorporated into a two-year mathematical-chemical technology.

In this chapter, we will examine the selection of this population and discuss how the questionnaire was developed. Basic assumptions and limitations imposed in this study are also discussed.

Selection of Population

A list was made of every post-secondary technical school in the United States, as derived from the <u>Technician Education Yearbook 1980</u> (13), where chemical technology curriculums were indicated. Every other technical school on this list of 164 schools (Appendix C) was sampled (for a total of 82 schools that indicated they offered a chemical technology program). There was no list for mathematical technology to be found in the Technician Education Yearbook 1980 (13).

A list was made of chemical manufacturers, in the United States, representing more than 90% of the chemical production capacity. It was derived from the Directory (5), published by the Chemical Manufacturers Association (CMA). Every other company on the list of 187 companies (Appendix B) was sampled (for a total of 93 companies).

The combined 93 chemical manufacturers (Appendix B) and 84 technical schools (Appendix C) made a composite potential population of 175 members.

Development of the Questionnaire for Mathematical-Chemical Course Content

1. The questionnaire was developed from course content published in the United States Department of Health, Education, and Welfare Technical Education Program Series (15) (16) (18).

2. The published course content was listed and randomized by placing it in alphabetical sequence within each of two course content areas.

3. The two course content areas, mathematical and chemical, were offered, in questionnaire form, to the chemical manufacturers and technical schools.

4. To accommodate these two course content areas, the questionnaire was divided into two parts: Part I listed the area of chemical course content items and Part II listed the area of mathematical course content items.

5. Each item in the two-part questionnaire was to be checked, on an interval scale, to indicate varying emphasis of acceptability. The

degree of acceptability ranged from 1 (non-essential) to 5 (essential).

6. Space was provided at the end of Part I for adding any chemical course content deemed essential and Part II for adding any mathematical content deemed essential.

A copy of the questionnaire used is in Appendix D.

Assumptions

In the course of this study, to assimilate the data, the following assumptions were made:

1. There is a need for mathematical-chemical technology.

2. The interpretation of content nomenclature, by participants will be considered constant.

3. No bias will be injected regardless of variant educational and occupational experiences from the respondents.

4. The instructions, given in the letter of transmittal and on the questionnaire itself, will be fully comprehended by all respondents.

Collection of Data

To identify persons qualified to complete the questionnaire in technical schools, the following steps were taken:

1. Each school administrator was asked to submit a name and address (Appendix A, p. 43), via enclosed postcard (Appendix A, p. 44), of a faculty member having knowledge in mathematical and chemical technologies.

2. Each person, whose name appeared on the return postcard, was then contacted by letter (Appendix A, p. 45), and received the enclosed questionnaire (Appendix D) to complete for determination of mathematical

and chemical course content for a two-year mathematical-chemical technology.

3. After two weeks, if no postcard was received, another letter to the technical school administrator was mailed (Appendix A, p. 46) urging them to return a completed postcard. The follow-up then continued as indicated in step 2 above.

In finding persons qualified to complete the questionnaire to be sent to chemical manufacturers, the following steps were taken:

1. The first contact (Appendix A, p. 43) is analogous to the correspondence to the technical schools, in asking them to submit a name and address, via enclosed postcard (Appendix A, p. 44), of an employee having a knowledge of mathematical and chemical technologies.

2. If a response was obtained immediately, the questionnaire (Appendix D), with accompanying letter (Appendix A, p. 45), was mailed to the named person.

3. A final letter (Appendix A, p. 47) requested the individual chemical manufacturers to forward the survey to a qualified person in their specialization as opposed to waiting for a response on a postcard and mailing the questionnaire direct to that individual.

Systematizing the Data

A frequency distribution table, part of which included chemical manufacturers' responses and part of which included technical schools' responses, was used to categorically tabulate each course content item on the questionnaire.

Other than an occassional questionnaire item left unanswered, two technical schools and one chemical manufacturer completed half of the survey. The completed portions were included in the "Responses of

Technical Schools and Chemical Manufacturers by Chemical and Mathematical Course Content" (Appendix E). This accounts for the differences in totals of responses to items of the questionnaire.

Analyzing the Data

To determine the mathematical and chemical course content required in a mathematical-chemical technology, the use of a table (Appendix E) was employed. A clear understanding of the terminology used is of immediate necessity.

Terminology of Statistical Symbols Explicated (11) (19):

Symbols:	Interpretation:
n	number of responses per item
$\bar{X}$	mean
$\bar{\bar{X}}$	grand mean $= \dfrac{\bar{X}_1 n_1 + \bar{X}_2 n_2}{n_1 + n_2}$

To determine mathematical-chemical course content, the criteria for given value of essentiality for course need will be 3.00 or greater.

Limitations

This study was limited to 82 technical schools listing a chemical technology program in Technician Education Yearbook 1980 (13) and 94 chemical manufacturers listed in the Chemical Manufacturers Association's Directory. The results of this data, therefore, are only directly applicable for purposes of comparing the two groups surveyed.

The needs of those completing a questionnaire might differ from each other, and the results should not be generalized to any specific program.

CHAPTER IV

FINDINGS OF THE STUDY

The purpose of this study was to answer the following questions:

1. What chemical course content should be included in a two-year mathematical-chemical technology as recommended by chemical manufacturers and technical schools?

2. What mathematical course content should be included in a two-year mathematical-chemical technology as recommended by chemical manufacturers and technical schools?

This chapter will concern itself with return rates, the results of analyses, and derived emphasis placed on course content.

Return Rates

Initial return rates of schools indicated a response rate of 78% of the technical schools responding from all the technical schools contacted (Appendix C).

Initial return rates from chemical manufacturers indicated a response of 36.6% for companies responding from all the industries contacted (Appendix B).

A second letter (Appendix A, p. 45) was sent to those technical schools and chemical manufacturers showing a time lag. In this letter of transmittal, technical schools were asked to make the initial contact that they had failed to make in supplying a name to whom the questionnaire could be mailed. Chemical manufacturers were mailed the questionnaires and were requested to forward the questionnaires to save time (Appendix A, p. 47).

The final return rate for technical schools was 37.8% of the total mail-out list (Appendix C). The final return rate for chemical manufacturers was 22.3% of the total mail-out list (Appendix B).

Of chemical manufacturers' questionnaires returned, 4.76% had write-ins for mathematical course content, 23.81% had write-ins for chemical course content, and 19.05% had write-ins for both content areas.

Of the technical schools' questionnaires returned, 6.67% had write-ins for mathematical course content, 33.33% had write-ins for chemical course content and 10% had write-ins for mathematical and chemical course content.

Results of Analyses

In this chapter, the findings of the study are shown in eleven tables. The complete detailed findings are contained in Appendix E. Tables I and II give the technical schools' responses to course content as ranked by means. Tables III and IV give chemical manufacturers' responses as ranked by means. Tables V and VI provide the responses of technical schools and chemical manufacturers in giving their opinions for course content as ranked by grand mean. Tables I - VI include only those course items having an emphasis of acceptability range of 3.00 or greater.

TABLE I

TECHNICAL SCHOOL RESPONDENTS' RANKING
OF CHEMICAL COURSE CONTENT

Content	$\bar{X}$
Develop Basic Laboratory Techniques	4.97
Introduction to Laboratory Equipment	4.90
Titration	4.90
Formulae and Chemical Equations	4.80
Acids, Bases, and Salts	4.76
Properties of Solutions	4.70
Classification and Nomenclature	4.66
Weights and Volume Relations	4.66
Scientific Measurements	4.64
Evaluation of Experimental Measurement	4.60
Valence and Oxidation Numbers	4.55
General Operations in Quantitative Analysis	4.53
Colorimetry and Spectrophotometry	4.50
Chemical Activity and Bonding	4.47
Chromotography	4.47
Oxidation	4.43
Indicators and pH	4.40
Ionization	4.40
Gravimetric Determinations	4.37
Periodic Classification	4.37
Chemical Changes and Energy Transformations	4.33
Application of Redox Reactions	4.28

TABLE I (Continued)

Content	$\bar{X}$
Simple Compounds of Carbon	4.28
Structure of Atoms	4.28
Gravimetric Stoichiometry	4.27
Nature of Matter	4.24
Gaseous State	4.20
Hydrocarbons	4.20
Solutions and Colloids	4.17
Water and the Liquid State	4.10
Electrochemistry	4.07
Alcohols and Phenols	3.97
Aldehydes and Ketones	3.90
Analysis of Multi-Component Materials	3.86
Active Metals	3.79
Oxygen/Hydrogen	3.67
Analysis of Electrical Conduction	3.55
Metals and Metal Alloys	3.53
Halogen Compounds	3.43
Electrodeposition	3.38
Flame Photometry	3.37
Ethers	3.23
Nitrogen	3.03
Radio/Chemistry	3.03
Carboxylic and Diaconium Compounds	3.10

TABLE II

TECHNICAL SCHOOL RESPONDENTS' RANKING
OF MATHEMATICAL COURSE CONTENT

Content	$\bar{X}$
Graphic Representation	4.93
Ratio, Proportion, and Percent	4.93
Exponents and Radicals	4.83
Basic Calculator	4.73
Solving Linear Equations	4.67
Operations of Algebra	4.63
Probability and Sampling	4.57
Logarithms	4.53
Quadratic Equation and Formula	4.53
Conversions (Common Units to Metric & Vice Versa)	4.47
Factoring	4.43
Computer Application	4.37
Statistics	4.30
Trigonometric Function for Right Angles	3.80
Computer Housekeeping Techniques	3.75
Vectors	3.53
Organization of Data Processing System	3.50
Program Debugging	3.47
Program Testing	3.47
Applied Problems in Plane Geometry	3.37
Loops and Indexing	3.33
Trigonometric Graphing	3.31

TABLE II (Continued)

Content	$\bar{X}$
Subroutines of Computers	3.30
Integration	3.17
Limits	3.17
Programing a Random Access Device	3.14
Trigonometric Functions for Oblique Angles	3.07
Determinants	3.03
Programing a Tape System	3.03
Differentiation	3.00
Macro Programing	3.00

TABLE III

CHEMICAL MANUFACTURER RESPONDENTS' RANKING
OF CHEMICAL COURSE CONTENT

Content	$\bar{X}$
Acids, Bases and Salts	4.76
Development of Basic Laboratory Techniques	4.67
Formulae and Chemical Equations	4.62
Evaluation of Experimental Measurement	4.48
Introduction to Laboratory Equipment	4.33
Titration	4.33
Weight and Volume Relationships	4.33
Classification and Nomenclature	4.29
General Operations and Quantitative Analysis	4.24
Scientific Measurements	4.24
Simple Compounds of Carbon	4.10
Chemical Changes and Energy Transformations	4.00
Chemical Activity and Bonding	3.95
Oxidation	3.91
Indicators and pH	3.86
Properties of Solutions	3.86
Valence and Oxidation Number	3.86
Chromotography	3.81
Colorimetry and Spectrophotometry	3.76
Gaseous State	3.76
Gravimetric Stoichiometry	3.76
Application of Redox Reactions	3.71

TABLE III (Continued)

Content	$\bar{X}$
Hydrocarbons	3.67
Ionization	3.67
Periodic Classification	3.67
Nature of Matter	3.62
Gravimetric Determination	3.52
Halogen Compounds	3.48
Aldehydes and Ketones	3.43
Active Metals	3.40
Alcohols and Phenols	3.38
Oxygen/Hydrogen	3.38
Analysis of Multi-Component Materials	3.33
Structure of Atoms	3.33
Water and the Liquid State	3.24
Solutions and Colloids	3.14
Sulfur Compounds	3.00

TABLE IV

CHEMICAL MANUFACTURER RESPONDENTS' RANKING OF MATHEMATICAL COURSE CONTENT

Content	$\bar{X}$
Conversions (Common Units to Metric and Vice Versa)	4.80
Ratio, Proportion, and Percentage	4.80
Graphic Representation	4.60
Computer Applications	4.30
Operation of Algebra	4.30
Probability and Sampling	4.30
Statistics	4.30
Basic Calculator	4.25
Logarithms	4.25
Solving Linear Equations	4.25
Exponents and Radicals	4.15
Factoring	4.00
Quadratic Equation and Formula	3.50
Analytic Geometry	3.35
Computer Housekeeping Techniques	3.35
Organization of Data Processing System	3.35
Program Testing	3.20
Limits	3.16
Applied Problems in Plane Geometry	3.15
Differentiations	3.15

TABLE IV (Continued)

Content	$\bar{X}$
Integration	3.10
Program Debugging	3.10
Loops and Indexing	3.05
Trigonometric Functions for Right Angles	3.05

TABLE V

TECHNICAL SCHOOL AND CHEMICAL MANUFACTURER RESPONDENTS' OF CHEMICAL COURSE CONTENT

Content	$\bar{\bar{X}}$
Develop Basic Laboratory Technique	4.85
Acids, Bases, and Salts	4.76
Formulae and Chemical Equations	4.73
Introduction to Laboratory Equipment	4.67
Titration	4.66
Evaluation of Experimental Measurement	4.55
Weight and Volume Relations	4.52
Classification and Nomenclature	4.51
Scientific Measurements	4.47
General Operations and Quantitative Analysis	4.41
Properties of Solutions	4.35
Chemical Activity and Bonding	4.26
Valence and Oxidation Numbers	4.26
Oxidation	4.22
Chemical Changes and Energy Transformations	4.20
Chromotography	4.20
Colorimetry and Spectrophotometry	4.20
Simple Compounds of Carbon	4.20
Indicators and pH	4.18
Ionization	4.10
Periodic Classification	4.08
Gravimetric Stoichiometry	4.06

TABLE V (Continued)

Content	$\bar{\bar{X}}$
Application of Redox Reactions	4.04
Gaseous State	4.02
Gravimetric Determination	4.02
Hydrocarbons	3.98
Nature of Matter	3.98
Structure of Atoms	3.88
Solutions and Colloids	3.74
Water and the Liquid State	3.74
Alcohols and Phenols	3.73
Aldehydes and Ketones	3.70
Analysis of Multi-Component Materials	3.64
Active Metals	3.63
Oxygen/Hydrogen	3.55
Electrochemistry	3.49
Halogen Compounds	3.45
Analysis of Electrical Conduction	3.16
Flame Photometry	3.10
Metals and Metal Alloys	3.10
Ethers	3.09

TABLE VI

TECHNICAL SCHOOL AND CHEMICAL MANUFACTURER RESPONDENTS' OF CHEMICAL COURSE CONTENT

Content	$\bar{\bar{X}}$
Ratio, Proportion, and Percentage	4.88
Graphic Representation	4.80
Conversions (Common Units to Metric and Vice Versa)	4.60
Exponents and Radicals	4.56
Basic Calculator	4.54
Operation of Algebra	4.50
Solving Linear Equations	4.50
Probability and Sampling	4.46
Logarithms	4.42
Computer Applications	4.34
Statistics	4.30
Factoring	4.26
Quadratic Equation and Formula	4.12
Computer Housekeeping Techniques	3.58
Trigonometric Function for Right Angles	3.50
Organization of Data Processing Systems	3.44
Program Testing	3.36
Program Debugging	3.32
Applied Problems in Plane Geometry	3.28
Vectors	3.28

TABLE VI (Continued)

Content	$\bar{\bar{X}}$
Loops and Indexing	3.22
Limits	3.17
Integration	3.14
Subroutines of Computers	3.14
Trigonometric Graphing	3.10
Analytic Geometry	3.08
Differentiation	3.06

The questionnaire asked, of the respondents, the addition of any write-ins they may deem essential in the areas of mathematical and chemical course content. Tables VII, VIII, IX, and X provide a list of those additions to the mathematical and chemical course content areas, including degree of essentiality per item added. Some course content areas were repeated as write-ins of more than one surveyed respondent.

Difference in Emphasis Placed on Course Content by Chemical Manufacturers and Technical Schools

In comparing the percentage of mathematical and chemical course content areas of response as given by the technical schools and chemical manufacturers, a difference in emphasis placed on mathematical course content and chemical course content can be readily seen. Table XI provides such a comparison.

In Table XI, the denominators indicate the total number of responses for each given area and the numerators signify the total number of ordinal responses having an emphasis value of 3.00 or greater. The percentage reflects the percent of response of 3.00 or greater emphasis.

TABLE VII

FREQUENCY DISTRIBUTION FOR CHEMICAL COURSE CONTENT WRITE-INS BY TECHNICAL SCHOOLS

Content	Frequency Non-essential↔essential 1	2	3	4	5
Kinetics	0	0	1	2	0
Nuclear Magnetic Resonance	0	0	0	1	1
T.R.	0	0	0	0	1
Polymers and Plastics	0	0	0	1	0
Atomic Absorption Spectrophotometry	0	0	0	1	5
Spectrophotometry (Ultra-Violet, Visible, Infra Red)	0	0	1	0	4
Basic Industrial Unit Operations	0	0	1	0	0
Laws of Basic Thermo-Dynamics	0	0	0	1	2
Equivalent Weight & Equivalent Calculations	0	0	0	0	1
Transitional Levels and Complex Ions	0	0	0	0	2
Preparation of Solutions (Molar, Normal)	0	0	0	0	2
Calculations of Solution Concentration	0	0	0	0	3
Industrial Chemistry Processes	0	0	0	0	2
Gas Chromotography	0	0	0	0	4
Laboratory Safety	0	0	0	0	2
Phase Equilibrium	0	0	0	0	1
Quantum Mechanics	0	0	0	1	0
High Pressure Liquid Chromotography	0	0	0	0	1
Thin Layer Chromotography	0	0	0	0	1
Gas, Liquid Chromotography	0	0	0	0	1

TABLE VII (Continued)

Content	Frequency Non-essential↔essential 1	2	3	4	5
Water Analysis	0	0	0	0	1
Food Analysis	0	0	0	0	1
Equilibria (K_a, K_w, K_{sp})	0	0	0	0	1
Atomic Absorption	0	0	0	0	1
Distillation	0	0	0	0	1
Qualitative Analysis	0	0	0	0	1
Organic Laboratory Procedures	0	0	0	0	1

TABLE VIII

FREQUENCY DISTRIBUTION FOR MATHEMATICAL COURSE CONTENT WRITE-INS BY TECHNICAL SCHOOLS

Content	Frequency Non-essential↔essential 1	2	3	4	5
Conversion (Power of 10/Ordinary Form)	0	0	0	0	1
Dimensional Analysis (Factor Label Method)	0	0	0	0	1
Relative Rate	0	0	0	1	0
Boundary Value	0	0	0	1	0
Application of Math to Chemical Systems	0	0	0	1	0
Matrices	0	0	1	0	0
Inequalities	0	0	0	1	0
Solving Systems of Equations	0	0	1	0	0
Operations of Algebraic Functions	0	0	0	1	0
Numerical Computation Methods	0	0	0	1	0
Regression Analysis	0	0	0	1	0
Optomization	0	0	0	1	0
Non Parametrics Statistics	0	0	0	1	0
Conversion (Metric to Other Metric)	0	0	0	0	1

TABLE IX

FREQUENCY DISTRIBUTION FOR CHEMICAL COURSE CONTENT WRITE-INS BY CHEMICAL MANUFACTURERS

Content	Frequency Non-essential↔essential				
Gas Chromotography	0	0	0	0	1
Technical Report Writing and Journal Use	0	0	1	0	3
General Mechanics, Laboratory Motors, etc.	0	0	0	1	0
Rheology of Liquids and Metals	0	0	0	0	1
Fluid Flow--Plug and Turbulent	0	0	0	0	1
Basic Heat Transfer	0	0	0	0	1
Ultra-Violet Rays and Effects	0	0	0	0	1
Oxygen--Ozone Chemistry	0	0	0	1	0
Infra Red and Nuclear Magnetic Resonance Spectometry	0	0	0	0	1
Equilibria (K_a, K_w, K_{sp})	0	0	0	0	1
Experimental Design	0	0	0	0	1
Polymerization	0	0	0	0	2
Instrumental Analysis Training	0	0	0	0	1
Industrial Chemistry Processes	0	0	0	0	1
Laboratory Safety	0	0	0	0	1
Atomic Absorption Spectroscope	0	0	0	1	0
Specific Ion Electrodes	0	0	1	0	0
Photography Principles (Developing)	0	0	1	0	0
Scanning Electron Microscope	0	0	1	0	0

TABLE X

FREQUENCY DISTRIBUTION FOR MATHEMATICAL COURSE CONTENT WRITE-INS BY CHEMICAL MANUFACTURERS

Content	Frequency Non-essential↔essential 1	2	3	4	5
Taylor's Polynomials	0	0	0	0	1
Simple Differential Equation	0	0	0	1	0
Finite Mathematics	0	0	0	1	0
Basic Arithmetic	0	0	0	0	2
Experimental Design	0	0	0	0	1
Micro Computer	0	0	0	0	1

TABLE XI

MATHEMATICAL COURSE CONTENT AND CHEMICAL COURSE CONTENT BY CHEMICAL MANUFACTURERS AND TECHNICAL SCHOOLS

	Technical Schools	Chemical Manufacturers
Chemical	45/51 88.24%	37/51 72.55%
Mathematical	31/42 73.81%	24/42 57.14%

CHAPTER V

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

The purpose of this study was to answer the following questions:

1. What chemical course content should be included in a two-year mathematical-chemical technology as recommended by chemical manufacturers and technical schools?

2. What mathematical course content should be included in a two-year mathematical-chemical technology as recommended by chemical manufacturers and technical schools?

This chapter will examine findings with several conclusions borne upon the findings to determine course content as outlined in the purpose of this study. Finally recommendations are offered for applications of this study.

Summary

A questionnaire was compiled to determine mathematical and chemical course content essential for a mathematical-chemical technology. After lists were gotten for technical schools and chemical manufacturers in the United States (13) (5), persons identified as being knowledgeable in the areas of mathematical and chemical technology were contacted through correspondance, to complete a questionnaire. (A listing of chemical manufacturers can be found in Appendix B, technical schools in Appendix C, and a copy of the survey in Appendix D.)

It was found that the following course content should be included in a two-year coalescent mathematical-chemical technology program, as determined by those courses having an emphasis of acceptability of 3.00 or greater. The list was derived from the grand means ($\bar{\bar{X}}$), found in Tables V and VI, and is ranked from more essential to less essential (5.00 to 3.00 respectively).

Chemical course content: develop basic laboratory technique; acids, bases, and salts; formulae and chemical equations; introduction to laboratory equipment; titration; evaluation of experimental measurement; weight and volume relations; classification and nomenclature; scientific measurements; general operations and quantitative analysis; properties of solutions; chemical activity and bonding; valence and oxidation numbers; oxidation; chemical changes and energy transformations; chromotography; colorimetry and spectrophotometry; simple compounds of carbon; indicators and pH; ionization; periodic classificaton; gravimetric stoichometry; application of redox reactions; gaseous state; gravimetric determinations; hydrocarbons; nature of matter; structure of atoms; solutions/colloids; water and the liquid state; alcohols/phenols; aldehydes/ketones; analysis of multi-component materials; active metals; oxygen/hydrogen; electrochemistry; halogen compounds; analysis of electrical conduction; flame photometry; metals/metal alloys; and ethers.

The mathematical course content was also ranked by the grand mean ($\bar{\bar{X}}$) from more essential (5.00) to less essential (3.00), and included below in order of essentiality.

Mathematical course content: ratio, proportion, and percentage; graphic representation; conversions (common units to metric and vice versa); expondents and radicals; basic calculator; operation of algebra; solving linear equations; probability and sampling; logarithms; computer applications; statistics; factoring; quadratic equation and formula; computer housekeeping techniques; trigonometric function for right angles; organization of data processing systems; program testing; program debugging; applied problems in plane geometry; vectors; loops and indexing; limits; integration; subroutines of computers; trigonometric graphing; analytic geometry; and differentiation.

It was determined that 80.39% of the proposed chemical course content and 64.29% of the proposed mathematical course content, as given on the questionnaire, met the requirement of this study as qualifying to be included in a two-year coalescent mathematical-chemical technology program.

It was also found that the technical schools indicated, by greater percentage, more emphasis; as opposed to the chemical manufacturers, on both the mathematical and chemical course content areas (73.81% and 88.24% respectively). This compares with the chemical manufacturers having 57.14% for mathematical course content and 72.55% for chemical course content.

Looking to the mathematical and chemical course content areas, it was found that the chemical course content area received a larger percentage of acceptability from the technical schools and chemical manufacturers (88.24% and 72.55% respectively) as compared with the mathematical course content area (73.81% and 54.14% respectively).

Conclusions

The study concluded that:

1. Questionnaires might have been completed by persons with stronger backgrounds in chemistry than in mathematics.

2. Chemical manufacturers appeared to be more conscientious in completing the questionnaire.

3. Chemical manufacturers seemed to give a wider range of essentiality to the course content in the questionnaire.

4. Seemingly, traditional computer course contents were not given a strong degree of essentialness.

5. Apparently, as a group, technical schools were able to return questionnaires faster than chemical manufacturers.

Recommendations

Recommendations for a two-year coalescent mathematical-chemical technology program include:

1. The findings of this study should be considered in developing a two-year coalescent mathematical-chemical technology curriculum.

2. The additional write-ins, both in the mathematical course content area and chemical course content area, should be considered in future follow-up studies with the findings of this study.

3. The educational objectives of the mathematical-chemical course content should be determined.

4. An advisory committee, made up of representatives from chemical industries and technical schools offering a chemical technology program, should be used in the development of a mathematical-chemical technology program.

5. An extensive study should be conducted into all aspects of the novel mathematical technology.

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APPENDIX A

OUTGOING CORRESPONDANCE TO CHEMICAL MANUFACTURERS AND TECHNICAL SCHOOLS

FIRST SAMPLE LETTER TO CHEMICAL MANUFACTURERS AND TECHNICAL SCHOOLS

[Date]

[Executive Corporative Member
or School Administrator
Title
Address]

[Salutation:]

We in the Technical Education Department of Oklahoma State University are in the process of conducting a study to determine the content needed in a "two-year" hybrid curriculum involving a merger of chemical and mathematical technologies.

Your coveted help is essential to this study. All I would ask of you is the name and address of [an employee or faculty member] knowledgeable in both chemical and mathematical technologies. For your convenience in responding, please complete and mail the self-addressed post card enclosed. Thank you so much for your time, cooperation, and support.

Sincerely,

Donald Dowdy
Research Associate

DRD/dd
Enclosure

POST CARDS SENT TO CHEMICAL MANUFACTURERS

AND TECHNICAL SCHOOLS

NAME OF COMPANY: ____________________

NAME OF EMPLOYEE: ____________________

POSITION: ____________________

ADDRESS: ____________________

____

____

NAME OF SCHOOL: ____________________

NAME OF FACULTY MEMBER: ____________________

POSITION: ____________________

ADDRESS: ____________________

____

____

SECOND SAMPLE LETTER TO CHEMICAL

MANUFACTURERS AND TECHNICAL

SCHOOLS

[Date]

[Executive Corporative Member
or School Administrator
Title
Address]

[Salutation:]

We in the Technical Education Department of Oklahoma State University are in the process of conducting a study to determine the content needed in a "two-year" hybrid curriculum involving a merger of chemical and mathematical technologies.

[Name of corporate executive or school administrator] has given us your name as a [person or faculty member] knowledgeable in both chemical and mathematical technologies. Your help and confidential opinion are very essential to this study as we are striving to develop course content for mathematical chemical technology.

Please complete and return the enclosed survey which only suggests course content. Feel free to add to or delete from this initial list where you deem appropriate. For your convenience, a self-addressed, stamped envelope has also been enclosed.

Each course content area has its own range to indicate varying emphasis of acceptability ranging from non-essential to essential. These courses should be appropriate for those commonly found in schools of technology.

Thank you so much for your time, help, and support.

Sincerely,

Donald Dowdy
Research Associate

THIRD SAMPLE LETTER TO TECHNICAL SCHOOLS

[Date]

[Name of School Administrator
Title
Address]

[Salutation:]

We in the Technical Education Department of Oklahoma State University are looking forward to hearing from you in order to formulate a more viable curriculum for a new hybrid offering in the area of mathematical-chemical technology. This comes as a culmination of intense study into the projected needs for such a program.

We would only ask that you supply us with the name, position, and address of a faculty member knowledgeable in the two technologies of mathematics and chemistry.

We were afraid that maybe you didn't receive our initial letter with return postcard or perhaps you have no such person to recommend to us. In that case, we would like confirmation of that.

In any event, please let us hear from you. Your response is important to us and critical to this study. If you've already responded, please forgive the redundancy of this message and accept our deep appreciation.

We would like to be generous with our study and, upon request, would like to share, with the recommended person, a copy of our findings.

Thank you so kindly for your time and help. Sincere best wishes and much success at [name of institution] in all your endeavors.

Sincerely,

Donald Dowdy
Research Associate

DRD/dd

THIRD SAMPLE LETTER TO MANUFACTURERS

[Date]

[Name of Corporate Executive
Title
Address]

[Salutation:]

We in the Technical Education Department of Oklahoma State University are looking forward to hearing from you in order to formulate a more viable curriculum for a new hybrid offering in the area of mathematical-chemical technology. This comes as a culmination of intense study into the projected needs for such a program.

We are regrettably under an extreme time limitation for the assimilation of survey responses. Therefore, we're asking that you please forward this survey to a person knowledgeable in the two technologies of mathematics and chemistry.

If it be the case that you have no such qualified person to whom the survey may be sent, we would like confirmation of that.

In any event, please let us hear from you. Your response is important to us and critical to this study. If you've already responded, please forgive the redundancy of this message and accept our deep appreciation.

We would like to be generous with our study and would gladly share, with the person completing the survey, a copy of our findings.

In this unprincipled request of having you forward this survey, we would covet your understanding and exoneration.

Thank you so much for your time and help. Sincere best wishes and much success at [name of company] in all your endeavors.

Sincerely,

Donald Dowdy
Research Associate

APPENDIX B

ALPHABETICAL LISTING OF AMERICAN CHEMICAL MANUFACTURERS CONTACTED

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WESTVACO CORPORATION
Dottie D. Sewell
Administrative Assistant
299 Park Avenue
New York, New York 10017

APPENDIX C

TECHNICAL SCHOOLS CONTACTED AS

ALPHABETIZED BY STATE

TECHNICAL SCHOOLS CONTACTED

JOHN CALHOUN COMMUNITY COLLEGE
Richard Turner
Box 427
Decatur, Alabama 35601

NORTHEAST ALABAMA STATE JR. COLLEGE
Charles M. Pendley
P.O. Box 159
Rainsville, Alabama 35986

UNIVERSITY OF SOUTHERN ALABAMA
James Bodo
307 University Boulevard
Mobile, Alabama 36688

UNIVERSITY OF ALASKA
Howard Cutter
Fairbanks, Alaska 99701

PINAL COUNTY COMMUNITY COLLEGE
Joe Heal
Woodruff at Overfield Road
Coolidge, Arizona 85228

CERRITOS COLLEGE
Ralph Chadwick
11110 East Alondra Boulevard
Norwalk, California 90650

CITY COLLEGE OF SAN FRANCISCO
Jules Fraden
50 Phelan Avenue
San Francisco, California 94112

PIERCE COLLEGE
Don Love
6201 Winnetka Avenue
Woodland Hills, California 91364

MERRITT COLLEGE
Lloyd Baysdorfer
12500 Campus Drive
Oakland, California 94629

ASNUNTUCK COMMUNITY COLLEGE
William Searle
Box 68
Enfield, Connecticut 06082

HENRY ABBOTT REG. VO. TECH. SCH.
Otto A. Truderung
Hayestown Avenue
Danbury, Connecticut 06810

QUINNIPAC COLLEGE
Stanley S. Katz
Mount Carmel Avenue
Hamden, Connecticut 06518

DELAWARE TECH. & COMM. COLLEGE
Jean E. Thomas
400 Christiana-Stanton Road
Newark, Delaware 19702

UNIVERSITY OF THE DISTRICT OF COL.
Lyle Carter
4200 Connecticut Avenue
Washington, D. C. 20008

SAVANNAH AREA VO-TECH SCHOOL
A. L. Pollock
214 West Bay Street
Savannah, Georgia 31401

THE LOOP COLLEGE
Dan Burrows
64 East Lake Street
Chicago, Illinois 60601

TECHNICAL SCHOOLS CONTACTED (CONTINUED)

PURDUE UNIVERSITY-CALUMET
R. W. Reach
2233 171st Street
Hammond, Indiana 46323

EASTERN KENTUCKY UNIVERSITY
Jack A. Luy
Richmond, Kentucky 40475

ALLEGANY COMMUNITY COLLEGE
Robert L. Youngblood
P.O. Box 1695
Cumberland, Maryland 21502

ALPENA COMMUNITY COLLEGE
Alan Reed
666 Johnson Street
Alpena, Michigan 49707

FERRIS STATE COLLEGE
John C. Van der Molen
901 South State Street
Big Rapids, Michigan 49307

MUSKEGON COMMUNITY COLLEGE
Frank P. Marczak
221 South Quarterline Road
Muskegon, Michigan 49443

ROCHESTER AREA VO-TECH INSTITUTE
Charles Harwood
1926 Southeast 2nd
Rochester, Minnesota 55901

MARY HOLMES COLLEGE
William Royal
West Point, Mississippi 39773

UNIVERSITY OF NEW HAMPSHIRE
Richard S. Davis
Durham, New Hampshire 03824

SIMPSON COLLEGE
Richard B. Lancaster
Indianola, Iowa 50125

KENTUCKY WESLEYAN COLLEGE
Donald D. Douglass
3000 Frederica Street
Owensboro, Kentucky 42301

HOLYOKE COMMUNITY COLLEGE
Mr. L'Heureux
303 Homestead Avenue
Holyoke, Massachusetts 01040

CHARLES STEWART MOTT COMM. COLLEGE
Marjorie McBrien
1401 East Court
Flint, Michigan 48503

LAWRENCE INSTITUTE OF TECHNOLOGY
Richard E. Michel
21000 West Ten Mile Road
Southfield, Michigan 48075

COLLEGE OF SAINT TERESA
Dorothy E. Landes
Broadway and Cummings
Winona, Minnesota 55901

SUBURBAN HENNEPIN CITY AREA VO-TECH
Richard E. Emery
1820 North Xenium Lane
Minneapolis, Minnesota 55441

STATE FAIR COMMUNITY COLLEGE
Nila Hibdon
Sedalia, Missouri 65301

ESSEX COUNTY COLLEGE
Herbert E. Seuorzo
303 University Avenue
Newark, New Jersey 07102

TECHNICAL SCHOOLS CONTACTED (CONTINUED)

FELICIAN COLLEGE
Sister Hiltrude Koba
260 South Main Street
Lodi, New Jersey 07644

MIDDLESEX CONTY COLLEGE
Richard H. Lowe
Edison, New Jersey 08817

UNION COUNTY TECHNICAL INSTITUTE
Dean Cynthia Niv
1776 Raritan Road
Scotch Plains, New Jersey 07076

BRONX COMMUNITY COLLEGE
Dean Carl J. Polowczyk
University Avenue & West 181 Street
Bronx, New York 10453

BROOME COMMUNITY COLLEGE
Joseph Gay
Binghamton, New York 13902

ERIE COMMUNITY COLLEGE/NORTH
Lean E. Butler
1309 Main Street
Buffalo, New York 14209

HUDSON VALLEY COMMUNITY COLLEGE
Interim Dean Reuben Merchant
80 Vandenbergh Avenue
Troy, New York 12180

NEW YORK CITY COMMUNITY COLLEGE
Ursula Schwerin
300 Jay Street
Brooklyn, New York 11201

ONONDAGA COMMUNITY COLLEGE
Roger J. Manges
Onandaga Hill
Syracus, New York 13215

SAUNDERS TRADES & TECHNICAL H.S.
Francis J. Tierney
104 South Broadway
Yonkers, New York 10701

STATE UNIVERSITY OF N.Y. (ALFRED)
David H. Huntington
Alfred, New York 14802

APPALACHIAN STATE UNIVERSITY
John E. Thomas
101 Sanford Hall
Boone, North Carolina 28608

CAPE FEAR TECHNICAL INSTITUTE
Mathew C. Donahue
411 North Front Street
Greenville, North Carolina 27834

PITT COMMUNITY COLLEGE
Joseph Downing
P.O. Drawer 7007
Greenville, North Carolina 27834

WAKE TECHNICAL COLLEGE
R. C. Koontz
Route 10, Box 200
Raleigh, North Carolina 27603

MAGNET SCIENCE HIGH SCHOOL
L. J. Frederico
4600 Detroit Avenue
Cleveland, Ohio 44102

LORAIN COUNTY COMMUNITY COLLEGE
Walter H. Edling
1005 North Abbe Road
Elyria, Ohio 44035

UNIVERSITY OF AKRON
R. C. Weyrick
304 East Bachtel Avenue
Akron, Ohio 44325

TECHNICAL SCHOOLS CONTACTED (CONTINUED)

UNIVERSITY OF TOLEDO
COMMUNITY & TECHNICAL COLLEGE
Fred J. Raniele
Toledo, Ohio 43606

COLLEGE OF APPLIED SCIENCE OF
THE UNIVERSITY OF CINCINNATI
John C. Spille
100 East Central Parkway
Cincinnati, Ohio 45210

CONNORS STATE COLLEGE
Harry Jackson
Warner, Oklahoma 74469

EASTERN OKLAHOMA STATE COLLEGE
Roy D. Vieux
Wilburton, Oklahoma 74578

SOUTHEASTERN OKLAHOMA STATE UNIV.
Ernest Starch
Durant, Oklahoma 74701

CHEMEKETA COMMUNITY COLLEGE
Nancy Borchgrevink
P.O. Box 14007
Salem, Oregon 97309

BUCKS COUNTY TECHNICAL SCHOOL
Herbert Mandel
Wistar Road
Fairless Hills, Pa. 19030

DELAWARE COUNTY AREA VO-TECH SCHOOL
James N. Keiler
Sixth & Olive Streets
Media, Pennsylvania 19063

HARRISBURG AREA COMMUNITY COLLEGE
James A. Odom, Jr.
3300 Cameron Street Road
Harrisburg, Pennsylvania 17110

KEYSTONE JUNIOR COLLEGE
William F. Messner
College Road
LaPlume, Pennsylvania 18440

MURRELL DOBBINS AREA VO-TECH SCH.
Edward Magliocco
Lehigh Avenue & 22nd Street
Philadelphia, Pennsylvania 19132

NORTHERN CHESTER COUNTY TECH. SCH.
Sanford J. Pariser
Charlestown Road
Phoenixville, Pennsylvania 19460

PENNSYLVANIA STATE UNIVERSITY
Herbert G. McGibbeny
University Drive
McKeesport, Pennsylvania 15132

ADMINISTRATION REGIONAL COLLEGE
Carlos E. Reoyo
Box 21850, U.P.R. Station
Rio Piedras, Puerto Rico 00931

HUMACAO UNIVERSITY COLLEGE
Yolando Vaillant de Candelario
CUH, Humacao, Puerto Rico 00661

TECHNOLOGICAL INSTITUTION OF P.R.
Guillermo Montalvo
Alegria Street-Las Virtudes
Rio Piedras, Puerto Rico 00924

WEST BAY VO-TECH SCHOOL
John R. Ball
15 Foster Drive
Coventry, Rhode Island 02816

GREENVILLE TECHNICAL COLLEGE
Ron Conally
P.O. Box 5616, Station B
Greenville, South Carolina 29606

TECHNICAL SCHOOLS CONTACTED (CONTINUED)

BRYAN COLLEGE
Glen H. Liebig
Dayton, Tennessee 37321

STATE TECHNICAL INST. (KNOXVILLE)
Jan R. Sonner
3435 Division Street
Knoxville, Tennessee 37919

TRI-CITIES STATE TECHNICAL INST.
T. H. Haws
P.O. Box 246
Blountville, Tennessee 37617

AMARILLO COLLEGE
Charles D. Lutz, Jr.
P.O. Box 447
Amarillo, Texas 79178

LEE COLLEGE
C. J. Collum
P.O. Box 818
Baytown, Texas 77520

TEXAS STATE TECHNICAL INSTITUTE
J. Barry Ballard
Waco, Texas 76705

BRIGHAM YOUNG UNIVERSITY
Kay F. Brown
Provo, Utah 84602

L.H. BATES VO-TECH INSTITUTE
Milton S. Rouse
1102 South Yakima Avenue
Tacoma, Washington 98405

SEATTLE CENTRAL COMMUNITY COLLEGE
Public D. Lorenz
1701 Broadway
Seattle, Washington 98122

DAVIS & ELKINS COLLEGE
Margaret Goddon
Elkins, West Virginia 26241

W. VA. NORTHERN COMMUNITY COLLEGE
Gregory Adkins
College Square
Wheeling, West Virginia 26003

CASPER COLLEGE
Ted Cross
125 College Drive
Casper, Wyoming 82601

APPENDIX D

MATHEMATICAL-CHEMICAL TECHNOLOGY

QUESTIONNAIRE FOR COURSE

CONTENT

MATHEMATICAL-CHEMICAL TECHNOLOGY

SURVEY FOR COURSE CONTENT

INSTRUCTIONS:

(1) Circle the appropriate number to indicate degree of acceptability within the given range of non-essential (being 1) to essential (being 5). The higher the number, the greater the need.

(2) Do not feel compelled to choose or delete courses simply on the basis that they are or are not regarded as "typical" offerings for a mathematical technology curriculum or a chemical technology curriculum. In other words, within the bounds of a technology program, total freedom of opinion is requested.

(3) Content should be applicable to a "two-year" technology program.

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* Information received by you will be held in confidence. This information will be used only in tallied form to be reported as a group response.

[INDIVIDUAL'S NAME]

[SCHOOL OR MANUFACTURER]

Part I: Responses regarding chemical content:

	Non-essential↔Essential				
Acids, Bases, & Salts	1	2	3	4	5
Active Metals	1	2	3	4	5
Alcohol and Phenols	1	2	3	4	5
Aldehydes and Ketones	1	2	3	4	5
Analysis by Electrical Conduction	1	2	3	4	5

	Non-essential↔Essential				
Analysis of Multi-Component Materials	1	2	3	4	5
Application of Redox Reactions	1	2	3	4	5
Boron Compounds	1	2	3	4	5
Carbohydrates	1	2	3	4	5
Carboxylic and Diazonium Compounds	1	2	3	4	5
Chemical Activity and Bonding	1	2	3	4	5
Chemical Changes and Energy Transformations	1	2	3	4	5
Chromatography	1	2	3	4	5
Classification and Nomenclature	1	2	3	4	5
Colorimetry and Spectrophotometry	1	2	3	4	5
Develop Basic Laboratory Techniques	1	2	3	4	5
Electrochemistry	1	2	3	4	5
Electrodeposition	1	2	3	4	5
Ethers	1	2	3	4	5
Evaluation of Experimental Measurement	1	2	3	4	5
Flame Photometry	1	2	3	4	5
Formulas and Chemical Equations	1	2	3	4	5
Gaseous State	1	2	3	4	5
General Operations in Quantitative Analysis	1	2	3	4	5
Gravimetric Determination	1	2	3	4	5
Gravimetric Stoichiometry	1	2	3	4	5
Halogen Compounds	1	2	3	4	5
Heterocyclic Compounds	1	2	3	4	5
Hydrocarbons	1	2	3	4	5
Indicators and pH	1	2	3	4	5
Introduction to Laboratory Equipment	1	2	3	4	5

	Non-essential↔Essential				
Ionization	1	2	3	4	5
Metals and Metal Alloys	1	2	3	4	5
Nature of Matter	1	2	3	4	5
Nitrogen	1	2	3	4	5
Oxidation	1	2	3	4	5
Oxygen/Hydrogen	1	2	3	4	5
Periodic Classification	1	2	3	4	5
Properties of Solutions	1	2	3	4	5
Radio/Chemistry	1	2	3	4	5
Scientific Measurements	1	2	3	4	5
Simple Compounds of Carbon	1	2	3	4	5
Solutions and Colloids	1	2	3	4	5
Stereoisomerism	1	2	3	4	5
Structure of Atoms	1	2	3	4	5
Sulfur Compounds	1	2	3	4	5
Titration	1	2	3	4	5
Valence and Oxidation Numbers	1	2	3	4	5
Water and the Liquid State	1	2	3	4	5
Weight and Volume Relations	1	2	3	4	5
X-ray Diffraction	1	2	3	4	5

* Please feel free to add chemical content below:

______________________________	1	2	3	4	5
______________________________	1	2	3	4	5
______________________________	1	2	3	4	5
______________________________	1	2	3	4	5
______________________________	1	2	3	4	5

Part II: Responses regarding mathematical content:

	Non-essential↔Essential				
Analytic Geometry	1	2	3	4	5
Applied Problems in Plane Geometry	1	2	3	4	5
Applied Problems in Solid Geometry	1	2	3	4	5
Basic Calculator	1	2	3	4	5
Binomial Theories	1	2	3	4	5
Calculus of Function of Several Variables	1	2	3	4	5
Complex Numbers	1	2	3	4	5
Computer Application	1	2	3	4	5
Computer Housekeeping Techniques	1	2	3	4	5
Conversions (Common Units to Metric & Vice Versa).	1	2	3	4	5
Determinants	1	2	3	4	5
Differentiation	1	2	3	4	5
Exponents and Radicals	1	2	3	4	5
Factoring	1	2	3	4	5
Graphic Representation	1	2	3	4	5
Instructions: Cord System	1	2	3	4	5
Integration	1	2	3	4	5
Job Timing of Computers	1	2	3	4	5
Limits	1	2	3	4	5
Logarithms	1	2	3	4	5
Macro Programing	1	2	3	4	5
Multiple Integral Calculus	1	2	3	4	5
Operation of Algebra	1	2	3	4	5
Organization of the Data Processing System	1	2	3	4	5
Probability and Sampling	1	2	3	4	5

	Non-essential↔Essential				
Program Debugging	1	2	3	4	5
Program Testing	1	2	3	4	5
Programing a Random Access Device	1	2	3	4	5
Programing a Tape System	1	2	3	4	5
Progressions	1	2	3	4	5
Quadratic Equation and Formula	1	2	3	4	5
Ratio Proportion and Percentage	1	2	3	4	5
Solving Linear Equations	1	2	3	4	5
Statistics	1	2	3	4	5
Subroutines of Computers	1	2	3	4	5
Trigonometric Function for Oblique Angles	1	2	3	4	5
Trigonometric Function for Right Angles	1	2	3	4	5
Trigonometric Graphing	1	2	3	4	5
Trigonometric Identities and Equations	1	2	3	4	5
Vectors	1	2	3	4	5
Vector Calculus	1	2	3	4	5

* Please feel free to add mathematical content below:

______________________	1	2	3	4	5
______________________	1	2	3	4	5
______________________	1	2	3	4	5
______________________	1	2	3	4	5
______________________	1	2	3	4	5

* If you would like to receive a copy of the survey results, please indicate by checking the appropriate box below:

☐ YES

☐ NO

APPENDIX E

RESPONSES OF TECHNICAL SCHOOLS AND CHEMICAL MANUFACTURERS BY CHEMICAL AND MATHEMATICAL COURSE CONTENT

RESPONSES OF TECHNICAL SCHOOLS AND CHEMICAL MANUFACTURERS BY CHEMICAL COURSE CONTENT

CONTENT	TECHNICAL SCHOOLS Response Frequency NE←→E							CHEMICAL MANUFACTURERS Response Frequency NE←→E							
	1	2	3	4	5	n_1	$\bar{X}_1$	1	2	3	4	5	n_2	$\bar{X}_2$	$\bar{\bar{X}}$
Acids, Bases, and Salts	0	0	2	3	25	30	4.76	0	0	1	3	17	21	4.76	4.76
Active Metals	0	4	5	13	7	29	3.79	0	3	9	5	3	20	3.40	3.63
Alcohols and Phenols	0	1	10	8	11	30	3.97	1	4	6	6	4	21	3.38	3.73
Aldehydes and Ketones	0	4	5	10	10	29	3.90	1	4	5	7	4	21	3.43	3.70
Analysis of Electrical Conduction	1	2	12	8	6	29	3.55	4	4	10	2	1	21	2.62	3.16
Analysis of Multi-Component Materials	0	1	10	10	8	29	3.86	1	4	6	7	3	21	3.33	3.64
Application of Redox Reactions	0	0	7	7	15	29	4.28	0	3	6	6	6	21	3.71	4.04
Boron Compounds	11	14	4	1	0	30	1.83	8	10	3	0	0	21	1.76	1.80
Carbohydrates	4	10	8	3	5	30	2.83	6	4	7	4	0	21	2.43	2.66
Carboxylic and Diazonium Compounds	4	6	9	5	6	30	3.10	4	5	7	4	1	21	2.67	2.92
Chemical Activity and Bonding	0	2	3	4	21	30	4.47	0	2	5	6	8	21	3.95	4.26
Chemical Changes and Energy Transformations	0	2	3	8	17	30	4.33	0	2	4	7	8	21	4.00	4.20
Chromotography	0	1	4	5	20	30	4.47	1	1	4	10	5	21	3.81	4.20
Classification and Nomenclature	0	0	2	6	21	29	4.66	0	0	6	3	12	21	4.29	4.51
Colorimetry and Spectrophotometry	0	0	4	7	19	30	4.50	0	2	6	8	5	21	3.76	4.20
Develop Basic Laboratory Technique	0	0	0	1	29	30	4.97	0	1	1	2	17	21	4.67	4.85
Electrochemistry	0	1	5	15	9	30	4.07	4	4	9	3	1	21	2.67	3.49
Electrodeposition	2	3	12	6	6	29	3.38	5	8	4	4	0	21	2.33	2.94

RESPONSES OF TECHNICAL SCHOOLS AND CHEMICAL MANUFACTURERS BY CHEMICAL COURSE CONTENT (CONTINUED)

CONTENT	TECHNICAL SCHOOLS							CHEMICAL MANUFACTURERS							
	Response Frequency NE←→E							Response Frequency NE←→E							
	1	2	3	4	5	n_1	$\bar{X}_1$	1	2	3	4	5	n_2	$\bar{X}_2$	$\bar{\bar{X}}$
Ethers	4	3	10	8	5	30	3.23	2	5	8	5	1	21	2.90	3.09
Evaluation of Experimental Measurement	0	0	1	10	19	30	4.60	0	0	1	9	11	21	4.48	4.55
Flame Photometry	1	5	10	10	4	30	3.37	1	8	8	4	0	21	2.71	3.10
Formulae and Chemical Equations	0	0	1	4	25	30	3.80	0	0	1	6	14	21	4.62	4.73
Gaseous State	0	0	7	10	13	30	4.20	0	1	8	7	5	21	3.76	4.02
General Operations in Quantitative Analysis	0	3	1	3	23	30	4.53	0	1	3	7	10	21	4.24	4.41
Gravimetric Determinations	0	2	5	3	20	30	4.37	2	2	6	5	6	21	3.52	4.02
Gravimetric Stoichiometry	0	2	3	10	15	30	4.27	0	2	8	4	7	21	3.76	4.06
Halogen Compounds	1	6	7	11	5	30	3.43	1	4	6	4	6	21	3.48	3.45
Hetrocyclic Compounds	5	7	9	7	2	30	2.80	3	6	6	6	0	21	2.71	2.76
Hydrocarbons	0	1	6	9	14	30	4.20	0	5	3	7	6	21	3.67	3.98
Indicators and pH	0	0	5	8	17	30	4.40	1	2	5	4	9	21	3.86	4.18
Introduction to Laboratory Equipment	0	0	0	3	27	30	4.90	0	2	2	4	13	21	4.33	4.67
Ionization	0	0	5	8	17	30	4.40	0	1	9	7	4	21	3.67	4.10
Metals and Metal Alloys	0	3	11	13	3	30	3.53	5	4	10	1	1	21	2.48	3.10
Nature of Matter	0	1	5	9	14	29	4.25	2	1	6	6	6	21	3.62	3.98
Nitrogen	1	6	13	8	2	30	3.03	3	4	9	3	2	21	2.86	2.96
Oxidation	0	0	3	11	16	30	4.43	1	1	3	10	6	21	3.91	4.22

RESPONSES OF TECHNICAL SCHOOLS AND CHEMICAL MANUFACTURERS BY CHEMICAL COURSE CONTENT (CONTINUED)

CONTENT	TECHNICAL SCHOOLS							CHEMICAL MANUFACTURERS							
	Response Frequency NE← →E							Response Frequency NE← →E							
	1	2	3	4	5	n_1	$\bar{X}_1$	1	2	3	4	5	n_2	$\bar{X}_2$	$\bar{\bar{X}}$
Oxygen/Hydrogen	0	4	8	12	6	30	3.67	3	1	6	7	4	21	3.38	3.55
Periodic Classification	0	1	4	8	17	30	4.37	1	1	8	5	6	21	3.67	4.08
Properties of Solutions	0	0	1	7	22	30	3.70	0	0	8	8	5	21	3.86	4.35
Radio Chemistry	1	9	10	6	3	29	3.03	6	6	6	2	1	21	2.33	2.74
Scientific Measurements	0	0	1	8	19	28	4.64	0	1	4	5	11	21	4.24	4.47
Simple Compounds of Carbon	0	0	8	5	16	29	4.28	0	1	7	2	11	21	4.10	4.20
Solutions and Colloids	0	2	6	6	15	29	4.17	1	5	7	6	2	21	3.14	3.74
Stereoisomers	5	8	4	8	4	29	2.93	8	4	5	2	2	21	2.33	2.68
Structure of Atoms	1	3	1	6	18	29	4.28	2	3	7	4	5	21	3.33	3.88
Sulfur Compounds	1	10	11	5	2	29	2.90	2	4	9	4	2	21	3.00	2.94
Titrations	0	0	1	1	27	29	4.90	1	1	0	7	12	21	4.33	4.66
Valence and Oxidation Numbers	0	0	4	5	20	29	4.55	0	4	3	6	8	21	3.86	4.26
Water and the Liquid State	0	2	7	6	14	29	4.10	0	4	10	5	2	21	3.24	3.74
Weight and Volume Relations	0	0	1	8	20	29	4.66	0	1	4	3	13	21	4.33	4.52
X-ray Diffraction	7	13	6	1	2	29	2.24	10	6	4	1	0	21	1.81	2.06

RESPONSES OF TECHNICAL SCHOOLS AND CHEMICAL MANUFACTURERS BY MATHEMATICAL COURSE CONTENT

CONTENT	TECHNICAL SCHOOLS							CHEMICAL MANUFACTURERS							
	Response Frequency NE←→E							Response Frequency NE←→E							
	1	2	3	4	5	n_1	$\bar{X}_1$	1	2	3	4	5	n_2	$\bar{X}_2$	$\bar{\bar{X}}$
Analytic Geometry	3	8	9	5	3	28	2.89	0	3	10	4	3	20	3.35	3.08
Applied Problems in Plane Geometry	1	7	7	10	5	30	3.37	3	1	9	4	3	20	3.15	3.28
Applied Problems in Solid Geometry	3	12	9	4	2	30	2.67	5	3	6	3	2	19	2.68	2.67
Basic Calculator	0	1	1	3	25	30	4.73	1	0	4	3	12	20	4.25	4.54
Binomial Theorems	6	7	6	8	3	30	2.83	3	5	7	0	5	20	2.95	2.88
Calculus of Function of Several Variables	10	7	9	3	0	29	2.17	3	7	4	5	1	20	2.70	2.39
Complex Numbers	7	7	8	2	5	29	2.69	3	10	5	0	2	20	2.40	2.57
Computer Application	1	0	4	7	18	30	4.37	0	0	4	6	10	20	4.30	4.34
Computer Housekeeping Techniques	2	1	8	8	9	28	3.75	4	1	6	2	7	20	3.35	3.58
Conversion (Common to Metric & Vice Versa)	2	0	3	2	23	30	4.47	0	0	0	4	16	20	4.80	4.60
Determinants	2	5	14	6	2	29	3.03	3	6	6	3	2	20	2.75	2.92
Differentiation	5	5	11	3	6	30	3.00	1	7	3	6	3	20	3.15	3.06
Exponents and Radicals	0	0	1	3	26	30	4.83	0	1	4	6	9	20	4.15	4.56
Factoring	1	0	3	7	19	30	4.43	0	0	5	10	5	20	4.00	4.26
Graphic Representation	0	0	0	2	27	29	4.93	0	0	0	8	12	20	4.60	4.80
Instructions: Cord System	4	5	7	1	0	17	2.29	5	5	3	0	0	13	1.85	2.10
Integration	3	7	9	4	7	30	3.17	1	6	6	4	3	20	3.10	3.14
Job Timing of Computers	3	4	12	6	1	26	2.92	3	6	7	4	0	20	2.60	2.78

RESPONSES OF TECHNICAL SCHOOLS AND CHEMICAL MANUFACTURERS BY MATHEMATICAL COURSE CONTENT (CONTINUED)

CONTENT	TECHNICAL SCHOOLS							CHEMICAL MANUFACTURERS							
	Response Frequency NE←→E							Response Frequency NE←→E							
	1	2	3	4	5	n_1	$\bar{X}_1$	1	2	3	4	5	n_2	$\bar{X}_2$	$\bar{\bar{X}}$
Limits	2	6	12	5	5	30	3.17	2	3	5	8	1	19	3.16	3.17
Logarithms	0	1	2	7	20	30	4.53	0	3	1	4	12	20	4.25	4.42
Loops and Indexing	3	4	9	8	6	30	3.33	1	4	7	7	0	19	3.05	3.22
Macro Programing	5	6	5	6	5	27	3.00	4	2	6	6	0	18	2.78	2.91
Multiple Integral Calculus	13	9	7	1	0	30	1.87	8	5	4	3	0	20	2.10	1.96
Operation of Algebra	0	2	2	1	25	30	4.63	0	1	3	5	11	20	4.30	4.50
Operations of Data Processing System	2	4	10	5	9	30	3.50	1	3	5	10	1	20	3.35	3.44
Probability and Sampling	0	1	1	8	20	30	4.57	0	0	3	8	9	20	4.30	4.46
Program Debugging	4	3	7	7	9	30	3.47	1	5	7	2	4	20	3.17	3.32
Program Testing	2	5	7	9	7	30	3.47	0	6	6	6	2	20	3.20	3.36
Programing a Random Access Device	2	6	10	6	4	28	3.14	4	6	5	2	3	20	2.70	2.96
Programing a Tape System	2	8	10	5	4	29	3.03	3	7	4	5	1	20	2.70	2.90
Progressions	4	10	8	4	3	29	2.27	5	4	3	3	3	20	2.65	2.69
Quadratic Equation and Formula	0	0	4	6	20	30	4.53	2	2	5	6	5	20	3.50	4.12
Ratio, Proportion, and Percentage	0	0	0	2	28	30	4.93	0	0	0	4	16	20	4.80	4.88
Solving Linear Equations	0	2	1	2	25	30	4.67	0	0	5	5	10	20	4.25	4.50
Statistics	0	0	4	13	13	30	4.30	0	0	3	8	9	20	4.30	4.30

RESPONSES OF TECHNICAL SCHOOLS AND CHEMICAL MANUFACTURERS BY MATHEMATICAL COURSE CONTENT (CONTINUED)

CONTENT	TECHNICAL SCHOOLS Response Frequency NE←→E							CHEMICAL MANUFACTURERS Response Frequency NE←→E							
	1	2	3	4	5	n_1	$\bar{X}_1$	1	2	3	4	5	n_2	$\bar{X}_2$	$\bar{\bar{X}}$
Subroutines of Computers	3	3	12	6	6	30	3.30	0	6	11	2	1	20	2.90	3.14
Trigonometric Functions of Oblique Angles	3	10	5	6	6	30	3.07	6	3	7	2	2	20	2.55	2.86
Trigonometric Functions of Right Angles	2	0	9	10	9	30	3.80	3	3	7	4	3	20	3.05	3.50
Trigonometric Graphing	2	5	10	6	6	29	3.31	2	5	8	3	1	19	2.79	3.10
Trigonometric Identities and Equations	5	8	9	4	4	30	2.80	4	4	6	4	2	20	2.80	2.80
Vectors	4	3	5	9	9	30	3.53	4	3	6	5	2	20	2.90	3.28
Vector Calculus	11	7	6	6	0	30	2.23	10	5	1	3	0	19	1.84	2.08

VITA

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Candidate for the Degree of

Master of Science

Thesis: MATHEMATICAL AND CHEMICAL CONTENT RECOMMENDED FOR A MATHEMATICAL-CHEMICAL TECHNOLOGY PROGRAM

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