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Scope of Study: This report is designed for the reader who is not familiar with the concepts and terms of elementary modern algebra. The bibliography consists basically of references which include the concepts of sets and the abstract structures of modern algebra--groups, rings, integral domains, and fields. The concepts of set and group are introduced by explanation and illustration in an effort to show the reader the applications of these concepts in classroom situations.

Findings and conclusions: The bibliography lists those sources which should prove useful to the teacher who is unfamiliar with the basic terms and concepts of elementary modern algebra. An asterisk preceding a reference indicates, in the author's opinion, those sources which would best serve as introductory materials.

ADVISER'S APPROVAL ____________________

BIBLIOGRAPHY OF ELEMENTARY MODERN ALGEBRA

By

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BIBLIOGRAPHY OF ELEMENTARY MODERN ALGEBRA

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PREFACE

The basic terms and concepts of modern algebra are incorporated in several areas of mathematics. In this report, the author has attempted to list available references from which basic terms and concepts of elementary modern algebra may be obtained.

The author is indebted to her adviser, Dr. James H. Zant, for his assistance and guidance.

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CHAPTER I

INTRODUCTION

Mathematics teachers have been seeking techniques which will promote greater understanding of mathematical concepts. This search has prompted suggested changes in the traditional mathematics courses. High school mathematics curriculum of today was developed fifty to seventy-five years ago. Adjustments in the mathematics curriculum are needed for the present age of rapid advances in sciences and technology.

The problem of providing proper instruction for each student is a tremendous one. Since the student's future career or occupation is unknown, the mathematics curriculum must emphasize general principles, ideas, and techniques. Computational skills are secondary to understanding. An understanding of mathematical concepts enables the student to learn mathematical skills of the present and to develop new skills as the future demands it.

The Commission on Mathematics of the College Entrance Examination Board, the School Mathematics Study Group, and others have suggested using concepts, including language and symbolism, from modern mathematics to promote a better understanding of mathematics. Contemporary mathematics will contribute concepts which will aid the student in reaching an understanding of the fundamental ideas of mathematics. The new concepts can arouse interest as well as promote understanding. Old ideas are broadened while introducing important new ones. The language of modern mathematics is useful in providing clarification and simplification of mathematical terms. New symbolism and concepts should be introduced when they clarify, simplify, or unify the fundamental ideas of mathematics.

Many of these suggestions for mathematics curriculum revisions will be incorporated in textbooks published in the near future. There is a need, therefore, for mathematics teachers to prepare themselves to teach courses using these new concepts and approaching the subjects with the new emphasis. An understanding of the basic terms and concepts of elementary modern algebra would be valuable to the mathematics teacher.

Teachers who wish to acquire an understanding of the basic terms and concepts of elementary modern algebra may find the following chapters a useful guide. A few of the basic terms and concepts are introduced in chapter two. These terms and concepts are used to illustrate the applications of modern algebra in teaching the traditional algebra course.

CHAPTER II

ILLUSTRATIONS OF THE USE OF MODERN CONCEPTS IN TEACHING ALGEBRA

There are four important abstract structures of modern algebra. These are groups, rings, integral domains, and fields. These structures are defined in terms of the number of operations and the characteristics of the set under the operations. A teacher who has an understanding of these abstract structures and an understanding of sets may be prepared to teach mathematics courses using these new concepts.

The notion of set is probably the simplest concept which can be useful in increasing mathematics understanding. A set is a collection composed of objects called members or elements. A finite set can be designated by listing the objects that belong to it. Capital letters are used as the names of sets and small letters as elements of sets. If x is an element of set A, it is written $x \in A$. If y does not belong to A, it is written $y \notin A$. The membership of a set is indicated by enclosing, in braces, all elements or a descriptive phrase; e.g., $A = \{a, b, c\}$ and $B = \{x$, such that $x > 0\}$ or $\{x \mid x > 0\}$ where the bar is read "such that."

Students are familiar with sets designated by such words as "family," "group," "class," and many other words. The members of the family are elements of the set. Consider the members of the family that are over twenty-five years of age. These members constitute a subset, E, of family, F, which is symbolized $E \subset F$. If all the members of the set are under twenty-five, E is an empty or null set. If E is not empty and not equal F, it is a proper subset.

The language and symbolism of sets may be used in making definitions clear and concise. This is exhibited in defining variable. A variable is a letter used to represent an arbitrary element of a set containing more than one element. Let S be the set of real numbers and let x be an element of S such that $x + 3 = 7$. In this case x is a variable and represents the element in S which makes $x + 3 = 7$ a true statement.

It is customary to denote the coordinates of a point in the Cartesian plane by ordered pairs of numbers. The notation for ordered pairs involves two elements in parenthesis with the elements separated by a comma; thus (x,y) and (2,5) are notations for ordered pairs. It should be noted that x and 2 are in the first position and y and 5 are in the second position. The order of elements is very important for (2,5) is not the same ordered pair as (5,2). Sets of ordered pairs can now be considered. Any set of numbers can yield a set of ordered pairs. Let $T = \{1,2,3\}$. From T, a set of all ordered pairs whose coordinates belong to T can be formed as illustrated. $\{(1,1), (1,2), (1,3), (2,1), (2,2), (2,3), (3,1), (3,2), (3,3)\}$ The foregoing set of ordered pairs is called the Cartesian set of T or Cartesian product of $T \times T$ (read "T cross T"). If S is the set of all real numbers, the graph of $S \times S$ is the whole plane. The fundamental assumption of analytic geometry is thus illustrated. There is exactly one point of the plane corresponding to each element of the set $S \times S$ and there is exactly one element of $S \times S$ corresponding to each point of the plane.

Ordered pairs are used to designate the elements which satisfy an equation with two variables. Let (x,y) be the ordered pair that makes the statement $x = y + 1$ true. The set of ordered pairs which makes the statement true is called the solution set. The solution set can be denoted M = $\{(x,y)$ such that $x = y + 1\}$. Each ordered pair of the solution set can be graphed in the usual way. The graph of a statement in two variables is the graph of its solution set. This viewpoint broadens and clarifies the concept of a graph.

The language of sets clarifies and simplifies mathematical vocabulary. This is illustrated in the following definitions of locus and function. A locus is the set of those points, and only those points, that satisfy a given condition. The condition may be an equation or inequality; thus the solution set of the equation or inequality corresponds to the set of points that make up the locus. A function is an association which attaches to each element in some set one, and only one, element in another set. This involves the idea of a set of ordered pairs. As well as clarity and simplicity, the concept of a set also gives unity to the study of equations, inequalities, relations, and functions.

A binary operation on S is a function with $S \times S$ forming the set of all elements which occur in the first position and all elements occuring in the second position belong to S.. Some operations are important enough to have special names. For example, the set of positive numbers has operations called addition and multiplication. Addition associates with each ordered pair (a,b) of positive numbers a sum a + b. multiplication associates with each ordered pair (a,b) of positive integers a product $a \cdot b$.

Operations may have special properties. These properties are of basic importance in our number system. For example, both addition and multiplication are commutative. This property is exhibited by the examples $2 + 3 = 3 + 2$ and $2 \cdot 3 = 3 \cdot 2$. In modern algebra, certain systems are defined according to the properties of the operations. These abstract structures are especially useful in reaching an understanding of our number system.

One of the abstract structures of modern algebra is a group. A group is defined as a system, G, of elements having a binary operation, designated by *, which has the following properties:

1. Closure. If a and b are in G, then a*b is in G.
2. Associative. For all a,b, and c in G a*(b*c) = (a*b)*c.
3. Identity. There is an element, e, such that for any element, a, in G a*e = e*a = a.
4. Inverse. For each element, a, in G there is an element, a^{-1}, in G such that $a*a^{-1} = a^{-1}*a = e$.

Consider the set A, of positive and negative integers and zero under the operation of addition. The sum of any two elements in A is an element of A; thus the closure property is satisfied. The associative property is also satisfied for a + (b + c) = (a + b) + c. This is illustrated by an example of 4 + (2 + 3) = (4 + 2) + 3. There exists an element in A, 0, such that a + 0 = 0 + a = a; therefore the identity property is satisfied. For each element, a, in the set there is another element in the set, -a, such that a+(-a) = (-a) + a = 0. The set of positive and negative integers and zero is a group under the operation of addition.

Consider the set of whole numbers under the operation of multiplication. This is not a group for the operation does not have the inverse property. The identity for multiplication is one (1) for a·1 = 1·a = a. For every whole number there is not a whole number which, when multiplied, yields a product of one. Since the inverse property is not satisfied, the set of whole numbers under the operation of multiplication is not a group.

Students often fail to understand the closure property for mulitplication of real numbers. To satisfy this property, the product of any two real numbers must be a real number. The meaning given to the product of two real numbers must hold for the multiplication of all real numbers. From arithmetic the following properties are known for multiplication of positive numbers a, b, and c:

$ab = ba$

$a(bc) = (ab)c$

$(a)(1) = a$

$(a)(0) = 0$

$a(b+c) = ab+ac$

These properties must still hold for the multiplication of negative and positive real numbers.

Some possible products may be considered: (2)(3), (2)(-3), (-2)(-3), (-2)(0), (0)(0), (2)(0). Using the preceding properties, the products of all but the second, third, and fourth examples can be obtained. The multiplication property of 0 must be true for all real numbers; therefore (-2)(0) must equal 0. The two remaining questions, (2) (-3) = ? and (-2)(-3) = ?, can be answered as follows:

$0 = (2)(0)$

$0 = (2)\left[3 + (-3)\right]$, by writing $0 = 3 + (-3)$;

$0 = (2)(3) + (2)(-3)$, if the distributive property must hold for all real numbers;

$0 = 6 + (2)(-3)$.

If the properties of multiplication are to hold for all real numbers, then (2)(-3) must be -6 for $0 = 6 + (-6)$.

Consider (-2)(-3) in a similar manner.

$0 = (-3)(0)$, if the multiplication property of 0 must hold for real numbers;

$0 = (-3)\,[2 + (-2)]$, by writing $0 = 2 + (-2)$;

$0 = (-3)(2) + (-3)(-2)$, if the distributive property must hold for real numbers;

$0 = (2)(-3) + (-2)(-3)$, if the commutative property must hold for real numbers;

$0 = (-6) + (-2)(-3)$, by the previous result $(2)(-3) = -6$.

The product of (-2) and (-3) must be the opposite of -6 if the properties of multiplication hold for real numbers; therefore $(-2)(-3) = 6$. Regardless of the signs, the product of any two real numbers is a real number. Multiplication of real numbers has the closure property.

The preceding are examples of applications of modern mathematics. With an understanding of elementary modern algebra a teacher can develop applications of modern mathematics for his mathematics courses.

CHAPTER III

BIBLIOGRAPHY

The references included in the following bibliography contain information from which basic terms, symbols, and concepts of elementary modern algebra may be obtained. These basic terms and concepts are sets and the four important abstract structures of modern algebra---groups, rings, integral domains, and fields. These references are briefly annotated to aid the reader in selecting the references most useful to him. Each annotation indicates which of these basic terms are included in the reference. A reference was considered elementary if the basic terms were defined rather than assumed. An asterisk preceding a reference indicates those sources which would best serve as introductory materials to elementary modern algebra.

Albert, Abraham Adrian. Fundamental Concepts of Higher Algebra. Chicago: University of Chicago Press, 1956. 165 p.

This book begins with the discussion of properties of groups, rings, and fields, but rapidly advances to more complex topics including vector spaces and matrices.

*Albert, Abraham Adrian. Modern Higher Algebra. Chicago: University of Chicago Press, 1938. 319 p.

The beginning of this book is an elementary treatment of groups and rings. The terminology used, however, is slightly different from the more recent publications.

*Alexandroff, Pavel Sergeevich. An Introduction to the Theory of Groups. New York: Hafner Publishing Company, Incorporated, 1959. 109 p.

The discussion of group theory is designed for the reader with a background of algebra and geometry.

*Allendoerfer, Carl Barnett and Cletus Odia Oakley. Principles of Mathematics. New York: McGraw-Hill Book Company, 1955. pp 69-182.
Little background is assumed in this introductory college text which includes groups, fields, sets, and functions.

Andree, Richard V. Selections from Modern Abstract Algebra. New York: Henry Holt and Company, 1958. 212 p.
This book, designed to develop "mathematical maturity" includes discussions of groups, fields, rings, and ideals. The contents can be considered of college sophomore level.

*Artin, Emil. Modern Developments in Algebra. Boulder: University of Colorado, 1953. 128 p.
The first two chapters contain a very brief treatment of sets, groups, rings, and fields.

Beaumont, Ross A. and Richard W. Ball. Introduction to Modern Algebra and Matrix Theory. New York: Rinehart and Company, Incorporated, 1957. pp 123-202.
Groups, rings, integral domains, and properties of the number system are discussed using matrices, summation, and other advanced terms.

Bell, Eric Temple. The Handmaiden of the Sciences. Baltimore: Williams and Wilkins Company, 1937. pp 180-197.
A brief explanation of group properties is made more understandable by the included examples.

Bernays, Paul. Aximatic Set Theory. Amsterdam: North-Holland Publishing Company, 1958. 226 p.
The extensive treatment of set theory may appear difficult because symbolism is used throughout the book.

Birkhoff, Garrett and Saunders MacLane. A Survey of Modern Algebra. New York: The Macmillan Company, 1941. 450 p.
Presupposing only high school algebra, the first ten chapters develop, with many examples and applications, the abstract concepts of integral domains, fields, and groups. Chapters XI and XII deal with classes and cardinal numbers. The last three chapters introduce commutative algebra and arithmetic.

Boehm, George A. W. The New World of Mathematics. New York: The Dial Press, 1959. pp 24-29.
A concise discussion of group concept includes a brief and understandable treatment of operation tables.

Chicago University. Fundamental Mathematics. Chicago: University of Chicago Press, 1948. pp 1-533.
Volume I of this publication contains a discussion of sets, operations on sets, relations, and functions. Volume II deals with fields and examples of fields.

Commission of Mathematics. Introductory Probability and Statistical Inference, Revised Preliminary Edition. New York: College Entrance Examination Board, 1959. 243 p.

This text, written for twelfth year high school, makes use of elementary theory of sets to convey meaning concisely. The appendices reviews the necessary background. Appendix I is entitled "The Mathematics of Collections of Objects---Theory of Sets" and deals with set notation, properties, operations, and functions. Appendix II, "Permutations and Selections", includes subsets and binomial theorem.

*Commission on Mathematics. Report of the Commission on Mathematics, Appendices. New York: College Entrance Examination Board, 1959. pp 1-109.

Sets, relations, and functions are explained with examples and applications.

*Commission on Mathematics. Sets, Relations, and Functions. New York: College Entrance Examination Board, 1958. 35 p.

This pamphlet, designed for teachers, is a presentation of subject matter that teachers will need to know and with which they will want to acquaint themselves. Many illustrations are included in the presentation.

*Committee on the Undergraduate Program of the Mathematical Association of America. Elementary Mathematics of Sets With Applications. Ann Arbor: Cushing-Malloy Incorporated, 1958. 168 p.

This book is designed for college freshmen with a slight knowledge of calculus. Chapters include sets and subsets, applications, mathematical systems, and algebraic structures.

*Courant, Richard and Herbert Robbins. What is Mathematics? London: Oxford University Press, 1941. pp 108-112.

Four pages of this book deals with sets in a very brief and logical manner.

Fraenkel, Abraham Adolf. Abstract Set Theory. Amsterdam: North-Holland Publishing Company, 1953. 479 p.

This book contains a very detailed discussion of the theory of sets.

Fraenkel, Abraham Adolf and Yehoshua Bar-Hillel. Foundations of Set Theory. Amsterdam: North-Holland Publishing Company, 1958. 415 p.

A background of college mathematics is required to understand this more advanced treatment of the theory of sets.

Freund, John E. Modern Introduction to Mathematics. Englewood Cliffs: Prentice-Hall, Incorporated, 1956. pp 224-243, 415-450.

Chapter fifteen, entitled "Elementary Mathematical Systems", deals briefly with systems or sets, operations on the sets, isomorphisms, and groups. Chapter twenty-three, "Logic", presents and uses Venn diagrams in discussing related classes, algebra of classes, properties of classes, and relations.

Hall, Marshall Jr. The Theory of Groups. New York: The Macmillan Company, 1959. 434 p.
Group theory is treated in a complete and logical manner.

Hasse, Helmut. Higher Algebra. New York: Frederick Ungar Publishing Company, 1954. 336 p.
Some college mathematics is required to understand this book which begins with a discussion of rings, fields, and integral domains and continues with groups.

Hughart, Stanley P. Some Topics from Modern Mathematics for Secondary School Sciences Teachers. Stillwater: Oklahoma State University, 1958. pp 164-216.
Sets, relations between sets, operations on sets, relations, functions, and operations are presented in this book.

James, Glenn. The Tree of Mathematics. Pacoima: The Digest Press, 1957. pp 251-276.
Many terms of modern algebra are briefly and clearly introduced in a manner understandable to the advanced high school student.

Johnson, Richard E. First Course in Abstract Algebra. New York: Prentice-Hall, 1953. 257 p.
Basic concepts, integral domains, fields, and groups are included in this logically developed course in abstract algebra.

Kemeny, John B., James Laurie Snell, and Gerald L. Thompson. Introduction to Finite Mathematics. Englewood Cliffs: Prentice-Hall, Incorporated, 1957. pp 54-79.
The second chapter of this book deals with sets and subsets.

*Kershner, R. B. and L. R. Wilcox. The Anatomy of Mathematics. New York: The Ronald Press Company, 1950. 416 p.
Bridging the gap between classical and modern approaches to mathematics is the purpose of this book. Sets, fields, and groups are discussed at length in a manner which could be understood by the layman. Many of the basic terms of elementary modern algebra are explained.

Kiss, Stephen A. Transformations of Lattices and Structures of Logic. New York: Stephen A. Kiss, 1947. pp 7-71.
Sets, groups, and rings are discussed as preliminary material to more complex topics.

Kleene, Stephen Cole. Introduction to Mathematics. Princeton: D. Van Nostrand Company, Incorporated, 1952. pp 1-19.
The theory of sets begins this introduction to mathematics.

Kline, Morris. Survey of Higher Mathematics. New York: New York University, 1949. pp 142-155.
Groups, rings, and fields are briefly included in this higher mathematics survey.

Levi, Howard. Elements of Algebra. New York: Chelsea Publishing Company, 1954. 160 p.
The first chapter deals specifically with sets while the succeeding chapters use operations on sets, relations, and order to explain the elements of algebra.

Lieber, Lillian Rosanoff. Galois and Theory of Groups. Lancaster: The Science Press Printing Company, 1932. 58 p.
This book has a very unique treatment of sets and group theory.

Lomont, John S. Applications of Finite Groups. New York: Academic Press, 1959. 346 p.
Basic terms of elementary modern algebra are included in the second chapter which is concerned with groups. The remainder of the book deals with more complex topics.

Luce, R. D. Studies in Mathematics. School Mathematics Study Group, Box 2029, Yale Station, New Haven, Connecticut, 1959. Volume I, pp 1-168.
This volume, entitled "Some Basic Mathematical Concepts", is an extensive exposition of the basic concepts of elementary set theory together with illustrations of the use of set concepts in various parts of mathematics.

MacDuffee, Cyrus Colton. An Introduction to Abstract Algebra. New York: John Wiley and Sons, Incorporated, 1947. 303 p.
This book is a combination of number theory, group theory, and formal algebra. Special cases of number theory are first discussed, then abstract ideas of group theory and formal algebra are presented.

Mathewson, Louis Clark. Elementary Theory of Finite Groups. New York: Houghton Mifflin Company, Incorporated, 1959. pp 134-173, 244-321, 548-586.
Requiring a background of plane geometry and elementary algebra, this book deals with the elementary theory of sets and relations. The last chapter, "Abstract Mathematical Theories", includes sections on fields, groups, and group theory.

McCoy, Neal Henry. Rings and Ideals. Baltimore: The Waverly Press, 1948. 216 p.
Beginning with definitions and fundamental properties of rings this book proceeds to more complex topics.

Meserve, Bruce E. Fundamental Concepts of Algebra. Cambridge: Addison-Wesley Publishing Company, Incorporated, 1953. pp 1-98.
Concepts of higher mathematics are introduced with relation to elementary mathematics. Sets, equivalence relations, order relations, inverses, fields, groups, and residue classes are discussed.

Miller, Kenneth S. Elements of Modern Abstract Algebra. New York: Harper and Brothers, Publishers, 1958. 188 p.
Some preliminary knowledge of the terms is required to understand this treatment of groups, rings, ideals, and fields.

*National Council of Teachers of Mathematics. Insights into Modern Mathematics. Washington, D. C.: National Council of Teachers of Mathematics, 1957. pp 36-65, 100-145.
"Operating with Set" and "Algebra" are chapter titles. The latter deals with groups, homomorphism, isomorphism, rings, and fields.

Newman, James R. The World of Mathematics. New York: Simon and Schuster, 1956. pp 1538-1576.
This deals with the group concept and the theory of groups.

Newman, Maxwell Herman Alexander. Elements of the Topology of Plane Sets of Points. Cambridge: Cambridge University Press, 1954. 214 p.
Sets are extensively discussed including closed and open sets in metric spaces, compact sets, connected sets, and other complex topics.

Pedoe, Daniel. The Gentle Art of Mathematics. London: The English University Press Limited, 1958. pp 65-76, 90-108.
The pages indicated deal with classes, groups, and rings.

*Richardson, Moses. Fundamentals of Mathematics. New York: The Macmillan Company, 1958. pp 176-209, 459-478.
One chapter, "The Algebra of Logic and Related Topics", deals with sets and another chapter, "Some Simple Mathematical Sciences", deals with relations and groups.

Sawyer, Walter Warwick. A Concrete Approach to Abstract Algebra. San Francisco: W. H. Freeman and Company, 1959. 233 p.
This book contains a field centered approach to abstract algebra. From familiar arithmetic, it proceeds to discussion of fields, vectors, and vector spaces.

*School Mathematics Study Group. Mathematics for High School First Course In Algebra. School Mathematics Study Group, Box 2029, Yale Station, New Haven, Connecticut, 1959. 547 p.
This text, written for eleventh year high school, uses basic terms and concepts of elementary modern algebra to explain the number system and traditional material of algebra, introductory trigonometry, vectors, and geometry.

Stabler, Edward Russell. An Introduction to Mathematical Thought. Reading: Addison-Wesley Publishing Company, Incorporated, 1953. 268 p.
Included in this book are chapters on fields, groups, rings, Boolean Algebra, relations, order systems, and lattices as well as some basic introduction to sets.

*Swain, Robert L. Modern Mathematics for High School Teachers of Science and Mathematics. Stillwater: Oklahoma State University, 1958. pp 1-118.
This book, written to be useful to high school science and mathematics teachers, deals with sets, operations, relations, and functions.

*Swain, Robert L. Understanding Arithmetic. New York: Rinehart and Company,

Incorporated, 1957. pp 27-46.
Sets and numbers are discussed in a manner which could be useful in teaching elementary school children.

Thurston, Hugh Ansfrid. The Number System. London: Blackie and Son Limited, 1956. 134 p.
Pure algebra is introduced throughout in explaining the number system. The preface contains a chart showing the analogy of the arithmetical system and abstract mathematics.

Van der Waerden, Bartel Leendert. Modern Algebra. New York: Frederick Ungar Publishing Company, 1949.
Many terms of modern algebra are introduced in a well organized manner.

Weyl, Hermann. The Classical Groups, Their Invariants and Representations. Princeton: Princeton University Press, 1946. pp 1-27.
An advanced background is required to understand this discussion of fields, rings, ideals, and groups.

*Wilder, Raymond Louis. Introduction to the Foundations of Mathematics. New York: John Wiley and Sons, Incorporated, 1956. pp 52-134, 158-189.
This book deals with subjects which include the theory of sets, infinite sets, well-ordered sets, and groups.

Young, John Wesley. Lectures on Fundamental Concepts of Algebra and Geometry. New York: The Macmillan Company, 1936. pp 43-58.
Consistency, independence, and categoricalness of a set of assumptions are included in this book.

CHAPTER IV

SUMMARY

High school mathematics textbooks and curriculum are in the process of change. Recommendations embody relatively minor changes in content, but important changes in the points of view of instruction and major changes in teaching emphasis. Appreciation of mathematical structure is emphasized. The unifying ideas of elementary modern algebra are used to promote a better understanding of mathematical concepts.

This report is written for the benefit of those mathematics teachers who wish to improve their teaching through independent reading. This report has been written with the conviction that mathematics teachers could incorporate modern mathematical advances into their courses by using this bibliography of elementary modern algebra.

The bibliography included in this report lists those books which were available on the Oklahoma State University campus and were found useful for introducing sets, groups, rings, integral domains, and fields. The bibliography is designed for the reader who is not familiar with the concepts and terms of modern algebra.

VITA

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Report: BIBLIOGRAPHY OF ELEMENTARY MODERN ALGEBRA

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