A STUDY OF SELECTED ATTITUDINAL FACTORS OF SECONDARY MATHEMATICS TEACHERS TOWARD CURRICULUM CHANGE AND IMPLEMENTATION IN STATISTICS EDUCATION

By

DEBORAH HOPKINS COLLUM

Bachelor of Science
Oklahoma Baptist University
Shawnee, Oklahoma
1972

Master of Science
University of Tulsa
Tulsa, Oklahoma
1975

Submitted to the Faculty of the
Graduate College of the
Oklahoma State University
in partial fulfillment of
the requirements for
the Degree of
DOCTOR OF EDUCATION
July, 1991

OKLAHOMA STATE UNIVERSITY

A STUDY OF SELECTED ATTITUDINAL FACTORS
OF SECONDARY MATHEMATICS TEACHERS
TOWARD CURRICULUM CHANGE AND
IMPLEMENTATION IN STATISTICS
EDUCATION

Thesis Approved:

Thesis Adviser

Dean of the Graduate College

PREFACE

This study directs attention toward the qualitative nature of teaching statistics at the secondary school level. Throughout years of classroom teaching and observing teachers as they interact with students, I have come to examine teachers' attitudes toward the subject they teach with as much interest as I direct toward the knowledge which they possess about that subject.

The data collected in this study has come from a variety of sources: state supervisors of mathematics throughout the nation, individual teachers across the United States who are actively incorporating data analysis into their mathematics curriculum, and a cross-section of secondary mathematics teachers in the state of Oklahoma whose attitudes toward this subject were unknown. Both qualitative and quantitative data analysis techniques have been used in an attempt to identify and describe some of the beliefs held by secondary mathematics teachers concerning implementation of elements of statistics into the mathematics curriculum.

I wish to express my sincere gratitude to the individuals who have assisted me in this project and during my coursework at Oklahoma State University. In particular, I wish to thank my major adviser, Dr. Douglas B. Aichele, for the guidance he has offered and the belief he has expressed in my success. I am also grateful to the other committee members, Dr. James R. Choike, Dr. Margaret M. Scott, Dr. Joyce S. Friske, and Dr. J. Leroy Folks, for their support, encouragement, and advisement during the course of this work. Additionally, my thanks goes to Dr. A. Susan Gay for assisting me in establishing contact with state supervisors of mathematics and teachers actively involved with implementing curriculum change in statistics education throughout the United States. I am very appreciative for her suggestions and encouragement.

Special thanks, going beyond my ability to adequately express in words, goes to my family and friends who have given me much needed moral support, especially during this past year. Each of these people have represented to me the hand of God at work in my life. My parents, Hubert and Mable Hopkins, have believed in my abilities to complete both this project and degree program. They have afforded me the freedom to concentrate my efforts on the task at hand by providing my children with the additional love and reassurance which they have so desperately needed this year. I thank my precious children, Clayton and Andrea, for their patience and willingness to share my attention with the demands of this study and with the demands of the entire program. Their belief in me has sustained me through the most pressing times.

My parents-in-law, Hugh and Catharine Collum, have

encouraged me from the beginning and have provided me with a place to stay as I have needed to spend concentrated amounts of time in Stillwater. For this help and support, I am very grateful. I have also valued dearly the expressions of support and concern from friends, including my church family and my colleagues from Oklahoma Baptist University, not only for my success but also for the well-being of my children. Among those who have opened not only their hearts but also their homes are Dr. Tom and Jackie Wilks, Tony and Nanette McMurry, Jane Bowers, and Dr. Robbie Mullins. I extend sincere thanks to all of these people.

TABLE OF CONTENTS

LIST OF TABLES

CHAPTER I

INTRODUCTION

Historical Perspective

The launching of Sputnik in October, 1957 awakened the United States in a very dramatic way to the necessity for reforming the common school science and mathematics curriculum. The primary focus at that point in time was national defense. In 1958, the United States Congress

> . . . responded to the Soviet technological challenge by mounting a crash scientific research and development program designed to launch an American satellite into space (Jennings, 1987, p. 104).

The National Defense Education Act of 1958 encouraged the development of programs in science, mathematics, and foreign languages in both common schools and in colleges. The effects of this legislation were felt throughout the United States with greatest strength in the decade of the 1960's.

"Modern" curriculum reform did not, however, begin in the 1960's. As early as the turn of the century, mathematics educator E. H. Moore was urging schools to adopt a more integrated mathematics curriculum, abolishing the separation of algebra, geometry, and physics (Cooney, 1988). At about the same time, John Perry emphasized the importance of applications and laboratory experiences in the teaching of mathematics (Cooney, 1988).

Recommendations for curriculum change have also consistently come from groups of mathematics educators as well as from individuals, such as Moore and Perry. In 1963, the Cambridge Conference on School Mathematics published its Goals for School Mathematics in which a variety of long-range goals were proposed. These included a more rigorous study of school mathematics, incorporating much of what had previously been considered college-level mathematics. Although the report included two proposals, one more accelerated than the other, it also proposed that all students have a "feeling" for probability and statistics as a fundamental component of the school mathematics curriculum. However, in a 1965 survey of College Board examinees, Williams reported that although content recommendations of the Commission on Mathematics had reached many schools, probability and statistics were the exceptions to this trend (National Council of Teachers of Mathematics, 1970).

In its Overview and Analysis of School Mathematics, Grades K-12, the National Advisory Committee on Mathematical Education (NACOME) addressed issues surrounding the phenomenon commonly known as the "new math" (Conference Board of the Mathematical Sciences, 1975). Urging that the term "new math" be used only as an historical label for the "very diversified series of developments that took place in school mathematics between 1955 and 1975," the authors of this document examined standardized test trends for this period of time (Conference Board of the Mathematical Sciences, 1975). Referring to such standardized test batteries as the Metropolitan Achievement Test, the Iowa Tests of Basic Skills, Comprehensive Tests of Basic Skills, and the California Achievement Test, the authors acknowledged that general declines in scores occurred from about 1962 through 1975. They pointed out, however, that the declines were not restricted to mathematics but were also consistent in reading and some language skill areas for the same period. The members of NACOME attributed some of this decline in mathematical achievement to a general decline in respect afforded the mathematical sciences in the post-Sputnik years. They also noted that all of American education had suffered as the result cultural changes in which the general public no longer held public education to be the solution to the nation's social ills. Such a decline in public trust was coupled with a decline in governmental funding of educational programs.

With particular reference to the area of statistics, the authors of the NACOME report recommended that statistical ideas be integrated throughout the curriculum at all levels. They suggested that this could be done in a variety of ways, including

1. the use of statistical topics to illustrate and

motivate the learning of other topics in mathematics;

2. the emphasis of statistical topics as an interdisciplinary subject, integrating mathematics with other subjects in the physical, natural, and social sciences as well as humanities; and

3. the development of separate courses in algebra-based and/or probability-based statistics.

These recommendations contained commonalities with both previous reports, such as the Cambridge Conference on School Mathematics, and subsequent documents, such as the milestone document Curriculum and Evaluation Standards for School Mathematics published by the National Council of Teachers of Mathematics (1989). Through the National Council of Teachers of Mathematics, the Standards carries the support of a network of teachers at the local, state, regional, and national levels which has the mechanism for implementing these recommendations on a large scale.

The 1980's brought new attention to American education. As noted by the counsel for the Committee on Education and Labor, U. S. House of Representatives in Washington, D. C., "the Sputnik of the 1980's" and beyond is economic competition (Jennings, 1987). Although President Reagan presented a "call to arms" to the United States in A Nation at Risk (U. S. Government Printing Office, 1983), he led efforts to cut federal spending for education by nearly one-third. Both he and his advisors believed that a diminished federal role would lead to improvement in the educational system through increased state initiatives. From all of the reform reports that were appearing in the early 1980's, a shift in revenue sources was not among any of the recommendations (Jennings, 1987).

In addition to involvement from groups such as the National Council of Teachers of Mathematics and the National Council of Supervisors of Mathematics and reports such as the Second International Mathematics Study (International Association for the Evaluation of Educational Achievement, 1985) and the National Assessment of Educational Progress (Kouba, V. L.; Carpenter, T. P.; and Swafford, J. O., 1989), the business community has taken a more active role in recent years in supporting educational reform as a means of promoting economic progress. This may be represented by the Committee for Economic Development which in September of 1987 issued a report, breaking with past reluctance about federal funding of educational and social programs, to urge full funding of two major programs for the disadvantaged. This is viewed by Jennings as recognition from the business community of the tie between success in education and economic growth of our nation (Jennings, 1987).

The September 19, 1988 issue of Business Week, was dedicated to the topic of "Human Capital." The repeated message was that America is "scrimping" on human capital. In 1851, European manufacturers concluded that the system of American manufacturing surpassed any that existed in Europe due largely to an educated American workforce. Today, only a little over one hundred years later, the United States finds itself viewing Japan in the same light. The functional literacy in Japan is 95%, compared to 80% for the United States (MacGraw-Hill, 1988).

In response to this awakening of forces outside the academic community to the need for reform in education, businesses such as IBM, MacGraw-Hill, Pacific Northwest Bell Telephone Co., MacDonalds, and American Bankers Insurance Group, are participating in "join-a-school" partnerships throughout the nation. These school-business partnerships represent a new chapter in American education, one which involves the business community and the private sector in the endeavor to improve the educational experiences of America's young people and to introduce them to the skills which will optimize their chances for success in the workplace.

The influence of the previously cited historical calls for significant reform in mathematics education and the increase in broad-based support for innovation in this area set the stage in the decade of the 1980's for a those interested in mathematics education to create a set of national guidelines addressing mathematical literacy. In 1989, the National Council of Teachers of Mathematics published the Curriculum and Evaluation Standards for School Mathematics. This document is a product of the Commission on Standards for School Mathematics which was established in 1986 by the Board of Directors of the National Council of

Teachers of Mathematics. The Curriculum and Evaluation Standards for School Mathematics (National Council of Teachers of Mathematics, 1989) was drafted in the summer of 1987 and revised in the summer of 1988 in a response to the call for reform in teaching and learning mathematics in A Nation at Risk (U. S. Government Printing Office, 1983)

There were two driving purposes in the development of the Curriculum and Evaluation Standards for School Mathematics.

> 1. Create a coherent vision of what it means to be mathematically literate both in a world that relies on calculators and computers to carry out mathematical procedures and in a world where mathematics is rapidly growing and is extensively being applied in diverse fields.
>
> 2. Create a set of standards to guide the revision of the school mathematics curriculum and its associated evaluation toward this vision (p. 1).

The Curriculum and Evaluation Standards for School Mathematics represents the first time in history that a unified set of national standards has been compiled with collaboration from mathematics educators, business, industry, and the private sector and that the resulting guidelines have been recommended by a national group of mathematics educators. Although previous reports have appeared with many similar recommendations, none have received the support from business, government, and the private sector which the Curriculum and Evaluation Standards for School Mathematics has garnered. It is precisely this collaboration which increases the likelihood that the guidelines proposed in the Curriculum and Evaluation Standards for School Mathematics will be implemented in such a way to effect lasting change in the teaching and learning of mathematics in schools in the United States.

Cooney (1988) has provided additional views on reform. He believes that some reforms in the past have been "paper reforms" and cites the School Mathematics Study Group as one such case. He believes that for reform to be truly effective, it

> . . . must be based on human innovation and activity (and) ... to accomplish that goal, two significant obstacles must be addressed: teachers' conceptions and students' conceptions of mathematics and the teaching of mathematics (p. 353).

This study has attempted to deal primarily with the aspect of "teacher conceptions" as they relate to implementation of the Curriculum and Evaluation Standards for School Mathematics in the area of statistics education. The term "teacher conceptions" is one coined by Cooney to describe the total collection of beliefs, concepts, and attitudes held by teachers which influence their behavior in the classroom. According to Cooney,

> . . . whether teachers implement the full intent of the Standards and not just the mathematics identified in the Standards depends on how the intended curriculum is filtered through the teachers' beliefs and conceptions of mathematics (p. 355).

Definitions

For the remainder of this study, the following terms will be used with the meanings and/or notations identified below.

The National Council of Teachers of Mathematics will be referred to as the NCTM; and its counterpart for mathematics supervisors, the National Council of Supervisors of Mathematics, will be referred to as the NCSM.

The NCTM's Curriculum and Evaluation Standards for School Mathematics will be referred to as the Standards.

The Second International Mathematics Study of 1985 will be referred to as SIMS.

The Association of State Supervisors of Mathematics will be referred to as the ASSM.

Teacher conceptions is a term coined by Cooney to refer to the total collection of beliefs, concepts, and attitudes held by teachers which influence their behavior in the classroom.

Statistics is a term which will refer to either

1. numerical data or

2. the body of techniques used to organize, summarize, and draw conclusions from a set of numerical data.

Exploratory data analysis (EDA) is a term which will refer to the variety of methods and tools which are appropriate for summarizing and describing a set of data.

"Data analysis is descriptive statistics reborn" (Moore, 1990). With new tools and greater emphasis on graphics, some topics which fall in the realm of data analysis are measures of central tendency, measures of variability, bar graphs, histograms, box-and-whisker plots, and scatter diagrams. The essence of EDA is ". . . looking for patterns in data without at first considering whether the data are representative of some larger universe" (Moore, 1990).

Inferential statistics is a term which includes the body of techniques used to draw conclusions from a set of data. Formal hypothesis testing is one aspect of inferential statistics.

Statistics education will refer to the curriculum and instructional issues and framework associated with the teaching and learning of topics encompassing the broad range from informal exploratory data analysis through inferential statistics.

Any reference to the United States or a state in the union may include the District of Columbia.

Statement of the Problem

This study is one which focuses on statistics education in common schools. The problem of the study is to provide descriptions, identifications, and suggestions outlined in the following paragraphs.

The first component of the study consisted of providing a description of the current status of statistics education in the secondary mathematics classroom as it relates to the _Standards_. Information for this part of the study came primarily from members of the Association of State Supervisors of Mathematics (ASSM) with supporting information coming from a sample of secondary mathematics teachers in the state of Oklahoma.

The second component of the study involved providing a description of attitudes of secondary mathematics teachers toward curriculum change in secondary statistics education and toward implementation of programs to effect such change. The bulk of the data for this segment of the study was generated by a sample of secondary mathematics teachers from Oklahoma. Members of the ASSM, however, also contributed their perceptions to a certain aspect of this part of the study.

Toward the goal of describing these selected attitudinal factors, tests of proportions were used in analyzing the data. For five areas of teacher conceptions and six content topics, the null hypothesis that 50% of the teachers agreed with the given statement was tested against the alternate hypothesis that the response ratio was significantly different than 50%. The hypothesized ratio of 50% corresponds to a null hypothesis that teachers have no pronounced opinion regarding the given attitudinal statement as it pertains to one of the six specific content areas.

The five areas of teacher conceptions investigated were

1. whether or not elements of statistics are included in the secondary mathematics curriculum,

2. whether or not the principal of their school supports including statistics topics in the secondary mathematics curriculum,

3. whether or not the treatment of statistics topics in the secondary mathematics curriculum is a function of the textbook being used in their classroom,

4. whether or not the mathematics curriculum of their school can be (has been) structured to include topics of statistics, and

5. whether or not the mathematics curriculum of their school is too overcommitted to include topics of statistics.

Each of these five areas was then paired with each of six specific content areas in statistics. The six content areas selected from the tenth secondary mathematics standard in the Standards included

1. constructing and drawing inferences from charts, tables, and graphs of data from real-world situations;

2. measures of central tendency;

3. measures of variability;

4. statistical correlation;

5. sampling procedures for gathering data; and

6. designing and conducting a statistical experiment to study a problem.

The combination of the areas of teacher conceptions with the statistics topic content areas resulted in 30 survey items sent to a sample of secondary mathematics teachers in Oklahoma. The corresponding 30 hypotheses were organized by teacher conceptions, and the results were reported in Tables 6-10, found in Chapter IV.

The perception of which topics of statistics are currently included in the secondary mathematics curriculum was addressed by both the secondary mathematics teachers in Oklahoma and the members of the ASSM. The response ratios from both of these groups of mathematics educators were compared for consistency of response. For each of the six content areas, a comparison was made which involved testing the null hypothesis that the difference between the two proportions was zero, i.e., there was no significant difference in the response ratio between the members of the two groups regarding each of the given content areas. The results of investigation for consistency of response appears in Table 11 of Chapter IV.

The final three aspects of the study were achieved by interviewing teachers who have actively exhibited interest in incorporating topics in statistics into the mathematics curriculum of their schools. The third component of the study was to provide an identification and a description of factors which contribute to a secondary mathematics teacher's positive attitude toward curriculum change in secondary statistics education and toward implementation of programs to effect such change. To accomplish this goal, mathematics teachers from six regions of the United States were interviewed. The six regions corresponded to the six caucus regions of the NCTM; and, as previously described, the six teachers were selected on the basis of an exhibited interest in incorporating elements of statistics into the mathematics curriculum of their school.

The fourth component of the study was to provide a description of procedures followed by teachers who have successfully implemented curriculum changes in secondary statistics education within their local school districts. The six previously described mathematics teachers shared their experiences, which were then examined for commonalities and differences.

The final component of the study was to provide suggestions for implementing the curriculum changes in statistics education which are promoted in the Standards. A composite of successful experiences identified by the six interviewees formed the basis for these suggested actions.

Importance of the Study

Jacobsen (1989) observed that if one were to read through any newspaper, highlighting the items which require the use of mathematics for interpretation, he would more likely encounter tools from the domain of statistics such as charts, tables, graphs, means, medians, percentages, estimates, correlations, and probabilities than he would be to find equations, geometric proofs or the use of trigonometry. Statistics finds its way into every newspaper from the front page through the business section, sports reporting, and advertizing. The use of and interpretation of data confronts all citizens. And although the study of statistics has been recommended as a fundamental component of the mathematics curriculum since the issuance of Goals for School Mathematics (Cambridge Conference on School Mathematics, 1963), statistics education is still a relative newcomer to the field of mathematics education (Burrill, 1990). A frequent workshop presenter through the Quantitative Literacy Project, Burrill noted that until the late 1960's, statistics was the domain of a few who were gifted in mathematics or who needed limited knowledge to make inferences within their chosen field. She also cited that only recently has the study of statistics as an application of the mathematical sciences made its way into the mathematics curriculum (1990).

One of the recommendations made in the Standards is that the study of statistics be considered a fundamental part of the mathematics curriculum in all secondary schools. Due to the relatively new status of statistics in the secondary mathematics curriculum, several questions arise pertaining to factors which will influence the successful implementation of the _Standards_ related to teaching and learning both descriptive and inferential statistics to secondary students.

Mohammad (1988) conducted research on the status of statistics education in the public schools in the United States which indicates that the three topics receiving most frequent attention nationwide were probability; calculation of mean, median, and mode of a set of numbers (measures of central tendency); and instruction on constructing tables to organize data. According to her survey, the three topics receiving the least attention in the high school curriculum were design of an experiment, surveys and sampling, and calculation of variance of a set of numbers (measures of dispersion). Mohammad also concluded that three topics were as likely to be excluded from the curriculum as they were to be included: data collection, data analysis, and drawing conclusions based on data analysis. Since these last three topics are specifically identified in the _Standards_ and the February 1990 issue of _The Mathematics Teacher_ as important in the study of statistics at the secondary level, updated information regarding the current status of statistics education in the United States has been needed in order to monitor progress in these areas.

Both Combs and Cooney have concluded through their individual research efforts that teachers' beliefs have great influence on the learning atmosphere in the classroom

(Combs, 1982; Cooney, 1988). However, little research is available concerning teachers' attitudes toward the teaching and learning of mathematics; and even less research has been conducted focusing on teachers' attitudes and conceptions toward the inclusion of statistics as a fundamental topic in the secondary mathematics curriculum. The results of this study are necessary to the evolving data base of information in statistics education.

A third major contribution of this study is of a practical nature. By describing procedures followed by teachers who have successfully implemented topics in statistics into the secondary mathematics curriculum and by identifying a plan which will be consistent with suggestions promoted in the Standards, the results of the information gathered regarding teachers' attitudes may be used to help teachers and administrators alike to collaborate in the development of an implementation plan which best reflects their teaching philosophy.

Thus, in light of the current climate of mathematics education as a new millennium nears, a study of this nature is of prime importance in providing information to help guide the implementation of standards which can lead the teaching and learning of mathematics in the United States to higher levels than have previously been achieved.

Assumptions

In the course of formulating responses to the tasks identified as focal to this study, certain assumptions must be made. They are identified below.

1. With regard to describing the current status of statistics education in the United States, it will be assumed that an adequate sample of schools and state agencies will be willing to participate in the process of providing information regarding topics which are considered part of the statistics curriculum at the secondary level.

2. With reference to teachers' conceptions, three assumptions will be made:

    a. that an adequate number of teachers will be willing to share openly with respect to their attitudes and beliefs concerning curriculum change in secondary statistics education and toward implementation of programs to effect such change;

    b. that teachers' beliefs, views, and preferences about mathematics and its teaching, whether consciously or unconsciously held, play a significant role in shaping their characteristic classroom behavior; and

    c. that any attempt to improve the quality of mathematics teaching must include an understanding of the teachers' conceptions and their relationship to practice.

3. In the study of factors influencing attitudes, there will be two assumptions:

a. that there do, indeed, exist certain factors which contribute to a teacher's positive attitude toward curriculum change in secondary statistics education and toward implementation of programs to effect such change; and

b. that it is possible to identify and describe such factors.

4. In focusing on implementation, two assumptions will also be made. They are as follows:

a. it is possible to both identify and describe procedures by which successful program implementation has taken place at the local school level, and

b. it will be possible, from the information gathered from the previous tasks, to formulate a general proposal for implementing the curriculum changes in statistics education which are suggested in the Standards.

Limitations

There are certain problems inherent in descriptive research. One concern was that mailed questionnaires would not be completed and returned. Surveys were mailed to state supervisors of mathematics in September 1990, and the response rate was 71%. The survey to the secondary mathematics teachers in Oklahoma was not ready for mailing until May 1, 1991. Because of normal delays in processing mail through the university mailing center, these teachers did not receive the survey instrument until mid-May. With the demands of year-end school activities and some schools already dismissed for summer vacation, the response rate on this survey was a disappointing 12%.

A second limitation inherent in descriptive research involved the participants themselves, especially in terms of their willingness to subject their beliefs to examination and their programs to scrutiny. The six interview subjects who are already actively involved in incorporating topics in statistics into their secondary mathematics classrooms seemed to be exceptionally open to sharing their views and attitudes with this writer. The willingness of the secondary mathematics teachers who returned the survey to be open about their beliefs was of greater concern.

The mailed surveys which were used to gather some information from participants may be biased by either the subjectivity of the researcher or by characteristics of the participants who chose to respond to the instrument. The instrument used for the personal interviews may also be biased by the subjectivity of the researcher. In both the survey and the interview instruments, the researcher has strived for objectivity.

Overview

The remainder of the study will be presented in four chapters. Chapter II includes a review of the literature relative to the study. It includes a summary of dissertations which have dealt with teachers' attitudes, beliefs, and backgrounds as well as curriculum change and general curriculum issues. It also contains a review of pertinent journal articles. Chapter III presents a description of the procedures by which the study was conducted, including the measuring techniques used in the different components of the study and the processes of data collection and analysis. In Chapter IV the results of the study will be reported, highlighting interesting and/or unusual findings and patterns discovered during the analysis of the survey, questionnaire, and interview responses. Chapter V will consist of a summary of the results of the study, with corresponding conclusions drawn from the analysis of the surveys, questionnaires, and interviews. Another major component of Chapter V will be the development and presentation of recommendations for implementing the type of curriculum changes in secondary statistics education which are advocated in the Standards. These implementation recommendations will represent a composite of factors and procedures identified from the participants and their responses. The focus will be the effort to balance applicability with theory and basis in research.

CHAPTER II

REVIEW OF LITERATURE

Introduction

This study has involved the analysis of selected attitudinal factors of secondary mathematics teachers toward curriculum change and implementation as it relates to statistics education. The study had five major components, and it was with regard to these components that the literature review was organized. Each component has been recalled and the related literature cited and discussed.

Current Status of Statistics Education

The first task of the problem was to provide a description of the current status of statistics education in the secondary mathematics classroom as it relates to the NCTM Standards (1989). In the minifocus issue of The Mathematics Teacher on the topic of Data Analysis, Burrill noted that even though the importance of statistics and probability has been recognized in a variety of reports, ". . . little has been done to include either of the topics in the curriculum, particularly for all levels of students" (February 1990, p. 79). The reports to which Burrill referred were A Nation at Risk (U. S. Government Printing Office, 1983) and Educating Americans for the Twenty-first Century (National Science Foundation, 1983).

Certain interest groups outside the immediate circle of mathematics educators are also attempting to encourage the study of statistics at both the elementary and secondary levels. In February 1990, The Mathematics Teacher reported that the Center for Statistical Education, associated with the American Statistical Association, has extended an offer of monetary prizes to students through competitions involving projects and posters promoting topics in statistics.

In this same issue of The Mathematics Teacher, Scheaffer, a professor of statistics at the University of Florida, said that he had noticed a

> . . . strong movement away from . . . 'classical statistics' to a more empirical, data-oriented approach to statistics, sometimes termed 'exploratory data analysis,' or EDA (p. 90).

He foresees that EDA approaches to applied statistics will continue to gain support over classical approaches in the years to come, including the use of box-and-whisker plots, scatter diagrams, and other informal techniques of inferential statistics in the making of conjectures and the search for patterns.

The NCSM, in its position paper "Essential Mathematics for the Twenty-first Century" has urged that students plan and carry out the collection and organization of data to answer questions in their everyday lives (1988). The

Mathematics Teacher reported that the NCSM has proposed that students be able to

1. construct, read, and draw conclusions from simple tables, maps, charts, and graphs;
2. present information about numerical data, such as measures of dispersion (range, deviation); and
3. recognize the basic uses and misuses of statistical representation and inference (May, 1989, p. 356).

It was reported in the Second International Mathematics Study that although it is true that there are instances in which teachers are regularly teaching elements of both descriptive and inferential statistics in their secondary mathematics classrooms and that topics in both probability and statistics now appear with regularity in secondary mathematics textbooks, the case for most secondary mathematics classrooms is that these topics in statistics education tend to be taught as "luxury" topics. Often their consideration is postponed until the latter part of the school year; and just as often, if time runs short, these are among the first topics to be cut from the curriculum (International Association for the Evaluation of Educational Achievement, 1985).

Mohammed (1988) conducted a national survey to ascertain the status of certain topics in statistics in the high school curriculum. The three topics receiving most frequent attention nationwide were probability; calculation of mean, median, and mode of a set of numbers (measures of central tendency); and instruction on constructing tables to organize or show data. The three topics receiving the least attention in the high school curriculum were design of an experiment, surveys and sampling, and calculation of variance of a set of numbers (measures of dispersion). Mohammed also concluded that three topics were as likely to be excluded from the curriculum as they were to be included: data collection, data analysis, and drawing conclusions based on data analysis.

Since 1983, the mathematics curriculum in the public schools of the state of New York has integrated topics in statistics in grades K-12. At the secondary level, the mathematics program is organized into a three-year sequence. Course I of this sequence includes collecting and organized data and measures of location (particularly measures of central tendency). Although new topics in statistics do not appear in Course II, the statistics-related topics previously covered are integrated into the Course II mathematics curriculum; and new topics in statistics reappear in Course III of this sequence. In Course III, previously introduced topics are reviewed and the new concepts of measures of dispersion and the Central Limit Theorem are treated. This mathematics sequence not only integrates topics in statistics into the mathematics program but treats all mathematics topics in an integrated approach.

Thus, the message from the professional educators is that topics in statistics should be an integral part of the mathematics curriculum. Although this message is echoed from the professional and business sectors, according to Mohammed (1988) the general rule in U. S. schools is that these topics are treated in only a cursory manner with measures of central tendency receiving the bulk of the attention and topics including data analysis being given the least attention. The integrated approach proposed not only in the Standards but also in other professional literature for many years, appears to be found more in theory than in practice in the United States with the curriculum of the schools in New York representing an exemplary exception to this pattern.

Attitudes of Secondary Mathematics Teachers Toward Curriculum Change in Statistics Education

The second component of this study was to provide a description of attitudes of secondary mathematics teachers toward curriculum change in secondary statistics education and toward implementation of programs to effect such change. Neither the Curriculum and Evaluation Standards for School Mathematics (NCTM, 1989) nor the Professional Standards for Teaching Mathematics (NCTM, 1991) specifically address the issue of teachers' attitudes. And, although several doctoral dissertations have involved secondary mathematics teachers, none of them have focused on teachers' beliefs and attitudes regarding the teaching of statistics.

Thompson (1982) used three case studies to focus on teachers' conceptions of mathematics and mathematics teaching. This involved three junior high school teachers and investigated not only the teachers' conceptions of mathematics and mathematics teaching but also the relationship between conceptions and practice. The assumption leading to the study was that teachers' beliefs, views, and preferences about mathematics and its teaching, whether consciously or unconsciously held, play a significant role in shaping their characteristic behavior. Also, to the extent that conceptions influence behavior, any attempt to improve the quality of mathematics teaching must begin with an understanding of the teachers' conceptions and their relationship to practice. According to Thompson, the findings supported the original assumption, i.e., that teachers' beliefs, views, and preferences about mathematic and its teaching play a significant, albeit subtle, role in shaping their behavior. In general, their views were reflected in their instructional practice.

Since some topics in statistics are relatively new to the mathematics curriculum, it is not necessarily true that previous findings regarding teachers' beliefs and attitudes toward curriculum change in mathematics education are generalizable to their beliefs and attitudes toward curriculum change in statistics education. In order to clarify the similarities and differences in teachers' conceptions as they pertain to mathematics education versus statistics education, it appears that further study in this area is justifiable.

Factors Affecting Teachers' Attitudes

Closely related to the problem of describing teachers' attitudes toward curriculum change and toward implementation of programs to effect such change, particularly as they touch secondary statistics education, is the problem of identifying and describing factors which contribute to positive attitudes toward curriculum change and toward implementation of programs to effect such change. The literature reflected in this section has focused on different types of factors which affect a teacher's behavior in the classroom.

The following studies identify a successful pre-college experience in mathematics and the interview process as tool for reflecting on a teacher's own behavior as factors which contribute to positive attitudes toward teaching mathematics. Owens (1987) focused on the preservice teacher and found that his or her pre-college experiences in mathematics played an important role determining a positive perception of mathematics and mathematics teaching while Grant (1984) and Kesler (1985) found that the interview process involved in conducting case studies had a positive effect on teachers' tendencies to reflect on their teaching behavior.

Brown (1985) presented results of an investigation which ended an eighteen month case study of a single teacher. The data suggested that the way the teacher thought about his role in the classroom and performed that role during his first year of teaching was most significantly influenced by his university teacher education program, by his perceptions of his students' conceptions of mathematics teaching, and by his students' maturity and ability levels.

Wiesner (1989) studied concept learning and the learning of strategies for teaching graphing, probability, and statistics among in-service elementary and secondary mathematics teachers. The sample consisted of 56 elementary and secondary school teachers from several large school districts who registered for a 12-hour workshop or were enrolled in a graduate methods course. All participants responded to survey items dealing with demographic data, educational training, attitudes, and beliefs regarding manipulatives and their use. At the end of the workshop, all participants took two post-tests. Those who had taken pre-calculus or above scored significantly higher than those whose level of high school mathematics was below that of Algebra II. Results from this study revealed that significant amounts of conceptual learning took place as a result of workshop participation.

The question of generalizability from mathematics education to statistics education is again appropriate.

With little literature available focusing specifically on factors contributing to a teacher's positive attitude toward curriculum change in statistics education and toward implementation of programs to effect such change, further investigation appears warranted.

Implementing Curriculum Change

At this stage of the literature review, it seems appropriate to combine the last two components of the study. The literature related to specific procedures followed by teachers who have successfully implemented curriculum changes within their school settings and particular plans for implementing curriculum change are interrelated.

A common theme running throughout the literature has been the need for teachers to be actively involved in all stages of curriculum planning and implementation which affects their own professional growth and development. Dillon-Peterson (1986) concluded that

> . . . the highest level of professional development is probably achieved when professionals accept the responsibility for assessing their own needs and carrying them out (p. 34).

She also asserted that teachers can be trusted to know what is good for their personal and professional development and to create effective means for achieving the goals which they set (Dillon-Peterson, 1986). She concluded that professional development is based on introspection and involves

1. reading, writing, and study;

2. interaction with significant others;

3. personal and professional experience;

4. conversation and discussion;

5. experimentation and innovation; and

6. confrontation.

Joyce and Showers (1982) have concluded that the process of changing one's way of thinking and teaching can be very uncomfortable. As a consequence, in order to make effective changes in curriculum and instruction techniques, both systematic training and coaching is required.

In a study of program and curriculum development in baccalaureate nursing education, Krumlauf (1985) found that factors most critical to curriculum planning during the period of program development in the four programs studied included having

1. sufficient time for curriculum planning prior to admission of students;

2. a qualified person responsible for directing curriculum;

3. stable leadership for the program;

4. a clearly defined mechanism for implementing curriculum change;

5. faculty involvement in the curriculum planning process;

6. limited class size in proportion to the number of faculty;

7. a clearly defined program purpose;

8. objectives which were consistent with professional practice;

9. community involvement in curriculum planning;

10. consistency of school and program goals and objectives;

11. use of a model;

12. objectives for learning experiences;

13. evaluation based on objectives;

14. adequate number of qualified faculty;

15. curriculum organization and continuity; and

16. reasonable teaching loads.

In a case study investigating planned curriculum change in an individual school, Odum (1985) focused on teachers' perceptions of the project, its organization, it processes, its curriculum concepts, and their own personal progress in achieving their goals. She found that seven factors of organizational structure were found to promote change. They were

1. time lines and research-based sequences that provide for continuous project emphasis spread over a year's time;

2. small-scale tryout and gradual phase-in of curriculum development model;

3. relevant time for teachers and strategically timed debriefing sessions;

4. project design that provides for organizational networking;

5. processes that involve teachers in networking and collaborative planning and curriculum development and that provide personal support, challenge, and continuous guided reflection;

6. use of existing organizational structure and informal organizational culture as "scaffolding" upon which to build project structure; and

7. supportive administrative leadership in a climate that nurtures risk-taking and changes.

Griffin (1986) also concluded that administrative leadership must provide financial, technical, and "ceremonial" support in order for either curriculum or teacher development plans to be implemented successfully. David (1986) agreed with certain aspects of Odum's study. He found that in order for staff development to impact curriculum change, the following should happen:

1. participants should be involved in the planning stages;

2. participants should be made to feel that they are professionals and that their input is desired;

3. sufficient time is provided for accomplishing program goals and for reflection; and

4. follow-up will be provided.

And, in a study regarding the perceptions of barriers to curriculum change in computer courses, Baharestan (1985) found that administrators tend to show more resistance to innovations pertaining to operational or planning aspects of change, while faculty tend to show more resistance to innovation pertaining to performance aspects of curriculum.

The National Council of Teachers of Mathematics' Commission on Teaching Standards for School Mathematics formed working groups to propose standards for teaching, for professional development of teachers, and for evaluation of teaching. In their final document, Professional Standards for Teaching Mathematics (National Council of Teachers of Mathematics, 1991), this commission made the following assumption.

> Changing the practices of mathematics teaching depends on teachers but teachers cannot effect such reform without substantial systematic support and change (p. 3).

These mathematics educators also noted that

> . . . the kind of instruction which is needed to implement the NCTM Curriculum and Evaluation Standards for School Mathematics requires a high degree of professionalism on the part of each teacher (p. 4).

Thus, it appears that in order for successful program implementation to occur, the following need to be included as aspects of the process:

1. teacher involvement in the planning process which culminates in curriculum change;

2. networking opportunities among teachers with common goals toward curriculum change; and

3. administrative support throughout the development and implementation process.

However, whether or not there exist peculiarities with regard to curriculum change and program implementation in statistics education remains to be an area in which further study is needed.

Summary

One common theme throughout the literature related to the components of this investigation is that very little study has been conducted which focuses on the qualitative aspects of statistics education. Since some topics in statistics are not yet standard in the mathematics curriculum, it may not automatically be assumed that a teacher who is enthusiastic about teaching other components of the mathematics curriculum will necessarily have a positive attitude toward teaching topics in statistics. Since the teacher's conceptions so influence the classroom atmosphere, the subject of teachers' attitudes toward curriculum change and program implementation in statistics education is both timely and important.

CHAPTER III

THE RESEARCH DESIGN

Introduction

Since the study of statistics is one which traditionally encompasses primarily "quantitative" techniques in the minds of many people, it may at first seem incongruent to conduct a "qualitative" study in connection with this subject. However, this investigation has focused on issues surrounding statistics education rather than on the study of statistics itself. As such, it has fallen most appropriately into the realm of the social sciences. The goal of descriptive research is to describe existing phenomena both systematically and accurately (Isaac and Michael, 1981). Such an approach is also appropriate for anyone who wants to study attitudes and beliefs (Weller and Romney, 1988).

This study focused on statistics education in the common schools. The problem of the study was to provide descriptions, identifications, and suggestions outlined in the following paragraphs.

The first component of the study consisted of providing a description of the current status of statistics education in the secondary mathematics classroom as it relates to the

Standards. Information for this part of the study came primarily from members of the ASSM with supporting information coming from a sample of secondary mathematics teachers in the state of Oklahoma.

The second component of the study involved providing a description of attitudes of secondary mathematics teachers toward curriculum change in secondary statistics education and toward implementation efforts to effect such change. The bulk of the data for this segment of the study was generated by a sample of secondary mathematics teachers from Oklahoma. Members of the ASSM, however, also contributed their perceptions to a certain aspect of this part of the study.

Toward the goal of describing these selected attitudinal factors, tests of proportions were used in analyzing the data. For five areas of teacher conceptions and six content topics, the null hypothesis that 50% of the teachers agreed with a given statement was tested against the alternate hypothesis that the response ratio was significantly different than 50%. The hypothesized ratio of 50% corresponds to a null hypothesis that teachers have no pronounced opinion regarding the given attitudinal statement as it pertains to one of the six specific content areas.

The five areas of teacher conceptions investigated were

1. whether or not elements of statistics are included in the secondary mathematics curriculum,

2. whether or not the principal of their school supports including statistics topics in the secondary mathematics curriculum,

3. whether or not the treatment of statistics topics in the secondary mathematics curriculum is a function of the textbook being used in their classroom,

4. whether or not the mathematics curriculum of their school can be (has been) structured to include topics of statistics, and

5. whether or not the mathematics curriculum of their school is too overcommitted to include topics of statistics.

Each of these five areas was then paired with each of six specific content areas in statistics. The six content areas selected from the tenth secondary mathematics standard in the Standards included

1. constructing and drawing inferences from charts, tables, and graphs of data from real-world situations;

2. measures of central tendency;

3. measures of variability;

4. statistical correlation;

5. sampling procedures for gathering data; and

6. designing and conducting a statistical experiment to study a problem.

The combination of the areas of teacher conceptions with the statistics topic content areas resulted in 30 survey items sent to a sample of secondary mathematics teachers in Oklahoma. The corresponding 30 hypotheses were organized by teacher conceptions, and the results are reported in Tables 6-10 of Chapter IV.

The perception of which topics of statistics are currently included in the secondary mathematics curriculum was addressed by both the secondary mathematics teachers in Oklahoma and the members of the ASSM. The response ratios from both groups of mathematics educators were compared for consistency of response. For each of the six content areas, a comparison was made which involved testing the null hypothesis that the difference between the two proportions was zero, i.e., that there was no significant difference in the response ratio between the members of the two groups regarding each of the given content areas. The results of investigation for consistency of response appears in Table 11 of Chapter IV.

The final three aspects of the study were achieved by interviewing teachers who have actively exhibited interest in incorporating topics from statistics into the mathematics curriculum of their schools. The third component of the study was to provide an identification and a description of factors which contribute to a secondary mathematics teacher's positive attitude toward curriculum change in secondary statistics education and toward implementation efforts to effect such change. To accomplish this goal, mathematics teachers from six regions of the United States were interviewed. The six regions corresponded to the six caucus regions of the NCTM; and, as previously described, the six teachers were selected on the basis of an exhibited interest in incorporating elements of statistics into the mathematics curriculum of their school.

The fourth component of the study was to provide a description of procedures followed by teachers who have successfully implemented curriculum changes in secondary statistics education within their local school districts. The six previously described mathematics teachers shared their experiences, which were then examined for commonalities and differences.

The final component of the study was to provide suggestions for implementing the curriculum changes in statistics education which are suggested in the Standards. A composite of successful experiences identified by the six interviewees formed the basis for these suggested actions.

The Measuring Techniques

In constructing both the survey and interview instruments, effort was made to address the issues of credibility, transferability, dependability, and confirmability (Lincoln and Guba, 1985). These issues correspond to internal validity, external validity, reliability, and objectivity of conventional quantitative research.

Marshall and Rossman (1989) describe the goal of credibility as that of ". . . demonstrating that the inquiry was conducted in such a manner as to ensure that the subject was accurately identified and described" (p. 145). To this end, the subject of the survey, statistics education, was defined to be consistent with that used in the tenth standard for grades 9-12 in the NCTM Standards.

Transferability refers to that aspect of qualitative research which seeks to demonstrate ". . . the applicability of one set of findings to another context" and rests more with the investigator who would make the transfer than with the original investigator (Marshall and Rossman, 1989, p. 145). To this end, however, tests of proportions were conducted comparing results about included curriculum topics from the survey of state supervisors and the survey of secondary mathematics teachers. Establishing consistent results and patterns for the two groups gives credence to the transferability of the study.

Dependability seeks to account for changing conditions in both the study and the design by the increasing refinement of the researcher's understanding of the setting (Marshall and Rossman, 1989). The first survey, to state supervisors of mathematics, was sent in September and allowed ample turn-around time for response. For the interview component of the study, five of the six research interviews were administered at the NCTM annual meeting in New Orleans in April 1991. The sixth interview was conducted by telephone because a personal interview could not be arranged. In all six instances, the interview was scheduled so that interruptions would not interfere with the interview itself.

The survey sent to the secondary mathematics teachers occurred under conditions which could possibly weaken the dependability of the results. This instrument was ready for distribution on May 1, 1991. Some respondents indicated that it was a full two weeks before the survey reached them. Although the surveys were sent to teachers by name, they were sent to the school address. Some of the schools may have dismissed for the academic year by the time the survey reached its destination. At any rate, the timing coincided with the flurry of end-of-year activities and likely received diminished response for that reason.

The final issue in participant-oriented research is that of confirmability, which corresponds to that of objectivity in quantitative research. This issue is of particular concern with respect to the interview portion of the study. Great care was taken to word the interview questions in the same manner and allowing ample response time for each subject. Lacking a second researcher to confirm impressions, the researcher recorded each interview with the aid of a microcassette recorder so that responses could be replayed for clarity in interpretation and nuance. Such mechanical recording allows greater objectivity and efficiency (Gay, 1987).

The Written Instruments

Survey of State Supervisors. The first goal of the study was to gain greater insight into the current status of statistics education in the secondary mathematics classrooms across the United States in light of the goals set forth in the Standards. In 1988, Mohammed conducted a study with a similar goal by surveying a sample of secondary mathematics teachers throughout the United States. In an effort to strengthen the generalizability of her results, the method of triangulation was used. Such an approach brings more than one source of data to bear on a single subject of study (Marshall and Rossman, 1989; Patton, 1987; Isaac and Michael, 1981). This researcher gathered similar data from an additional source, namely the mathematics curriculum supervisors in each of the fifty states plus the District of Columbia. A survey questionnaire prepared by the researcher was used as the assessment device. By bringing together information from more than one source, the results of the study extend the knowledge base related to the current status of statistics education in the United States. A table reporting the ratio of the number of state supervisors indicating that a given statistics content area is generally included in the mathematics curriculum for districts in their state to the total number of responses was constructed, and explanatory responses from the supervisors were organized and summarized. The computed ratios were then examined, using tests of proportions, to indicate whether a definite pattern, either positive or negative, was indicated.

Survey of Secondary Mathematics Teachers. A second survey, prepared by the researcher, was administered to a sample of secondary mathematics teachers from the state of Oklahoma. Their responses provided information used to help ascertain a description of the attitudes of secondary mathematics teachers toward including statistics topics in the secondary mathematic curriculum, toward curriculum change in secondary statistics education, and toward implementation of programs to effect such change. This instrument was similar in design format to one constructed by Cooney in conjunction with the Second International Mathematics Study to assess teachers' attitudes toward teaching middle school.

A forced response format, either agree or disagree, was the mode employed by Cooney's instrument. In a field test of the instrument for this study, a group of secondary mathematics teachers indicated that they preferred this forced-response format to a more expanded one ranging from "Strongly Disagree" to "Strongly Agree."

An attempt was made to reduce bias in this instrument with respect to both the order in which the format statements were presented and in which the content areas were included. Toward this end, the order of the format statements was randomly assigned and the assignment of content areas to each of the format statements was randomly generated.

The Research Interview

The research interview was included in this study as a tool for gathering data in greater depth than would be possible through the use of a survey or questionnaire (Gay, 1987; Isaac and Michael, 1981). It is included as an anecdotal component of the study. Directed to secondary mathematics teachers who are actively implementing topics of statistics into the mathematics curriculum, the questions in the instrument were designed to identify factors which have contributed to their positive attitudes toward these implementation efforts, outstanding features of the programs in which they are involved, and implementation procedures which they have found to be particularly successful.

The six teachers interviewed came from widely varied teaching circumstances and teaching experiences with respect to statistics education. For these reasons, the questions were semistructured in nature, followed by opportunities for clarification and unstructured comments. This approach was chosen to maximize the likelihood of gaining in-depth responses and insights which would be otherwise unobtainable (Gay, 1987).

The interview questions were previewed by a group of secondary mathematics teachers for content validity. Their suggested revisions helped to refine the instrument. Then prior to each interview, a few minutes was spent with each subject establishing rapport. Then the interviewer asked permission to record the interview on microcassette recorder to more greatly ensure accuracy in the recording process. Each interview subject readily agreed to the use of the recorder and seemed to quickly forget its presence. Pretesting the questionnaire, establishing rapport, and accurately recording the interviews are all aspects of descriptive research suggested by Gay (1987).

The Samples

The subjects in this study came from three different constituencies. Members of the Association of State Supervisors of Mathematics who are actively involved in the capacity of supervising mathematics curriculum in their respective states or the District of Columbia composed the sample for the first component of the study directed toward providing a description of the current status of statistics education. Each of these identified supervisors was mailed a questionnaire eliciting their input regarding the status of statistics education in their state.

Subjects for the interview component of the study were chosen by a process which Patton (1987) referred to as "purposeful sampling." In accordance with this process, cases are chosen for the sample which are "information rich" about issues central to the study. There are a variety of strategies for purposefully selecting information-rich cases. In this study, the strategy of "maximum variation sampling" (Patton, 1987) was chosen in order to provide participants from a variety of geographic and teaching circumstances. This technique allowed the researcher to

> . . . describe more thoroughly the variation in the group and to understand variations in experiences, while also investigating core elements and shared outcomes (p. 63).

The sample of secondary mathematics teachers was chosen from a list obtained through the Oklahoma State Department of Education. Teachers were chosen by the method of systematic random sampling which yields a sample as representative as a simple random sample (Mason, Lind, Marchal, 1991).

Collection of the Data

This study involved a descriptive investigation into various aspects of statistics education. Through a method known as triangulation, the study incorporated the use of both quantitative and qualitative data gathered from several sources for the purpose of providing both depth and detail to the different components of the study (Isaac and Michael, 1981; Patton, 1987; Marshall and Rossman, 1989).

In September 1990, a researcher-developed questionnaire was mailed to members of the Association of State Supervisors of Mathematics who are responsible for coordinating the mathematics curriculum in their states. Both qualitative and quantitative data was gathered regarding the status of statistics education in their respective states. Open-ended and fixed-response questions were included in the instrument for flexibility in response format. The fixed-response portion of the instrument requested information concerning selected content areas related to statistics which might be included in the secondary mathematics programs in the supervisor's state. The open-ended questions were semistructured and sought greater depth of information regarding the level to which statistics topics have found their way into the secondary mathematics programs in their states.

The research interview was administered to the six identified secondary mathematics teachers on April 18, 19, and 23, 1991. Five of the six teachers were interviewed in New Orleans, Louisiana during the annual meeting of the National Council of Teachers of Mathematics. The interview with the sixth teacher was conducted by telephone because a personal interview could not be arranged.

A survey developed by the researcher was mailed to a sample of secondary mathematics teachers in Oklahoma on May 1, 1991. These teachers were selected through systematic random sampling and vary greatly in geographic, social, and economic characteristics. Through a series of statements to which the respondents gave their opinions, they provided information regarding their attitudes toward curriculum change in secondary statistics education and toward implementation of programs to effect such change.

Analysis of the Data

Data collected from the open-ended questions posed to the members of the Association of State Supervisors of Mathematics were summarized and presented in narrative form. Specific program information collected from these participants was expressed in terms of tables and ratios. Tests of proportions were used to identify significant patterns of response regarding which topics in statistics are included in the supervisor's state. These ratios were later compared with ratios determined from the data collected from the survey of Oklahoma teachers for consistency of pattern response.

Responses to the portion of the research interview which provided background information for the interviewees were reported using methods of simple exploratory data analysis. When appropriate, information regarding mean and range values were included. Responses from the probing questions of the research interview were organized and summarized in tables and narrative form after the interview process was complete, allowing patterns to emerge naturally.

The researcher made every effort to reduce bias in the interview process by wording the interview questions in the same manner with each of the interview participants and by recording each interview using a microcassette recorder. The size of the recorder was unassuming and aided in the efficiency of recording the interview.

Tests of proportions were used in analyzing the data from the secondary mathematics teachers in Oklahoma. For five areas of teacher conceptions and six content topics, the null hypothesis that 50% of the teachers agreed with the given statement was tested against the alternate hypothesis that the response ratio was significantly different than 50%. The hypothesized ratio of 50% corresponds to a null hypothesis that teachers have no significant opinion regarding the given attitudinal statement as it pertains to one of the six specific content areas. A similar test of proportions was conducted with the quantitative data acquired from the members of the Association of State Supervisors of Mathematics (ASSM). One area of teacher conceptions was investigated with both the members of the ASSM and the secondary mathematics teachers in Oklahoma. It was the teacher's or supervisor's perception of whether or not the six content areas are included in the mathematics curriculum of their school or state. The results from both groups of mathematics educators were compared for consistency of response. This comparison involved testing the null hypothesis that the difference between the two proportions was zero for each of the six content areas, i.e., that there was no significant difference in the ratio of response between the members of the two groups regarding the six content areas.

The five areas of teacher conceptions investigated were

1. whether or not elements of statistics are included in the secondary mathematics curriculum,

2. whether or not their principal supports including statistics topics in the secondary mathematics curriculum,

3. whether or not the treatment of statistics topics in the secondary mathematics curriculum is a function of the textbook being used in their classroom,

4. whether or not the mathematics curriculum of their school can be (has been) structured to include topics of statistics, and

5. whether or not the mathematics curriculum of their school is too overcommitted to include topics of statistics.

Each of these five areas was then paired with each of six specific content areas in statistics. They included

1. constructing and drawing inferences from charts, tables, and graphs of data from real-world situations;

2. measures of central tendency;

3. measures of variability;

4. statistical correlation;

5. sampling procedures for gathering data; and

6. designing and conducting a statistical experiment to study a problem.

The combination of the areas of teacher conceptions with the statistics topic content areas resulted in the 30 survey items to the Oklahoma secondary mathematics teachers. The response rate for this last survey was low and brings into question the representative nature of the data collected from this group. However, rather than to totally disregard the data, this author has chosen to include it for the information which it does provide.

Results of the analysis are reported in Chapter IV, while conclusions and recommendations are discussed in Chapter V. In particular, Chapter V includes a summary of teachers' recommendations for implementing the curriculum changes in statistics education which are suggested in the Standards. These recommendations represent a composite of the implementation procedures identified as being successful by the mathematics teachers who participated in the study.

CHAPTER IV

ANALYSIS OF THE DATA

Introduction

The focus of this study was on issues surrounding statistics education in the mathematics classrooms of the secondary common schools of the United States. The study itself sought to provide the descriptions, identifications, and suggestions outlined in the following paragraphs.

The first component of the study consisted of providing a description of the current status of statistics education in the secondary mathematics classroom as it relates to the Standards. Information for this part of the study came primarily from members of the ASSM with supporting information coming from a sample of secondary mathematics teachers in the state of Oklahoma.

The second component of the study involved providing a description of attitudes of secondary mathematics teachers toward curriculum change in secondary statistics education and toward implementation efforts to effect such change. The bulk of the data for this segment of the study was generated by a sample of secondary mathematics teachers from

Oklahoma. Members of the ASSM, however, also contributed their perceptions to a certain aspect of this part of the study.

Toward the goal of describing these selected attitudinal factors, tests of proportions were used in analyzing the data. For five areas of teacher conceptions and six content topics, the null hypothesis that 50% of the teachers agreed with the given statement was tested against the alternate hypothesis that the response ratio was significantly different than 50%. The hypothesized ratio of 50% corresponds to a null hypothesis that teachers have no pronounced opinion regarding the given attitudinal statement as it pertains to one of the six specific content areas.

The five areas of teacher conceptions investigated were

1. whether or not elements of statistics are included in the secondary mathematics curriculum,

2. whether or not the principal of their school supports including statistics topics in the secondary mathematics curriculum,

3. whether or not the treatment of statistics topics in the secondary mathematics curriculum is a function of the textbook being used in their classroom,

4. whether or not the mathematics curriculum of their school can be (has been) structured to include topics of statistics, and

5. whether or not the mathematics curriculum of their school is too overcommitted to include topics of statistics.

Each of these five areas was then paired with each of six specific content areas in statistics. The six content areas selected from the tenth secondary mathematics standard in the Standards included

1. constructing and drawing inferences from charts, tables, and graphs of data from real-world situations;

2. measures of central tendency;

3. measures of variability;

4. statistical correlation;

5. sampling procedures for gathering data; and

6. designing and conducting a statistical experiment to study a problem.

The combination of the areas of teacher conceptions with the statistics topic content areas resulted in 30 survey items sent to a sample of secondary mathematics teachers in Oklahoma. The corresponding 30 hypotheses were organized by teacher conceptions, and the results are reported in Tables 6-10 of this chapter.

The perception of which topics of statistics are currently included in the secondary mathematics curriculum was addressed by both the secondary mathematics teachers in Oklahoma and the members of the ASSM. The response ratios from both of these groups of mathematics educators were compared for consistency of response. For each of the six content areas, a comparison was made which involved testing the null hypothesis that the difference between the two proportions was zero, i.e., there was no significant difference in the response ratio between the members of the two groups regarding each of the given content areas. The results of the investigation for consistency of response appears in Table 11 of this chapter.

The final three aspects of the study were achieved by interviewing teachers who have actively exhibited interest in incorporating topics in statistics into the mathematics curriculum of their schools. The third component of the study was to provide an identification and a description of factors which contribute to a secondary mathematics teacher's positive attitude toward curriculum change in secondary statistics education and toward implementation efforts to effect such change. To accomplish this goal, mathematics teachers from six regions of the United States were interviewed. The six regions corresponded to the six caucus regions of the NCTM; and, as previously described, the six teachers were selected on the basis of an exhibited interest in incorporating elements of statistics into the mathematics curriculum of their school.

The fourth component of the study was to provide a description of procedures followed by teachers who have successfully implemented curriculum changes in secondary statistics education within their local school districts.

The six previously described mathematics teachers shared their experiences which were then examined for commonalities and differences.

The final component of the study was to provide suggestions for implementing the guidelines for statistics in the secondary mathematics classroom as indicated in the Standards. A composite of successful experiences identified by the six interviewees formed the basis for these suggested actions.

Current Status of Statistics Education

In considering the current status of statistics education, an examination of resources available to secondary mathematics teachers is of particular interest. These resources include institutes, workshops, and network opportunities as well as written materials, computer software, newsletters, and magazines.

Institutes, Workshops, and Network Opportunities

Through its Center for Statistical Education, the American Statistical Association (ASA) conducts Quantitative Literacy (QL) Workshops. According to the ASA, these workshops are designed to

> . . . promote professional development among secondary school teachers of mathematics and science while preparing them for the instruction of statistical and probabilistic concepts in the classroom.

(Statistics Teacher Network, No. 27, p. 1)

The workshops are presented by a staff made up of teams of classroom teachers and statisticians who have worked with the QL Project. One feature of this approach is the network of classroom teachers and statisticians which form a support group within each of the geographic sites of the workshops. This network includes members from academia, government, and industry. Quantitative Literacy Workshops are sponsored and funded by a variety of sources including local school systems/districts, universities, local ASA Chapters, and, perhaps, local grant monies.

Long known for its contributions to education, the Woodrow Wilson National Fellowship Foundation conducts both one-week and four-week institutes in statistics. In an intensive four-week institute in statistics held at Princeton University, a select group of secondary school mathematics teachers complete the training necessary to conduct subsequent one-week institutes at sites around the nation. According to The Statistics Teacher Network, the emphasis in the one-week sessions is on simple exploratory data analysis, simulations, probability, sampling and inference as these topics relate to statistics in society with participants exploring ways to incorporate statistical ideas into the traditional mathematics curriculum at a variety of levels using methods and materials readily available in the classroom (Statistics Teacher Network, 1991).

Written Materials, Computer Software, and Newsletters

There is a wide variety of resource material available for teachers to use in their classrooms as they seek to incorporate elements of statistics into the mathematics curriculum. Many of these materials assume little or no previous experience with data analysis, while others include opportunities for using formal techniques in inferential statistics. In addition to articles and reviews which regularly appear in issues of NCTM periodical, The Arithmetic Teacher and The Mathematics Teacher, the following represent some of the materials available at the present time.

Quantitative Literacy Series. The members of the Joint Committee on the Curriculum in Statistics and Probability of the American Statistical Association and the National Council of Teachers of Mathematics developed a series of four books to help teachers incorporate concepts from probability and statistics into the mathematics curriculum. Exploring Data (Landwehr and Watkins, 1987) and Exploring Surveys and Information from Samples (Landwehr, Swift, and Watkins, 1987) are two of the books from this series which particularly address statistics concepts. These materials are used in the Quantitative Literacy Workshops conducted by the American Statistical Association through its Center for Statistical Education.

Teaching Statistics and Probability. The 1981 NCTM yearbook focuses on the subjects of teaching and learning about statistics and probability. Divided into eight parts, this yearbook includes essays and articles proposing a rationale for including these topics in the mathematics curriculum, samples of existing courses or programs which incorporate probability and statistics into the mathematics curriculum, descriptions of classroom activities promoting concept development in the areas of probability and statistics, applications, and the use of computers in developing concepts around these topics.

Computer Software. Each year more computer software becomes available which is specifically designed to aid teachers in classroom demonstrations and to aid students in developing concepts in probability and statistics and in analyzing data from projects. Examination of catalogs of supplementary educational materials such as those published by Dale Seymour, Sunburst, Creative Publications, and Queue include descriptions of software designed to meet a variety of teaching goals.

The Statistics Teacher Network. This newsletter is published three times each year by the Joint Committee on the Curriculum in Statistics and Probability of the American Statistical Association and the National Council of Teachers of Mathematics. Through its format, it reports announcements of workshops and institutes designed

> . . . to promote professional development among secondary school teachers of mathematics and science while preparing them for the instruction of statistical and probabilistic concepts in the classroom (No. 27, p. 1).

It also provides a valuable service by informing its readers of new developments in statistics education through reviews of books, articles, computer software, and calculators.

Survey Results from State Supervisors of Mathematics

In September, 1990, a survey was sent to members of the Association of State Supervisors of Mathematics in the 50 United States and the District of Columbia who a are particularly involved in secondary mathematics. Supervisors from 38 states responded to the survey.

Curriculum Organization. Of the supervisors from the 38 responding states, only four (11%) reported having a curriculum which mandates elements of statistics in the mathematics curriculum at the secondary level. They were Georgia, New York, Oregon, and Texas. Both New York and Oregon have been active in incorporating statistics topics and concepts into the mathematics curriculum since 1984.

In a statement issued by the New York State Education Department, the integrated mathematics curriculum was described as follows:

> In June 1984, the State Education Department (of New York) announced that the integrated three-year sequence would become the official Statewide program for Regents high school mathematics begin-

> ning in September 1987.
>
> This sequence addresses a 1985 recommendation of the College Entrance Examination Board: the high school mathematics curriculum should be organized so that the topics of computing, statistics, algebra, geometry, and functions are integrated into a three-year series of courses (p. v).

In May 1984, the Oregon Mathematics Education Council (OMEC) launched a mathematics curriculum project which developed a set of concept papers related to major issues of reform in mathematics education. Disseminated along with other concept papers by the Oregon Mathematics Project, the Oregon Mathematics Concept Paper #4 presented a rationale for including the study of statistical methods in the secondary mathematics curriculum as well as suggested instructional goals and activities for incorporating the study of statistics and probability into the mathematics curriculum.

From Georgia, Dr. William Roughead, mathematics coordinator, and Ms. Phyllis Martin, mathematics consultant, explained Georgia's efforts in the open-response portion of the survey.

> In 1988, the Georgia Board of Education approved the Quality Core Curriculum, a state-mandated curriculum for grades K-12. At the high school level, statistics objectives are included in the courses General Mathematics I, II, and III. Statistics objectives are also included in the courses Pre-algebra, Algebra II, and Advanced Algebra & Trigonometry. Elective courses entitled Statistics and Quantitative Literacy are included in the college preparatory and general/vocational sequences, respectively.
>
> By the fall of 1993, all school systems in Georgia must have brought their curriculum in line with the Quality Core Curriculum (QCC). This data is a result of the staggered implementation schedule the Georgia

Board adopted for the QCC.

Texas reported that they have a state-mandated curriculum which has a statistics strand for grades K-8 and specific essential elements (mandated course content) in the high school courses.

> The focus of Algebra I and Algebra II is on solving relevant and interesting problems and on applying algebraic principles in a variety of real-world situation. Collecting, representing, and processing data are major activities of contemporary society and are important new emphases in Algebra II. Students should learn to apply these techniques to solve problems and also to evaluate the many statistical claims they encounter in their daily lives. (Texas Education Agency, 1989)

Of the remaining states, four specifically noted that they are "local control" states in which each district is responsible for developing its own mathematics curriculum at all levels K-12. They were Colorado, Massachusetts, New Hampshire, and Wisconsin. In Wisconsin, however, state graduation requirements specify that all students must complete "elements of statistics" as part of their mathematics program, and this is evaluated through an exit examination which students must pass before they may graduate.

<u>Level of Implementation</u>. The mathematics supervisors were asked to estimate the percentage of schools in their state which do not consistently teach topics in statistics. Some supervisors based this estimate on objective data including enrolment records and curriculum reports submitted by districts in their states. Others based their estimates

on such subjective data as their personal impressions as they visited the various districts within their states.

Supervisors from four states reported having all secondary schools in their state consistently teaching topics in statistics in the mathematics curriculum. They were New York, Oregon, Virginia, and Wisconsin. Such results were not surprising from states which have a mandated curriculum for statistics education at the secondary level (New York and Oregon) nor were they surprising from a state which includes "elements of statistics" in an exit examination required for graduation (Wisconsin). There was no indication explaining the reason for Virginia's seemingly strong support for statistics education at the secondary level.

All other states participating in the survey reported that between 15% and 98% of the schools in their states do not consistently teach topics in statistics. Supervisors from seven states reported that 90% or more of their schools do not consistently teach topics in statistics. The mathematics specialist from Minnesota cited 1988-89 enrolment figures in support of her estimate that 95% of the secondary schools in her state do not consistently teach topics in statistics at the secondary level. That year, 24 of 435 districts taught 31 courses in statistics reaching 911 of 215,671 students. This figure is misleading in that the 911 students enrolled in the statistics courses were all secondary students while the total of 215,671 referred to all students K-12. There was no indication as to the number of students included in this total who would be considered as secondary students. From a state in which the mathematics supervisor estimated that 80% of the secondary schools in his state do not consistently teach topics in statistics came the comment that "since many teachers allow a book to drive their curriculum, unless there is emphasis on statistics (in the text), it is not taught."

Presentation Format. Next, the supervisors were asked to estimate, for the schools in their state that do teach topics in statistics, the percentage which teach them in a course separate from traditional mathematics courses and the percentage which teach them as an integrated part of the existing mathematics curriculum. Twenty-six states responded to this request. The mean estimate of the percentage of schools which teach topics in statistics separate from traditional mathematics courses was 33%, and the mean estimate of the percentage of schools which teach topics in statistics as an integrated part of the existing mathematics curriculum was 68%. Some states commented that schools in their states teach topics in statistics by both methods and, thus, reflected this overlap in their estimates.

Statistics Topics Included in the Secondary Mathematics Curriculum. Focusing on selected content areas identified in the secondary statistics standard of the Standards, the state supervisors offered their opinions regarding whether the content area is generally included in the secondary mathematics curriculum of the schools in their state. Table 1 summarizes their responses and indicates whether the ratio of teachers indicating that the particular topic is generally included in the curriculum is significantly different from a random assignment of included/not included. Tests of proportions were used to determine if the ratio differed significantly from 0.50. With 26 supervisors responding to this portion of the survey, the standard error was 0.09.

As indicated in the table, the supervisors believe that measures of central tendency are included, while statistical correlation and designing and conducting a statistical experiment to study a problem are generally not included as topics of study for secondary mathematics students.

Future Trends. Finally, the participating supervisors of mathematics were asked to comment on what changes, if any, they foresee in the near future for statistics education in their state. Thirty-six supervisors responded to this open-ended request. Thirty-two of them, representing 89%, predicted an increase in the emphasis on statistics as a topic of study in the mathematics curriculum in the near future. Nineteen percent see either no change in the near future, statistics as given low priority, or the changes as gradual in coming. Of these 36 respondents, 11,

TABLE 1

STATISTICS TOPICS INCLUDED IN THE SECONDARY MATHEMATICS CURRICULUM

Topic	Ratio	Standard Error	Z-value	p-value	Sign.
CTG	0.633	0.09	1.478	0.139	n.s.
Cen. Ten.	0.800	0.09	3.333	0.003	*
Var.	0.400	0.09	-1.111	0.267	n.s.
Corr.	0.233	0.09	-2.967	0.003	*
Experiment	0.133	0.09	-4.078	0.000	*

*	The result is significant at the 0.01 level.
n.s.	The result is not significant.
CTG	Constructing and drawing inferences from charts, tables, and graphs to summarize data from real-world situations
Cen. Ten.	Measures of central tendency
Var.	Measures of variability
Corr.	Statistical correlation
Experiment	Designing and conducting a statistical experiment to study a problem

representing 31%, specifically mentioned the influence of the NCTM Standards.

Some of the comments reflecting a positive view of the role of statistics in the mathematics curriculum for the near future may be noted among the following.

District of Columbia:

Statistics will become increasingly important. It is now an integral part of the pre K-6 curriculum; and at the secondary level, I hope all mathematics courses will use statistics as a motivator for mathematics content.

Georgia:

More statistics will be incorporated into mathematics courses and more Statistics and Quantitative Literacy courses will be offered as teachers become comfortable with these topics. Statistics will be included in Algebra II and Advanced Algebra and Trigonometry because of the College Board's recommendation that all high school students study statistics and because of our state's Quality Core Curriculum based on the Standards.

Illinois:

More schools will be teaching aspects of statistics at all levels, including elementary levels.

Kentucky:

We will see a change from statistics being treated as an independent course to being integrated into a core mathematics curriculum based on MAA and NCTM recommendations.

Maine:

I anticipate that more topics from statistics will be incorporated across the mathematics curriculum due to implementation of the Standards.

Massachusetts:

We are encouraging wide adoption of the NCTM Standards. This should greatly improve student participation in statistical methods and reasoning. We also administer a statewide assessment test in mathematics in grades 4, 8, and 12. It includes a significant number of items from probability and statistics. As a result, schools are introducing more of this material into their programs.

Minnesota:

As teachers attend workshops, courses, and conferences which include statistics, they will begin to integrate this into existing curriculum. Several districts have begun using University of Chicago Mathematics Program materials which include statistics, and many middle school and junior high teachers are beginning to use Quantitative Literacy materials.

Montana:

As schools change their programs to meet the Standards, all work in data analysis will increase significantly.

New Jersey:

As a result of our new statewide testing program, the eleventh-grade High School Proficiency Test (HSPTII) and eighth-grade Early Warning Test, I believe there will be dramatic changes in statistics education for all students attending New Jersey's public schools. New Jersey's public schools will align their mathematics curriculum with test objectives by 1992.

North Carolina:

We will see statistics studied by more students in our state due to

1. increased emphasis on statistics in the Standards,
2. more emphasis on statistics in new Algebra I and Algebra II textbooks, and
3. increased availability and use of graphing calculators and user-friendly computer software.

Also our state universities and the school of science and mathematics offer numerous staff development activities in our state.

South Carolina:

Within the next two years, I hope to see statistics added to the high school curriculum and emphasized in other courses throughout the K-12 curriculum.

Utah:

I see an increased emphasis in statistics education, particularly by including some of these topics in Discrete Mathematics. As we rewrite the state core, statistics topics will be included throughout the curriculum as recommended by the NCTM Standards. I do not foresee an emphasis on separate statistics courses.

Vermont:

More and better, especially at the elementary level. Infused into existing course structure rather than as a specific course. Interdisciplinary approaches will increase.

Wisconsin:

There will be

1. expanded emphasis on statistics in the elementary and middle grades, allowing a more sophisticated approach at the high school level;
2. better integration of statistics with other strands of the curriculum;
3. more extensive use of graphics software and other statistics-related software;
4. more integration of mathematics with social studies based on statistics applications; and
5. more instructional time allocated to the study of statistical methods.

Wyoming:

Statistics will be much more important because of the NCTM Standards.

Supervisors from a second group of states also foresee an increase in the role of statistics in the mathematics curriculum but in a different manner.

Arkansas:

More schools will explore offering a course in statistics which may be as an alternative to Calculus. I really do not see much integration of statistics topics into the already crowded algebra, geometry sequence.

Maryland:

More systems are offering courses in statistics instead of a "little" statistics in other courses.

Nebraska and New Mexico:

More high schools will offer a semester course in statistics, and statistics topics will be integrated into mathematics classes K-12.

Finally, a third group of supervisors offered opinions which predict little, if any, change in the role of statistics in the mathematics curriculum in the near future.

Alaska:

No changes, except in small pockets as the Standards gradually have impact.

Nevada:

Changes will be slow in coming. A writing team will be working on re-writing our secondary courses of study this year. I would guess that statistics will have a

low priority for a few years. (We're so far behind in all aspects of the Standards.)

New Hampshire:

In the near future, very little change is anticipated. In the future, 5-8 years, there should be much more emphasis on statistics, probably as an integrated part of senior mathematics.

Pennsylvania:

I anticipate a gradual increase in the teaching of statistics as more districts recognize its value.

Texas:

I foresee a gradual increase in emphasis on topics in statistics with more integration into the mathematics curriculum.

Factors Affecting Teachers' Attitudes

Six secondary mathematics teachers were interviewed in conjunction with the 69th annual meeting of the National

Council of Teachers of Mathematics held in New Orleans, Louisiana, April 17-19, 1991. The results of the interviews offered assistance in identifying and describing factors which contribute to a secondary mathematics teacher's positive attitude toward curriculum change in statistics education. The interview responses also aided in describing procedures followed by teachers who have successfully implemented curriculum changes in secondary statistics education within their local school districts.

Subject Identification. Each of the six teachers represented one of the six caucus regions of the NCTM: northeast, southeast, north central, central, west, or southwest. Three of the interview subjects teach high school mathematics, and three teach either middle school or junior high school mathematics. In order to preserve the subjects' identities, they will subsequently be referred to by the state in which they teach or the region which they represent.

Two of the interviewees were identified by their state mathematics supervisors as being actively involved in implementing elements of statistics into the mathematics curriculum in their respective states. Another was identified by articles she has had published in issues of The Mathematics Teacher concerning the implementation of statistics into the secondary mathematics curriculum. The remaining three participants were identified through a gathering of statistics educators which met in conjunction with the annual NCTM meeting.

<u>Profile Information</u>. With teaching experience ranging from 8 to 25 years, these six teachers represent an average (both mean and median) of 19 years experience each in the secondary mathematics classroom. Four teachers are associated with departments of between three and seven teachers, while the remaining two chair departments of 12 and 29 teachers. Five of the six teachers have served as department chair for their respective mathematics departments, and the same five of six reported that the master's degree is the highest degree which they have earned. (The bachelor's degree was the highest degree reported by the sixth teacher.)

<u>Implementation Efforts</u>. Two of the six teachers interviewed declared unequivocally that their schools are making conscious efforts to implement into the mathematics curriculum the recommendations as set forth in the <u>Standards</u>. The remaining four teachers expressed conditional affirmation that their school is making a conscious effort to implement recommendations being made by the <u>Standards</u>. Each of these four instructors emphasized that the level of commitment varied from teacher to teacher within the department and that the most enthusiastic supporters of the <u>Standards</u> were also the most actively involved in NCTM and its state affiliate.

Comments from the different interviewees help to clarify the responses. The interview subject from Illinois offered this explanation.

> I would <u>like</u> to say that as a whole we were making a conscious effort to follow the <u>Standards</u>, but not everybody is <u>totally</u> supportive of that movement. We have a lot of experienced people who have taught for 20 to 25 years, and some of them remember the problems that came with the "new math" and are reluctant to jump on the band wagon. So I'd be less than honest if I said that there's a unanimous move to implement <u>all</u> of the <u>Standards</u>.

She continued to say that she and five of her fellow colleagues (out of 29) in the mathematics department from her school attended the annual NCTM meeting in New Orleans and that this degree of involvement, even at the national level, was not at all uncommon. She emphasized that she could confidently say that her department was unanimous in its efforts to improve mathematics instruction. It was at the point of adopting a "movement" which caused concern for some.

From New Mexico, the interviewee explained the situation this way.

> We are <u>working</u> on it. We have one teacher in our department who's just trying to get through the year and wants to go to law school. We have two other teachers who are older; and while they're trying to be open to new ideas, it's harder for them. And then myself and one other teacher are doing a <u>lot</u> of changes and a <u>lot</u> of work with the <u>Standards</u>. I would say for the most part, everyone in my department is <u>open</u> to the <u>Standards</u> and are <u>trying</u> to implement them and are willing to try new and different things with their students.

In his department of six, which functions without a formal department chair, the interview subject from the state of Washington classified his department's implementation effort as being on an individual basis. Both he and one fellow mathematics teacher have been actively involved in implementation efforts within their own classrooms. However, without the benefit of departmental meetings, he feels the implementation process is less effective than it would be with a more unified, departmental, approach.

The teachers interviewed were asked to identify whether or not certain topics were included in their mathematics department's curriculum. These topics are ones that are particularly identified as goals in Standard 10 of the curriculum and evaluation standards for grades 9-12. The participants' responses are recorded in Table 2. In the table, "All" indicates that the topic is included in the mathematics curriculum for all students in the school, while "Some" indicates that the identified topic is available to a limited number of students through the secondary mathematics curriculum.

An advantage of the interview format is that clarification and explanation can accompany answers to questions in the survey. The interview subjects who responded that the specific topic of study is included in the mathematics curriculum for a limited number of students in their school in all cases felt the need to explain the

TABLE 2

STATISTICS TOPICS IN THE SECONDARY MATHEMATICS CURRICULUM

Topic	Included			
	All		Some	
	#	%	#	%
Charts, tables, graphs of data	6	100	0	0
Measures of central tendency	5	83	1	17
Measures of variability	4	67	2	33
Sampling procedures	5	83	1	17
Designing and conducting a statistical experiment	2	33	4	67
Interpreting statistical data	4	67	2	33
Hypothesis testing	2	33	2	33

circumstances creating the differentiated curriculum. Some indicated that individual teachers among their faculty, always including themselves, choose to consistently include these topics for their students. The remaining teachers who reported a differentiated curriculum explained that these topics were covered almost exclusively in a separate course such as Statistics, Probability and Statistics, Data Analysis, or Math Analysis.

Basis for Interest. Along a different vein of questioning, each interview subject responded to a request to identify the basis for his/her interest in including topics from statistics in the secondary mathematics curriculum. Four of the six cited personal interest as a primary motivating factor. As expressed by the participant from Wisconsin, "I liked it (statistics). It's just fun!" In each of the six cases, including those with a pre-existing interest in statistical topics, a very significant catalyst was some form of special training.

The participant from Illinois enhanced her personal interest by attending a Monte Carlo workshop in Champaign, Illinois in the early 1970's. There she met Ken Travers, who has been very instrumental in the success of the Illinois Institute for Statistics Education (IISE) at the University of Illinois, Champaign. She has worked with him off and on since that time in the IISE, primarily in the summers. During that period of time in the early 1970's, she was teaching a course called Essential Mathematics and sensed that statistics had something to offer in terms of a vehicle for teaching the topics that were currently being taught in a "dull and repetitive manner."

It seems that the interviewee from Illinois shares a characteristic with the other five subjects in that all six have participated in either the Illinois Institute for Statistics Education or a Woodrow Wilson Summer Institute in Statistics at some time or another. Three are "graduates" of the IISE, and three have had the Woodrow Wilson experience. To a person, each cited these experiences as exceptionally strong motivators for promoting their local efforts to implement topics of statistics into the mathematics curriculum.

An IISE "graduate" and a Woodrow Wilson "alumnus" specifically identified the Standards as factors which inspired them to incorporate statistics topics into the mathematics curriculum in their schools. Two other interview subjects echoed the sentiment expressed by the Illinois interviewee in that they felt the need for alternatives to traditional teaching techniques and course offerings. The subject from Wisconsin pin-pointed a time in her school, more than twenty years ago, when the faculty felt the need to design some options to study hall. She described the situation in this way.

> We decided that we, being our school, needed to do something different. Back twenty-something years ago, our kids took physical education every other day. So,

> two or three days a week, they had a study hall with nothing to do. We tried to design some options that they could take that would fill in this study hall. So the math department created a statistics course. That statistics course just stuck around, we've had it ever since. Some of those ideas kind of spilled over into other courses.

The Washington participant, a middle school teacher, expressed his dissatisfaction with the drill-and-practice method of teaching the middle school mathematics curriculum. He wanted to find "some other vehicle for teaching basic skills; and whatever that vehicle was, it had to be tied to the real world. It also had to be activity-based." He saw statistics as a natural choice for this vehicle. This tie to the real world was also identified as a strong motivator by the previously mentioned Woodrow Wilson Summer Institute participant. A high school mathematics instructor, this Tennessee teacher expressed her views.

> We need to utilize things they (the students) are going to be using in the real world; and let's face it, statistics is something they're going to use in any area they go into. So as I started trying to get a lot more practical about things, that's when I decided I needed to incorporate more of that (statistics).

<u>Teaching Approach</u>. In describing the statistics programs in their schools, all six interview subjects expressed preference for an integrated approach. The middle school teacher from Washington explained that when he returned to his classroom after having attended the Illinois Institute for Statistics Education, he had anticipated treating the statistics topics as a six-weeks unit. However, after thinking about the ways in which projects

involving statistics could help his students to master the basic skills included in the traditional curriculum, he came to revise his original opinion and to decide that integration was preferable. The other two middle school mathematics teachers, one from Maine and the other from New Mexico, agreed with their peer from Washington that integration was the preferred mode of implementation. The three also expressed agreement in saying that their experience at the middle school/junior high school level was that there was little uniformity in format. Whereas they each preferred to let statistics problems and projects be the vehicle for teaching the mathematics curriculum, thus using an integrated approach, other teachers in their respective departments might equally prefer to teach topics in statistics via separate units.

The high school mathematics teacher from Tennessee indicated that four of the twelve teachers in her department were actively incorporating statistics topics into their classes. Their preference is to integrate the topics throughout their courses. She went on to explain that her department is currently revising the curriculum and that statistics topics will be part of the Algebra I curriculum for all students beginning in the fall of 1991. These topics may, according to teacher preference, be either integrated throughout the course or taught as a separate unit.

Of the remaining two high school mathematics instructors, the one from Wisconsin indicated that statistics topics have been a standard part of the mathematics curriculum in her school for about twenty years and are included in the Algebra I course. The rationale for including these topics in the Algebra I course is that not all students in her school take Algebra II. The teaching approach, either integrated throughout the course or via separate unit, within the algebra class is determined by the individual instructor. The mathematics curriculum at this Wisconsin high school also includes a separate statistics course, which is open to anyone with an Algebra I background. It usually draws an enrolment of between 30 and 40 students per year.

The high school mathematics teacher from Illinois identified the statistics "program" at her school as a function of the textbook that they use. They have chosen a text for their average freshman mathematics course which integrates data analysis throughout the text. Their upper level freshman course, however, contains little emphasis on statistics, or data analysis. The teachers in her school are currently in the process of discussing how they can best satisfy the statistics standard in their curriculum. Since their sophomore and junior level courses currently include little data analysis, they are concentrating their efforts at these levels. In addition to these efforts, the students who continue with mathematics through their senior year may elect to take a one-semester course in statistics as an option to trigonometry, and statistics topics are systematically worked into the other senior-level courses. This interview subject enthusiastically emphasized that her school was exceptional from the stand point that at least ninety percent of the students go on to college and do, indeed continue with mathematics throughout their senior year of high school.

Program Features. Asked to identify some of the outstanding features of the statistics education program at their schools, i.e., to identify some factors of their programs which make it work well, the teachers provided a variety of responses. Table 3 summarizes these responses and reports the frequency of response.

On a note of elaboration, the interview subject feels strongly that the infectious enthusiasm of an individual teacher is a very important factor in the success of any program. She feels that this type of individual can stimulate a colleague to try something new, serving as a mentor and encourager for his/her colleagues.

Invited to think about the flip side of this question, the teachers offered their ideas concerning components of their programs which they would like to see change. These responses are summarized in Table 4.

Explaining their responses, the interview subject from Maine said that he would like to see interesting and

TABLE 3

OUTSTANDING FEATURES OF STATISTICS PROGRAMS

Feature	Frequency
Activity-based	4
Related to the real world	2
Open-ended problem solving opportunities	2
Opportunities for students to see mathematics from a new perspective	2
Vehicle for making connections between mathematics and other subject areas	2
Motivator for using technology (e.g., graphing calculators and computers)	2
Infectious enthusiasm of individual teacher	1
Teachers who are willing to try new ideas and teaching strategies	1

TABLE 4

FEATURES NEEDED IN STATISTICS PROGRAMS

Features	Frequency
More high quality problems to investigate	3
Easier access to computers	2
Greater departmental unity of purpose	2
Greater degree of integration into mathematics curriculum and connections with other subjects	1

thought-provoking problems generating the curriculum as opposed to the curriculum generating the problems which students study. The interviewee from Tennessee explained that she personally wants to get to the point at which she feels comfortable enough with the content so that the students are the generators of the research questions for investigation as opposed to having the problems be initiated by her in her role as the teacher. She feels that this is a matter of "letting go" and that this will come with experience.

Program Initiators. Each interview subject was then asked to identify the person or group of people who had been most responsible for implementing concepts of statistics into the mathematics program in his school. Table 5 summarizes these results.

In five of the six interviews, the subject identified himself as the person most responsible for actively bringing statistics topics into the secondary mathematics curriculum. (Declaring that he has certainly been instrumental in incorporating topics in statistics into the mathematics curriculum in his school, the sixth teacher credited one of his colleagues as the person who first brought the study of statistics into the mathematics curriculum in his school. This colleague encouraged the interview subject to attend the Illinois Institute for Statistics Education and inspired him to join the implementation efforts.)

TABLE 5

INDIVIDUALS WHO HAVE LED
IMPLEMENTATION EFFORTS

Individuals	Frequency
Interview subject	5
Principal	2
Colleague	1
Director of secondary education in the district	1
State mathematics coordinator	1
District superintendent	1

In each of the five instances for which the interview subject was, himself, the person most responsible for actively bringing topics in statistics into the secondary mathematics curriculum, that teacher credited special training received through such avenues as the Illinois Institute for Statistics Education or a Woodrow Wilson Summer Institute in Statistics, as a major factor in motivating him to return to his school and to become a driving force in making topics in statistics an integral part of the secondary mathematics curriculum.

Two teachers, one junior high and one senior high, were very quick to credit the principal at their schools in supporting their efforts to implement curriculum changes in statistics education. The high school teacher from Tennessee explained the situation in her school in this way.

> The principal is <u>very</u> supportive. The principal wants us on top of <u>all</u> of the new things that are going on in mathematics education. He is very willing for his teachers to get to workshops and to participate in activities that will get them more actively involved in what's going on.

From New Mexico, the junior high school teacher participant clarified her response with this explanation.

> I have been the one responsible (for implementation), but I have to admit that I have gotten <u>total</u> support from my principal, from the director of secondary education, and from the superintendent. I have an <u>extremely</u> supportive administration; and as long as <u>I</u> can back up what I want to do - to show them how this will help the kids, how it will relate to the <u>Standards</u> - then they will let me do it. And they have tried to buy a lot of things that I need, like computer software and books on statistics. They are going to implement a statistics course at our high school within the next

two years as a result of all of this.

The high school teacher from Wisconsin spoke of her administration and of the state department of education's attitude toward curriculum innovation.

> The environment in my school is not very typical. We have had complete freedom to do whatever we've want to in the math department in math programs. We've all worked together to design it (the mathematics program); and if we think something is interesting or innovative, we go out and do it.
>
> The administration lets the academic areas really be in charge of whatever they choose to do. In recent years, they (administrators) look more at some kind of control or justification. For a long time, they never <u>really</u> paid any attention. <u>We</u> defined our goals, our kids did very well, and they just didn't mess with it.
>
> So my department has done a lot. We wrote problem solving units which we put in algebra. We threw out all the story problems in algebra and replaced them with the problem solving unit that we wrote, and we got money from the state government to do that. We went off on a tangent and did transformational geometry. We taught `Of Human Endeavors' as part of our Math Topics class. We also taught Jacobs' <u>Geometry</u> to all of our low level kids, and that's probably one of the most exciting things we did. So, we just go <u>do</u> these things! So when we came across statistics and data analysis, we said, `Well, let's go for it, guys!' So, we are atypical in the fact that we are all always involved, that we've had a <u>lot</u> of freedom.

<u>Implementation Procedures</u>. The six interview subjects reached a level of consensus when asked how statistics topics have been implemented into the mathematics curriculum in their schools. They agreed that a major avenue for incorporating topics of statistics into the mathematics classes has been through informal routes. The interviewee from Illinois offered this response.

> Up until just about this year, most of the impetus came from almost <u>informal</u> discussions with people in

> the department who were already, in a sense, "on the band wagon."

The effect of institute and conference training was also named by all six teachers as being particularly important. The Illinois Institute for Statistics Education, Woodrow Wilson Summer Institutes in Statistics, and NCTM regional and national meetings were specifically identified. The teacher from Illinois further explained that when teachers in her department go to conferences and summer institutes, they return to share what they have learned with their colleagues through monthly departmental meetings. She believes that these meetings are very important in building unity among the teachers and enthusiasm for departmental goals. This school, with a mathematics department of 29 teachers, also has course curriculum leaders who coordinate the activities of the instructors who teach the same courses at the same levels. When these teachers meet on a quarterly basis, they have the opportunity to share teaching strategies and goals which apply specifically to their courses. According to this department chair, "We have a very strong informal network that, for us, has been very, very, effective."

Although four of the six teachers interviewed identified inservice training as being an important tool of implementation, they differed in their assessment of the level to which it is employed in their respective districts. One teacher reported that he conducts inservice training in both elementary and secondary schools around his native state of Maine, but he has never led the teachers in his own department in inservice training of statistical topics for the mathematics curriculum. Three other teachers reported that implementation has been, to differing degrees, a departmental effort in their schools. Following her participation in a Woodrow Wilson Summer Institute in Statistics in 1984, one of these three teachers returned to her suburban Wisconsin high school enthusiastic about implementing statistical concepts into the secondary mathematics curriculum. She convinced her fellow mathematics teachers of the importance of this subject, and they made a unanimous departmental decision to use the Quantitative Literacy materials in their classes. They applied for and were accepted as a testing site for these materials. This interview participant led inservice training for her colleagues as they incorporated these data analysis techniques into their courses. She has also been a workshop and seminar leader at the state, regional, and national levels. The remaining two teachers, one from New Mexico and the other from Illinois, have both conducted inservice training within their own departments and districts. The junior high teacher from New Mexico feels that this is still a rich source of implementation that has yet to be adequately tapped.

The teacher from New Mexico also identified the use of Eisenhower funds for bringing workshop and seminar leaders to her district as an implementation tool which her district employs. Additionally, she reported that she submits a "cash balance wish list" for materials, including calculators and computer software, with which to implement the recommendations of the Standards.

Education Campaigns. By their own characterization, there appears to be an area which has been largely neglected by this group of interview subjects, and that is the area of public education of their department's goals and aspirations. Three teachers indicated that their schools have school-business partnerships with local industries. However, the reports of these teachers indicate that the potential for sharing with students the richness, breadth, and value of mathematics remains a relatively untapped source. From New Mexico, the interview participant explained that the school-business partnership her school has with the local power plant primarily consists of representatives of the power plant coming to the school and talking with the students about mathematics, probability, and statistics. The relationship has not extended to the point, however, to which the students have the opportunity to explore for themselves the type of mathematically-related problems encountered by the power plant. Many of these problems naturally involve data, and their solutions involve data analysis.

Clarifying the relationship that her high school has with the Nissan Corporation, the interviewee from Tennessee explained that in this phase of the partnership, the emphasis is on acquisition of computer hardware. She anticipates that once the technology is in place, then the focus will turn to bringing representatives into the school to show the students and faculty how to use that technology in real-world applications.

Working with a chemical business in the areas of both mathematics and science, the interview subject from Washington explained that the chemical company is interested in promoting mathematics and science as vocations. He further explained that the current emphasis from the chemical company to the school is in providing "technology for specific things which will motivate kids in those areas (mathematics and science."

All six teachers agreed that they rely primarily on "word of mouth" to garner support for their mathematics department's program goals. New Mexico's interview subject reported that there is one time during the year in which her students participate in a candy sales project. The proceeds from this activity go to purchase supplies and equipment for use in her mathematics classes. At that time, she shares some of her goals with the parents of her students in order to justify the candy sales project; but she admitted that any support that her programs receive as a result of this effort is secondary to the equipment acquisition itself. No other teacher among the interview subjects has reportedly engaged in any type of organized effort to educate the public sector and to garner support for their programs from that segment of society.

Remaining Implementation Stages. At the mention of the stages of implementation remaining to be addressed in their schools, the six teachers offered a variety of suggestions. Four of the six teachers indicated that they still consider their schools to be in relatively early stages of implementation with much work remaining. A synopsis of their responses provides an overall summary.

Tennessee:

> I think that we are at an awareness stage now. We're getting it (topics in statistics) in the curriculum, but the teachers are going to have to realize that it can be integrated; and I'm going to have to sell them on it.

Illinois:

> I think we need to create materials that are easy enough for people to use. For instance, what I see for next year is that the person who did the two-day spreadsheet unit in the senior class will be working in the computer lab one period next year. I would like him do a presentation to the junior classes which would allow the kids to come to the computer lab with their teachers and to participate in this activity.
>
> At our school, we have a couple of problems in implementing statistics. One is that people think they don't have enough time to do it because we have such a packed curriculum. The other thing is that people sometimes don't feel comfortable doing something that is new and different.
>
> For instance, we could teach standard deviation using the computer in a two-day unit with a semi-expert; and so I would like to see us get materials ready to do that. There are other topics in statistics also that I would like to see the junior class do and that would be the normal curve and t-scores. In the freshman year, I would like to see more work with interpretation of graphs.

Maine:

I think there needs to be a lot more work done on the elementary level in giving them help on ways in which they can use statistics to get to some of their math content. It's just a matter of pointing them in the direction. It's not that they don't do that. They just don't do it probably in enough of a formalized thinking way.

It's like the Standards. I mean I think everybody (in my department) does the standards, uses the standards, and works on the standards; but they probably don't know it. So it needs to be pointed out to them that "What you just did was a statistics 'thing,' and this is how you might attach this to something else." So that kind of training and helping them to create problems that use statistics is what see needed in the high school and for myself.

Washington:

Our efforts need to be more organized but should be better formulated after my project for IISE (Illinois Institute for Statistics Education) is completed.

New Mexico:

We need to do a lot more inservicing and to get it throughout the whole district. Primarily, it's at my school, and we need to get people using it throughout the district. What we also need to do is to put into our media center software and probability kits and that sort of thing that people can check out and use because those sorts of things are too expensive to come out of an individual school's budget, for the most part. So we need to have a central resource for the district where people can come to check out things just like they do filmstrips or anything else.

I've ordered "Challenge of the Unknown," and that will be in the media center; and I'm trying to come up with the money to buy the videotape series, "Against All Odds." So we're building up a resource center for all those kinds of things, but that kind of thing just takes time.

As teachers recognize that they have the resources with which to do these things, then they'll use them a lot more. I know last summer when I was at the institute (IISE), I heard so many wonderful things; and I was so fired up and at the same time so frustrated because I knew what I lacked, what we didn't have. And so I've been working. A lot of what I've done this year is working on getting the things to do what I learned about in the institute because you just can't do a lot of statistics real well without a computer. You can <u>do</u> it, but it's so <u>cumbersome</u> that after a while the kids are just going, "Oh, no, more numbers!" Even with calculators. So they need something that will go fast so they can spend <u>they're</u> time,they're energy thinking about the whole problem, rather than 2 + 2 = 4 and that kind of drudgery.

<u>Wisconsin:</u>

What we <u>really</u> need to do is to get statistics into <u>every</u> course, not just in <u>algebra</u>. We need to redefine what we're doing so that it is <u>not</u> the traditional thing, to use a hands-on, databased approach to the whole of mathematics at the secondary level, not just one unit on statistics. We're moving in that direction in two ways, both informal and formal.

As people get more comfortable doing things, they see opportunities to do something. Some of those are in very informal ways. Then some of them work, and they start to formalize them. I just got through talking with a man that I did a workshop with last summer, and he said that he was just amazed at how many times he would start to do something and would reach back to something <u>we</u> did and would put it into his regular curriculum. Well, we need to do that at the secondary level so that the second-year algebra teacher, the calculus teacher, and the geometry teacher have that same kind of a background.

We are doing that now in kind of an informal way, but we're also doing it in hopefully a formal way. I am working with the American Statistical Association, and we have another NSF grant to design curriculum <u>based on data</u>. We'll design modules or booklets that could be used in existing curriculum.

<u>Obstacles to Implementation</u>. The obstacles encountered by these teachers as they attempt to implement the desired changes in statistics education fall into three basic categories: human attitudes, time, and money. Four teachers specifically identified natural human resistance to change as an obstacle to implementation of the statistics standard into the secondary mathematics curriculum. This may manifest itself in several ways. It may involve

changing a mind set about what content should be in the mathematics curriculum or about how to incorporate such new content into an already overburdened curriculum. It may also involve a resistance to experimenting with different teaching strategies and be sung to the familiar tune of "We've Never Done It That Way Before." The interview subject from the North Central region of the United States believes that changing the mind set of secondary mathematics teachers is more difficult on a nationwide basis than it is in an individual school. For that reason, she believes the impact of individual teachers upon their departments is of utmost importance.

Noted by two teachers on opposite coasts as an obstacle to implementation efforts is the limited amount of time they have for planning and writing materials that incorporate data analysis into the mathematics curriculum. The department chair from Maine expressed his desire in this way.

> I need to take a year off and just write problems. You know, that's the hardest thing is to get good material, creative material, while you're doing all the rest of the stuff.
>
> So, the only obstacle is time. We're very lucky because our administrators feel that we're the professionals who know what should be happening; and so they allow us to do basically what we want, trusting that the ultimate goal is to get kids to think mathematically.

On the other coast, the teacher from Washington, in his role as a middle school teacher, teaches basic mathematics, pre-algebra, science, and reading; and he is also involved with the school advisory council and after-school activities. His desire is for more time for planning as well as for curriculum development. Having previously sent one of his colleagues to the Illinois Institute for Statistics Education, this teacher's district had promised that they would arrange planning time, on a regular basis, for the two IISE-trained teachers to plan and develop curriculum materials which could be integrated into the mathematics curriculum in their district. The two, however, do not have the same planning period and have had great difficulty working around each other's schedules to find the necessary time blocks for such planning. The interviewee expressed frustration with this obstacle.

The interview participant from New Mexico expressed the third obstacle category very simply. She said that the main obstacle she has encountered has been "pretty much just money - or the lack thereof."

Teacher Reflections. The remaining two questions from the interview required the teachers to engage in some reflection. With the knowledge that they now possess, these teachers were asked to consider what, if anything, they would do differently if they had the implementation process to begin again. Three of the six teachers responded that they would do nothing really differently. One instructor who has been actively incorporating elements of statistics into her junior high mathematics classes for one year, since attending the Illinois Institute for Statistics Education last summer, expressed herself this way.

> You've got to start somewhere. There has always got to be a start. Next year I'll do things differently simply because I've had the experience. I had to start somewhere, and I had to spend time just getting the money together to buy the materials I needed. Next year I'll be doing a lot more inservicing.

A relative new-comer to the process of implementing statistics topics into the mathematics curriculum, the interview subject from Washington offered his viewpoint.

> I'm not unhappy with the process. It's just that I feel like the process isn't complete yet. I think going to the statistics institute was probably the best way for me to do it. I just sort of jumped in and swam.

From the other end of the experience spectrum, a teacher who has been active in integrating statistics topics into the mathematics curriculum of her Wisconsin high school for nearly twenty years and who has been a familiar voice on this topic on the national front stated a similar opinion.

> I would do nothing differently because I didn't really do anything. It's just kind of like I acted and reacted as the opportunities were there.

Of note in her statement is that this teacher recognized opportunities available to her, took advantage of them, and capitalized on the knowledge gained from those experiences to extend their usefulness to the advantage of her school.

The teacher from Maine expressed his desire to have started his efforts earlier.

> I would have started earlier. I think it came later in the process just because statistics is always that Chapter 14. Traditionally, that's where it is.

> While people have to be made aware of the *Standards*, they have to *doubly* be made aware of the statistics and probability sections of the *Standards*. They just don't *think* in those terms enough.
>
> I would work really hard at imbedding it as a basic core of knowledge that you just use in other problems and don't teach as a separate unit. We're starting to do that in Algebra I now with probability; and we're going to do more of it with the statistics, where you ask a question that's getting at some content but you use probability and statistics as a vehicle.

From New Mexico, the interview participant indicated that she would allow more time for development.

> I would *force* myself to not try to integrate too much at one time. I would spend more time on the gathering of data, letting the students *feel* what they are doing, instead of just saying, "All right, I've got to teach them how to do this."
>
> It takes *time* to do it. I have made myself a goal that every Friday I will do *something* with statistics.

Finally, the veteran teacher from Illinois, who is close to retirement, indicated that she would promote the topic more.

> I would try to create more of what I call the "dog and pony show." One teacher has a videotape that he sends out, and he really markets his course. He's a real show man. He *commands* attention. Now his personality is very different from mine, and there is no way that I could do that. But if I were doing things over again, I would try to find something that would fit *my* way; or I would find somebody in my school who could adopt that approach. So I think that *marketing* is one of the things that we haven't done as well as we could have.

Advice to Fellow Teachers. In the way of offering advice to teachers in other school districts who want to implement concepts of statistics into their school's secondary mathematics program, these interview subjects had a variety of suggestions. A common thread that ran through their comments may be summed up by the encouragement to just start! Take one small step in the direction of implementation. One teacher offered this advice. "Keep looking for opportunities, and don't think you have to change everything at the same time."

Another interviewee advised mathematics teachers to "find a problem which captures your imagination, one with which you feel comfortable, and start with that." Collectively, the interview subjects agreed that good places to find such problems is through participation in workshops, conferences, seminars, institutes, and inservice training which focus on statistics. These groups provide a great way for teachers to get involved in promoting the integration of statistics into the mathematics curriculum. By means of these organized efforts, a teacher can join a network of other instructors who are willing to share ideas, projects, teaching strategies, and materials they have tried and found to be helpful in the classroom. Specific materials mentioned included the Quantitative Literacy series of books available through Dale Seymour Publications, the NCTM statistics yearbook, and the North Carolina series on data analysis.

The teacher from the state of Washington suggested that each school or district appoint someone to be a "model" teacher in the area of statistics. The district's responsibility would be to provide that model teacher with all the resources necessary for him to serve as a role model and leader to his colleagues in incorporating the statistics standard into their mathematics curriculum. The model teacher's responsibility would be to take advantage of all opportunities available to him in the area of statistics education. This would include, but not be limited to, attending sessions at regional and national conferences dealing with topics in statistics; attending special institutes (such as those sponsored by the IISE or Woodrow Wilson); becoming part of a network of fellow teachers to find, develop, and share problem ideas, project ideas, teaching strategies, and other materials; and then actively conducting inservice training for his colleagues in his school and/or district to disseminate his knowledge to them. He would function as a resource person, providing guidance, encouragement, and support for his peers. This person might be the district mathematics supervisor or coordinator, but it might just as well be a classroom teacher with a special interest in this area.

The interview participant from Illinois advocated a dual approach. Her advice was to "work to get statistics into the existing courses and also work to become an advocate, a person who will really promote statistics in your school." The end result of this "marketing" strategy is the alteration of a fixed mind set. Toward this same goal, the subject from Wisconsin advised teachers in this way.

> They should make a conscious effort to change their own mind set about what they think they have to do, which is very hard. Most people right now are taking small steps.
>
> It's kind of like the workshop that we did yesterday (at the NCTM annual meeting in New Orleans). It was interesting. When we started off the workshop, people were sharing, after their first activity, about how on Friday afternoon they would do this activity, or they would use it the day before vacation. They didn't have the framework to tell them that you don't take this and put it in a little patch here or a little patch there. It has got to be part of the entire program. That's not what it's all about. So there's a mind set that has to be changed, and that's the hardest part.

Though not surprising, coming from this group of educators, the shared enthusiasm and high energy level was most encouraging and uplifting. Their willingness to be interviewed and to share their experiences with this writer was both appreciated and inspiring.

Attitudes of Secondary Mathematics Teachers Toward Curriculum Change in Statistics Education

The survey instrument sent to a sample of secondary mathematics teachers in the state of Oklahoma contained statement formats which were designed to ascertain whether the teachers' attitudes were basically positive or negative with regard to their beliefs concerning the following topics:

1. that elements of statistics be included in the secondary mathematics curriculum;

2. that the school principal supports the movement

to include elements of statistics in the secondary mathematics curriculum;

3. that the secondary mathematics curriculum of their school can be (or has been) structured to include topics in statistics for all secondary students;

4. that the placement of topics in statistics in their mathematics text influences their decision whether or not to include them as topics of study in their secondary mathematics classes; and

5. that the mathematics curriculum which they are responsible for teaching is too overcommitted to permit them to include statistics topics in the mathematics courses they teach.

Each statement format appeared in connection with each of six specific content areas identified as targets for implementation in the statistics standard of the NCTM's Standards. The six content areas included

1. constructing and drawing inferences from charts, tables, and graphs to summarize data from real-world situations;

2. measures of central tendency;

3. measures of variability;

4. statistical correlation;

5. sampling procedures for gathering data; and

6. designing and conducting a statistical experiment to study a problem and interpreting the results.

The remainder of this chapter will address the teachers' responses to the survey items. With a response format of agree/disagree, random response would predict that 50% of the teachers would agree with the statement while 50% would disagree with it. Thus, for each area and subarea, the ratio of teacher agreement to the total number of responses was tested against a null hypothesis that the teachers had no significant preference, i.e., that there was no significant pattern to the teachers' responses.

Including Elements of Statistics in the Secondary Mathematics Curriculum

For the six content areas combined, 41% of the respondents replied that they would be including elements of statistics in their mathematics classes. Fifty-nine percent of the teachers indicated that they would not be including such elements in their classes. With a standard error of 0.02 and a p-value of less than .01, this result indicates a generally negative tendency to include elements of statistics in the secondary mathematics classes in Oklahoma. Taking the six content areas separately, the results are summarized in Table 6. These indicate that the teachers in the sample were generally positive about including the study of charts, tables, and graphs to summarize data from real-world situations and about including measures of central tendency in the secondary mathematics curriculum of their

TABLE 6

INCLUDING STATISTICS TOPICS IN THE SECONDARY MATHEMATICS CURRICULUM

Topic	Ratio	Standard Error	Z-value	p-value	Sign.
CTG	0.651	0.048	3.146	0.003	*
Cen. Ten.	0.648	0.048	3.083	0.003	*
Var.	0.387	0.049	-2.306	0.021	**
Corr.	0.150	0.048	-7.292	0.000	*
Sampling	0.306	0.048	-4.042	0.000	*
Experiment	0.315	0.048	-3.854	0.000	*

*	The result is significant at the 0.01 level.
**	The result is significant at the 0.05 level.
CTG	Constructing and drawing inferences from charts, tables, and graphs of data from real-world situations.
Cen. Ten.	Measures of central tendency.
Var.	Measures of variability.
Corr.	Statistical correlation.
Sampling	Sampling procedures for gathering data.
Experiment	Designing and conducting a statistical experiment to study a problem.

school. However, they did not plan to include the remaining four content areas in the mathematics curriculum of their school: measures of variability; statistical correlation; sampling procedures for gathering data; or designing, conducting, and interpreting the results from a statistical experiment to study a problem.

Teachers' Perceptions of Their Principal's Support for Including Statistics Topics in the Secondary Mathematics Curriculum

Of the teachers responding to the survey, 69% of them indicated that they perceive their principals as being supportive, on the whole, of the movement to include elements of statistics in the secondary mathematics curriculum in Oklahoma. With a standard error of 0.02 and a p-value of less than 0.01, such a response is significant.

When broken down into the six content areas, these teachers perceive their principals as being supportive with respect to the following areas:

1. constructing and drawing inferences from charts, tables, and graphs of data to summarize data from real-world situations;
2. measures of central tendency;
3. measures of variability; and
4. sampling procedures for gathering data.

Results were inconclusive with respect to the topics of

1. statistical correlation and

2. designing and conducting an experiment to solve a problem and interpreting the results.

Table 7 summarizes the results from the survey with regard to these six content areas.

Topic Treatment as a Function of the Textbook

When asked to indicate if the placement of topics of statistics in the textbook affects their decision whether or not to include them as topics of study in their mathematics classrooms, both the overall as well as the specific content area responses were consistent with a random assignment of agree/disagree to each statement. For the six areas combined, 49% of the teachers indicated that whether statistics topics appear toward the end of the text rather than earlier in the text has an effect upon their decision whether or not to include them as topics of study for their students. This overall response rate had a standard error of 0.02 and a p-value of 0.453, indicating a non-significant result. Table 8 summarizes the results for the six content areas as they relate to the question of elements of statistics being independent of the text in the perception of the secondary mathematics teachers in Oklahoma.

TABLE 7

PRINCIPAL SUPPORT FOR INCLUDING STATISTICS TOPICS IN THE MATHEMATICS CURRICULUM

Topic	Ratio	Standard Error	Z-value	p-value	Sign.
CTG	0.779	0.049	5.694	0.000	*
Cen. Ten.	0.743	0.049	4.959	0.000	*
Var.	0.738	0.049	4.857	0.000	*
Corr.	0.569	0.050	1.380	0.168	n.s.
Sampling	0.790	0.049	5.918	0.000	*
Experiment	0.534	0.049	0.694	0.503	n.s.

*	The result is significant at the 0.01 level.
n.s.	The result is not significant.
CTG	Constructing and drawing inferences from charts, tables, and graphs of data from real-world situations.
Cen. Ten.	Measures of central tendency.
Var.	Measures of variability.
Corr.	Statistical correlation.
Sampling	Sampling procedures for gathering data.
Experiment	Designing and conducting a statistical experiment to study a problem.

TABLE 8

STATISTICS TOPICS INCLUDED AS A FUNCTION OF THE TEXTBOOK

Topic	Ratio	Standard Error	Z-value	p-value	Sign.
CTG	0.459	0.048	-0.854	0.395	n.s.
Cen. Ten.	0.458	0.048	-0.875	0.379	n.s.
Var.	0.500	0.049	0.000	1.000	n.s.
Corr.	0.490	0.049	-0.204	0.841	n.s.
Sampling	0.491	0.048	-0.188	0.849	n.s.
Experiment	0.514	0.048	0.292	0.772	n.s.

n.s. The result is not significant.

CTG Constructing and drawing inferences from charts, tables, and graphs of data from real-world situations.

Cen. Ten. Measures of central tendency.

Var. Measures of variability.

Corr. Statistical correlation.

Sampling Sampling procedures for gathering data.

Experiment Designing and conducting a statistical experiment to study a problem.

As portrayed in Table 8, the result achieved for the six content areas combined was consistent with those found when each of the content areas was examined individually. No clear pattern, either significantly positive or significantly negative, was indicated. By these results, it cannot be determined whether or not the secondary mathematics teachers view their decision whether to include statistics topics in the mathematics curriculum as being a function of the particular textbooks being used in their classes.

Teachers' Perceptions of Their School's Curriculum as Being Open to Restructuring

Each teacher in the sample was asked to agree or disagree with a statement format indicating that the mathematics curriculum of their school could be (or had been) structured to include topics of statistics for all secondary students. For the combined content areas, the results were inconclusive. Overall, 48% of the teachers indicated their belief that the mathematics curriculum in their school could be structured to include these topics. With a standard error of 0.02 and a p-value of 0.267, this result is consistent with a random response of agree/disagree.

Examining the six content areas individually, however, offered a different perspective. As depicted in Table 9,

TABLE 9

STRUCTURE OF MATHEMATICS CURRICULUM CAPABLE OF ACCOMMODATING TOPICS IN STATISTICS

Topic	Ratio	Standard Error	Z-value	p-value	Sign.
CTG	0.648	0.048	3.083	0.003	*
Cen. Ten.	0.736	0.049	4.816	0.000	*
Var.	0.364	0.048	-2.833	0.005	*
Corr.	0.269	0.048	-4.813	0.000	*
Sampling	0.454	0.048	-0.958	0.337	n.s.
Experiment	0.398	0.048	-2.125	0.033	**

*	The result is significant at the 0.01 level.
**	The result is significant at the 0.05 level.
n.s.	The result is not significant.
CTG	Constructing and drawing inferences from charts, tables, and graphs of data from real-world situations.
Cen. Ten.	Measures of central tendency.
Var.	Measures of variability.
Corr.	Statistical correlation.
Sampling	Sampling procedures for gathering data.
Experiment	Designing and conducting a statistical experiment to study a problem.

the indication is that the teachers in this sample believe that the mathematics curriculum can be structured to accommodate constructing and drawing inferences from charts, tables, and graphs of data to summarize data from real-world situations as well as measures of central tendency. They do not believe that their school's mathematics curriculum can be structured to include measures of variability, statistical correlation, and designing and conducting a statistical experiment to study a problem. Furthermore, they are divided in their belief that sampling procedures can find its way into the mathematics curriculum of their school.

<u>Overcommitted Curriculum</u>

Just as the response rate regarding the teachers' beliefs about the flexibility of the structure of their school's mathematics curriculum offered mixed results, so did that of their response rate with reference to the statement format asking whether they believe their mathematics curriculum to be too overcommitted to permit them to include elements of statistics as topics of study for their secondary students. For the combined content areas, 53% of the responding teachers believe the mathematics curriculum for which they are responsible is too over-burdened to incorporate statistics topics for all secondary students. Associated with a standard error of 0.02 and a p-value of 0.194, this result is consistent with an assignment of agree/disagree to the statement format.

However, when the six content areas were viewed individually, the teachers indicated their belief that the curriculum is not so overcommitted as to prohibit them from including constructing and drawing inferences from charts, tables, and graphs of real-world data or from including measures of central tendency in their classes. As shown in Table 10, they felt there was no room to incorporate measures of variability, statistical correlation, and designing and conducting a statistical experiment to study a problem. Their views regarding the ability of the curriculum to accommodate the study of sampling procedures did not follow a well-defined pattern, i.e., the results were not significant.

Consistency with State Supervisors

With respect to reporting specific content areas from statistics which are generally included in the secondary mathematics curriculum, results from both the state supervisors of mathematics and the Oklahoma secondary mathematics teachers were compared for consistency. Hypothesis tests about proportions compared ratios from the two samples were used, and the results are presented in Table 11. In all five content areas, the results indicate that the ratios are consistent with each other. Thus, even with the relatively small sample sizes,

TABLE 10

PERCEPTION OF MATHEMATICS CURRICULUM AS TOO OVERCOMMITTED TO INCLUDE STATISTICS TOPICS

Topic	Ratio	Standard Error	Z-value	p-value	Sign.
CTG	0.339	0.048	-3.354	0.003	*
Cen. Ten.	0.385	0.048	-2.396	0.008	*
Var.	0.636	0.048	2.833	0.005	*
Corr.	0.638	0.049	2.816	0.005	*
Sampling	0.556	0.048	1.167	0.246	n.s.
Experiment	0.611	0.048	2.313	0.021	**

*	The result is significant at the 0.01 level.
**	The result is significant at the 0.05 level.
n.s.	The result is not significant.
CTG	Constructing and drawing inferences from charts, tables, and graphs of data from real-world situations.
Cen. Ten.	Measures of central tendency.
Var.	Measures of variability.
Corr.	Statistical correlation.
Sampling	Sampling procedures for gathering data.
Experiment	Designing and conducting a statistical experiment to study a problem.

TABLE 11

COMPARISON OF OPINIONS OF STATE SUPERVISORS AND OKLAHOMA TEACHERS

Topic	Ratio Difference	Standard Error	Z-value	p-value	Sign.
CTG	-0.018	0.10	-0.18	0.8572	n.s.
Cen. Ten.	0.152	0.10	1.52	0.1286	n.s.
Var.	0.013	0.10	0.13	0.8966	n.s.
Corr.	0.083	0.10	0.83	0.4066	n.s.
Experiment	-0.182	0.10	-1.82	0.0688	n.s.

n.s. The result is not significant.

CTG Constructing and drawing inferences from charts, tables, and graphs of data from real-world situations.

Cen. Ten. Measures of Central Tendency.

Var. Measures of Variability.

Corr. Statistical correlation.

Experiment Designing and conducting a statistical experiment to study a problem.

the results tend to support the transferability of the ratios. Since the responses represented nominal level data, the comparison of ratios was more appropriate than the comparison of correlation coefficients.

Summary

This study was a venture into descriptive research with the goal of providing greater insight into the current status of statistics education and beliefs held by secondary mathematics classroom teachers concerning the role of statistics education in the secondary mathematics curriculum. Representatives from three populations contributed to the knowledge pool for the study, each offering valuable perspectives. Qualitative methods were predominant in the survey of state mathematics supervisors and in the anecdotal interviews of the regionally-selected mathematics teachers who are actively incorporating elements of statistics into their classrooms and mathematics programs. Hypothesis tests of proportions enhanced the descriptive aspect of analyzing the survey from the secondary teachers in Oklahoma.

Information gathered from all three groups supported conclusions made by Mohammed (1988) which had indicated that the study of charts, tables, and graphs to summarize data and the study of measures of central tendency (mean, median, and mode) were the topics of statistics which most frequently found their way into the secondary mathematics curriculum. Measures of variability, statistical correlation, sampling procedures, and designing and conducting an experiment to study a problem are topics which are likely to be neglected in the mathematics curriculum. The Oklahoma secondary mathematics teachers did not indicate optimism in anticipating that the mathematics curriculum at the local level was currently flexible enough to be structured to incorporate these same four topics.

The state supervisors and the interview subjects, however, agreed in their perception of the role of statistics as being on the rise in the mathematics curriculum in the future as the Standards gain in-roads in terms of both public awareness and teacher awareness. Neither group expects overnight success but anticipates the need for extensive teacher training and an active support network to provide resource information and training in both content knowledge and curriculum development. They envision such support as coming through the National Council of Teachers of Mathematics, NCTM affiliates, and specialized training organizations such as the Illinois Institute for Statistics Education and the Woodrow Wilson Summer Institutes in Statistics.

Perhaps the most valuable aspect of this study came from the interviews with teachers who are at the forefront of incorporating statistics education in their teaching.

They agreed that an alteration in mind set is perhaps the most significant change needed to implement the statistics standard of the Standards into the secondary mathematics curriculum. Some suggested that a change in terminology might aid the cause. Instead of referring to this content area as "statistics," it would be more appropriate to call it "data analysis." At the secondary level, there is less curricular emphasis given to topics of inferential statistics and more curricular emphasis given to topics of exploratory data analysis, including such descriptive techniques as charts, tables, graphs, box-and-whisker plots, and scatter diagrams.

Among the activities and/or persons identified by the interview subjects as having the greatest influence on changing their own mind sets include their own participation in specialized institutes, workshops, and seminars on statistics education. All six subjects credited either the Woodrow Wilson Summer Institutes in Statistics or the Illinois Institute for Statistics Education as being particularly inspirational. Several interview subjects suggested that an alternative to having a first-hand experience in one of these institutes is to find a colleague who has had such first-hand training and who is willing to serve as a mentor for other teachers in their school's mathematics department.

By the use of interviews and open-ended questions along with the fixed-response survey format, the findings of this study contribute to a better understanding of teachers' beliefs with regard to curriculum issues in statistics education.

CHAPTER V

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Summary

"Statistics, the science concerned with collection, analysis, and interpretation of numerical information is important in the life of every citizen" (Conference Board of the Mathematical Sciences, 1975, pp. 44-45). This statement, contained in the NACOME report, is as true today as it was when it was issued in 1975. The tools of statistics offer an alternative to heavy dependence upon individual opinion. This study focused on the current status of statistics education in the secondary mathematics curriculum and on attitudes of secondary mathematics educators toward curriculum change and implementation in the area of statistics education.

Three constituencies of educators shared their perspectives in the different phases of the study. State mathematics supervisors (n = 38) described the status of statistics education in their states and offered their views of the role of statistics in the mathematics curriculum for the near future as seen through the filter of mathematics education in their states. Mathematics teachers (n = 6) who are actively involved in incorporating elements of statistics into the mathematics curriculum of their schools composed a second group involved in the study. Their interviews contributed personal perspectives from teachers on the cutting edge of efforts to implement statistics into the secondary mathematics curriculum. A third group (n = 118) consisted of secondary mathematics teachers in the the state of Oklahoma. Their responses focused upon various topics associated with the implementation of statistics into the mathematics curriculum.

By use of both qualitative and quantitative methods, this study sought to provide descriptions, identifications, and suggestions outlined in the following paragraphs. The first component of the study consisted of providing a description of the current status of statistics education in the secondary mathematics classroom as it relates to the Standards.

The second component of the study involved providing a description of attitudes of secondary mathematics teachers toward curriculum change in secondary statistics education and toward implementation of programs to effect such change. Toward the goal of describing these selected attitudinal factors, tests of proportions were used in analyzing the data. For five areas of teacher conceptions and six content topics, the null hypothesis that 50% of the teachers agreed with the given statement was tested against the alternate hypothesis that the response ratio was significantly different than 50%. The hypothesized ratio of 50% corresponded to a null hypothesis that teachers had no pronounced opinion regarding the given attitudinal statement as it pertained to one of the six specific content areas.

The five areas of teacher conceptions investigated were

1. whether or not elements of statistics are included in the secondary mathematics curriculum,

2. whether or not the principal of their school supports including statistics topics in the secondary mathematics curriculum,

3. whether or not the treatment of statistics topics in the secondary mathematics curriculum is a function of the textbook being used in their classroom,

4. whether or not the mathematics curriculum of their school can be (has been) structured to include topics of statistics, and

5. whether or not the mathematics curriculum of their school is too overcommitted to include topics of statistics.

Each of these five areas was then paired with each of six specific content areas in statistics. The six content areas selected from the tenth secondary mathematics standard in the <u>Standards</u> included

1. constructing and drawing inferences from charts, tables, and graphs of data from real-world situations;

2. measures of central tendency;

3. measures of variability;

4. statistical correlation;

5. sampling procedures for gathering data; and

6. designing and conducting a statistical experiment to study a problem.

The combination of the areas of teacher conceptions with the statistics topic content areas resulted in 30 survey items sent to a sample of secondary mathematics teachers in Oklahoma. The corresponding 30 hypotheses were organized by teacher conceptions, and the results were reported in Tables 6-10 of Chapter IV.

The perception of which topics of statistics are currently included in the secondary mathematics curriculum was addressed by both the secondary mathematics teachers in Oklahoma and the members of the ASSM. The response ratios from both groups of mathematics educators were compared for consistency of response. For each of the six content areas, a comparison was made which involved testing the null hypothesis that the difference between the two proportions was zero, i.e., there was no significant difference in the response ratio between the members of the two groups regarding each of the given content areas. The results of investigation for consistency of response appeared in Table 11 of Chapter IV.

Table 12 represents a visual summary of the significant results from the analysis of survey responses received from the Oklahoma secondary mathematics teachers which also match an idealized profile. Similar in format to one developed by

Cooney for describing attitudes toward teaching middle school (International Association for the Evaluation of Educational Achievement, 1985), the numbered items within the table represent the 30 survey items; while the corresponding A or D represents the response Agree or Disagree, respectively. The indicated responses represented within the grid portray the response pattern of an ideal teacher who has a very positive attitude toward incorporating statistics topics into the secondary mathematics curriculum. Used for an individual teacher's response, a researcher could provide a profile of that teacher's beliefs in the following way. If the teacher responded "Agree" to the first survey item, then 1A would be circled in the profile. If, however, the teacher responded "Disagree" to that item, then 1A would not be circled. Likewise, if the teacher responded "Disagree" to item 8, then 8D would be circled in the rectangular grid. If the teacher responded "Agree" to item 8, however, 8D would not be circled.

After addressing each survey item, the number of circled responses may then be summed in the margins. The higher the sum, the more closely the teacher's responses correspond to the idealized profile. By focusing on Teacher Conceptions, one may gain insight to which of these areas a given teacher is more favorably inclined. Likewise, by focusing on Content Topics, one may gain insight to which statistics topics the teacher is more open to including in the mathematics curriculum. By circling the responses which correspond to significant survey results, which also conform to the idealized profile, and summing the number of significant results, vertically and horizontally, patterns of response with respect to teacher conceptions and content topics may be summarized for the entire group of teachers surveyed. It is this profile which appears in Table 12.

The final three aspects of the study were achieved by interviewing teachers who have actively exhibited interest in incorporating topics in statistics into the mathematics curriculum of their schools. The third part of the study provided an identification and a description of factors which contribute to a secondary mathematics teacher's positive attitude toward curriculum change in statistics education and toward implementation of programs to effect such change. Toward this goal, mathematics teachers from the six NCTM caucus regions of the United States were interviewed. As previously mentioned, these six teachers were selected on the basis of an exhibited interest in incorporating elements of statistics into their teaching.

The fourth component of the study was to provide a description of procedures followed by teachers who have successfully implemented curriculum changes in secondary statistics education within their local school districts. The six previously described mathematics teachers shared their experiences, which were then examined for commonalities and differences.

TABLE 12

TEACHER PROFILE

Teacher Conceptions	CTG	Cen. Ten.	Var.	Corr.	Samp.	Exp.							
	Content Topics												
Statistics Topics Included in Mathematics Curriculum	**1A**	**16A**	21A	26A	11A	6A	0	1	**2**	3	4	5	6
Principal Support for Including Statistics Topics in Mathematics Curriculum	**27A**	**7A**	**12A**	22A	**2A**	17A	0	1	2	3	**4**	5	6
Including Statistics Topics as a Function of the Text	8D	23D	13D	18D	28D	3D	**0**	1	2	3	4	5	6
Mathematics Cruuiculum Too Overcommitted to Include Statistics Topics	**9D**	**4D**	24D	19D	29D	14D	0	1	**2**	3	4	5	6
Mathematics Curriculum as Capable of Being Structured to Include Statistics Topics	**30A**	**20A**	10A	5A	25A	15A	0	1	**2**	3	4	5	6
	0	0	0	**0**	0	**0**							
	1	1	**1**	1	**1**	1							
	2	2	2	2	2	2							
	3	3	3	3	3	3							
	4	**4**	4	4	4	4							
	5	5	5	5	5	5							

The final component of the study was to provide suggestions for implementing the curriculum changes in statistics education which are promoted in the Standards. A composite of successful experiences identified by the six interviewees formed the basis for these suggested actions.

Conclusions

The following conclusions address each of the five focal issues of the study and provide insight into the educational climate affecting the direction of statistics education both now and in the near future.

1. The current status of statistics education remains relatively unchanged since the NACOME report (Conference Board of the Mathematical Sciences, 1975) was issued. The study of charts, tables, and graphs to summarize data from real-world situations and the study of measures of central tendency still dominate all other topics of statis-tics which find their way into the secondary mathematics curriculum at this time.

In each of five areas tested, using proportions, the mathematics supervisors and the Oklahoma teachers were consistent in their responses. The two groups indicated that the study of charts, tables, and graphs to summarize data from real-world situations and the study of central tendency are commonly included as topics in the secondary mathematics curriculum. The remaining three topics used for comparison (measures of variability, correlation, and conducting experiments) are less commonly addressed.

In an open-ended question addressed by the state supervisors concerning their views of future trends in statistics education, they indicated significant agreement (89%) that they foresee an increase in these topics in the mathematics curriculum in the next few years. With no reference to the NCTM Standards mentioned in the question, a significant percent (31%) of these supervisors credited their optimism to the anticipated impact of the Standards on mathematics education.

2. The Oklahoma teachers who responded to the second survey offered their opinions with respect to four factors of interest in connection to curriculum change in statistics education. Their responses to the four factors were, at times, content-specific.

An interesting result, from this researcher's point of view, was the significantly positive assessment of their principal's support for including topics from statistics in the mathematics curriculum. On the whole, these teachers rated their principals as supportive of any efforts to include these topics in the mathematics curriculum of their school.

The Oklahoma teachers were consistently undecided as to whether or not they attributed their decision to include topics of statistics in the mathematics curriculum of their classes as a function of its placement in the textbook. As many teachers responded that either early or late treatment of the topic(s) in the text influenced their decision whether or not to address them in their classes as did not. This pattern was consistent both on the whole and when examined according to specific content topics.

The pattern that these teachers established in responding to the request to identify which topics of statistics are included in their school's mathematics curriculum continued with the remaining two factors considered. They view their curriculum as being flexible enough in structure to accommodate the study of charts, tables, and graphs of data to summarize real-world situations and the study of measures of central tendency. They did not view their curriculum as capable of incorporating measures of variability, statistical correlation, or designing and conducting a statistical experiment to study a problem. With respect to being able to accommodate sampling procedures for gathering data, the response ratio yielded a value that was not significant.

This same pattern appeared again with regard to the issue of whether or not their curriculum was too over-committed to permit them to include topics of statistics into the mathematics curriculum of their classes. They felt that it was not so overcommitted to prohibit them from including the study of charts, tables, and graphs and the study of measures of central tendency and were undecided with respect to sampling procedures. However, they did feel that the curriculum was too overcommitted to permit them to include measures of variability, statistical correlation, and designing and conducting a statistical experiment to study a problem.

3. For teachers already actively involved in incorporating elements of statistics into the mathematics curriculum of their schools, the factor most frequently identified as having made a significant contribution to their positive attitude toward curriculum change in statistics education and toward their involvement in programs to effect such change was the experiences they had as the result of attending either the Illinois Institute for Statistics Education or of participating in a Woodrow Wilson Summer Institute in Statistics. They attributed their enthusiasm not only to the training received through the institute but also to the support system of fellow teachers and trainers associated with the experience.

Other factors contributing to their positive attitudes included the support and/or freedom afforded them by principals, mathematics supervisors, and other administrators. In some instances, this support was not necessarily perceived as overt but as implied. Other teachers gained inspiration from colleagues whose own interest in the subject was infectious, encouraging colleagues to be risk-takers and innovators in their own classrooms, willing to change their mind sets and to break perceived bonds of traditionally accepted teaching techniques.

4. With respect to procedures followed by the

interviewed teachers who have successfully implemented components of statistics into the mathematics programs of their schools, the procedures appear to be very informal. The majority of the interview subjects have implemented curriculum changes a little at a time and on an individual basis. Those teachers who have a long-established record of interest in statistics education have, over time, taken the initiative to share their efforts with fellow department members and to initiate more formal implementation plans. However, the teachers who have more recently taken active roles in this area have, to this point, tended to confine their efforts to their own individual classes.

5. The most compelling suggestion made by the teachers who are currently making progress in the implementation process is to "just do it!" They urge teachers to become familiar with available literature on the subject through such sources as The Mathematics Teacher, The Statistics Network Newsletter, and the Quantitative Literacy series. They also recommend that interested teachers attend as many local, state, regional, and national meetings of the NCTM and its affiliated organizations, seeking out the meetings and workshops focusing on implementing statistics topics into the mathematics curriculum. Then most of all, they suggest attending an institute which specializes in promoting statistics education through the mathematics curriculum.

They further recommend focusing on one aspect or interesting problem at a time and not trying to implement all content areas at once, allowing adequate time for preparation and planning in order to assure the highest likelihood of success. Then once that goal is achieved, they recommend stretching to another step and conquering it.

Implicit to the best developed success, according to the interviewed teachers, is becoming part of a network of other teachers who share a common interest. This will likely involve contact with teachers from other schools, districts, and perhaps states as the teacher searches for interesting problems and projects to use.

Recommendations

Four recommendations are offered for mathematics educators who are interested in implementing curriculum change in statistics education as recommended in the NCTM Standards.

1. Identify and tap into in-house human resources. A growing number of teachers have had special training in techniques for both teaching and implementing topics of statistics into the secondary mathematics curriculum. As these teachers return to their respective school districts, they should be encouraged to share their knowledge and skills with their fellow colleagues and administrators. Inservice training appears to be an area which has been somewhat neglected as an avenue of transmitting not only knowledge and skills but also infectious enthusiasm for

implementing elements of statistics into the secondary mathematics curriculum.

Burrill (1989) cited inservice activities as an intended mode of transmitting the knowledge and skills gained through the Quantitative Literacy project and Woodrow Wilson Summer Institutes in Statistics to local teachers of science and mathematics. Interview subjects have indicated that although their intentions were to share their experiences via inservice activities, they had not explored this avenue very fully.

2. Encourage teachers who exhibit an interest in implementing statistics topics into the mathematics curriculum to attend institutes which can provide them not only specialized training but also can introduce them to a support system which will help them to persevere in their implementation efforts. Two primary catalysts for inspiring teachers to implement topics of statistics into the secondary mathematics curriculum in their schools are the Illinois Institute for Statistics Education and the Woodrow Wilson Summer Institutes in Statistics. If the networking capabilities through these institutes are strengthened, then the effects of the training they provide can be multiplied rapidly (Burrill, 1989).

These institutes, however, can accommodate only a limited number of participants at a given time. Travel distances and expenses, even when underwritten, can be inhibiting factors for individual teachers as they decide whether or not to participate in this type of specialized training. A greater number of universities offering this type of training could reach a greater number of secondary mathematics teachers in a shorter amount of time. As the Standards are actively implemented, a demand for this type of training will hopefully increase. Thus, a second recommendation is that universities and other forums develop and conduct specialized training seminars to supplement the efforts of the already established IISE and Woodrow Wilson Summer Institutes in Statistics.

3. More emphasis should be devoted to educating administrators, parents, school board members, business leaders, and the general public about the important role that data analysis plays in the mathematics curriculum of the 1990's and beyond. This recommendation to educate the various constituencies who benefit from a mathematically literate populace appeared in the NACOME report (Conference Board of the Mathematical Sciences, 1975) with regard to statistics education. It remains as appropriate today as it was 16 years ago.

There are teachers throughout the nation who are enthusiastic about implementing the statistics standards recommended by the NCTM Curriculum and Evaluation Standards for School Mathematics. This implementation process, however, includes more than just the teaching of skills. It also includes a component involving attitudes and values. Not only must students accept the importance of statistical techniques in organizing, summarizing, and drawing inferences from data; but administrators, parents, and business leaders must also support the entire implementation process. Thus, curriculum change in the arena of statistics education must include educating all of these components of society. Such education involves aspects of public relations.

The teachers interviewed during the course of this study were very enthusiastic when it came to sharing their knowledge within the confines of their own classrooms. Only a few, however, had considered the need to make a concerted effort to address negative attitudes held by many people toward the field of statistics and toward conclusions drawn by means of using statistical techniques. It has been demonstrated that public education campaigns can significantly affect public perception of social issues. The recent national campaign to promote literacy in our nation has raised public awareness to the problem of a adult illiteracy. A similar nationwide focus on the need for quantitative literacy, which includes competence in using and interpreting data, can complement the classroom teacher's efforts in implementing such quantitative literacy into his/her individual classroom. A nationwide focus, however, is greatly enhanced by ground force efforts of individual classroom teachers.

SELECTED BIBLIOGRAPHY

American Statistical Association and National Council of Teachers of Mathematics. The Statistics Teacher Network. Terre Haute, IN: Rose-Hulman Institute of Technology. No. 27 (1991): 1-8.

Anderson, R. M. "A Partnership Model for Manpower Training." (Doctoral Dissertation, Columbia University Teachers College, 1984.) Dissertation Abstracts International (1984): AAC8424196.

Baharestan, M. "Perceptions of Barriers to Curriculum Change in Computer Courses at Four-Year Schools of Technology: A Comparison of Faculty and Administrators." (Doctoral Dissertation, Rutgers the State University of New Jersey, 1985.) Dissertation Abstracts International (1985): AAC8524202.

Begle, E. G. Critical Variables in Mathematics Education: Findings from a Survey of the Empirical Literature. Washington, D. C.: Mathematical Association of America, 1979.

Brown, C. A. "A Study of the Socialization to Teaching of a Beginning Secondary Mathematics Teacher." (Doctoral Dissertation, University of Georgia, 1985.) Dissertation Abstracts International (1985): AAC8524317.

Burrill, G. "Statistics and Probability." Mathematics Teacher. Reston, VA: National Council of Teachers of Mathematics. 83.2 (1990): 113-118.

---. "Quantitative Literacy in the United States." Studies in Mathematics Education: The Teaching of Statistics. Paris: United Nations Educational, Scientific and Cultural Organization, 1989.

Cambridge Conference on School Mathematics. Goals for School Mathematics. Boston, MA: Houghton Mifflin Company, 1963.

Cockcroft, W. H. (Chairman). Mathematics Counts: Report of the Committee of Inquiry into the Teaching of Mathematics in Schools. London: Her Majesty's Stationery Office, 1982.

Combs, A. W. A Personal Approach to Teaching : Beliefs That Make a Difference. Boston, MA: Allyn and Bacon, 1982.

Conference Board of the Mathematical Sciences. Overview and Analysis of School Mathematics, Grades K-12. Washington, D. C.: Conference Board of the Mathematical Sciences, 1975.

Cooney, T. J. "The Issue of Reform: What Have We Learned From Yesteryear?" Mathematics Teacher. 81.5 (1988): 352-363.

David, D. A. "Staff Development as a Vehicle for Curriculum Change." (Doctoral Dissertation, State University of New York at Buffalo, 1986.) Dissertation Abstracts International (1986): AAC8702180.

Dillon-Peterson, B. "Trusting Teachers to Know What's Good for Them," Improving Teaching, ASCD Yearbook, 1986. 29-35.

Gay, L. R. Educational Research: Competencies for Analysis and Application. Third edition. Columbus, OH: Merrill Publishing Company, 1987.

Griffin, G. "Thinking About Teaching," Improving Teaching, ASCD Yearbook, 1986. 101-113.

Grant, C. E. "A Study of the Relationship Between Secondary Mathematics Teachers' Beliefs About the Teaching-Learning Process and Their Observed Classroom Behaviors." (Doctoral Dissertation, The University of North Dakota, 1984.) Dissertation Abstracts International (1984): AAC8507627.

Hewett, J. E. (Editor). Stats: The Magazine for Students of Statistics. Spring, 1989, Number 1. Alexandria, VA: American Statistical Association, 1989.

Howser, M. A. "Reluctant Teachers: Why Some People Learn and Grow and Others Do Not." (Doctoral Dissertation, University of Oregon, 1989.) Dissertation Abstracts International (1989): AAC0567327.

Howson, G.; Wilson, B. School Mathematics in the 1990's. Cambridge, MA: Cambridge University Press, 1986.

International Association for the Evaluation of Educational Achievement. Second International Mathematics Study Summary Report for the United States. Champaign, IL: Stipes Publishing Co., 1985.

Isaac, S. and Michael, W. B. Handbook in Research and Evaluation. 2nd ed. San Diego, CA: EdITS, 1981.

Jacobsen, E. "Why in the World Should We Teach Statistics?" Studies in Mathematics Education: The Teaching of Statistics. Paris: United Nations Educational, Scientific and Cultural Organization, 1989.

Jennings, J. J. "The Sputnik of the Eighties." Phi Delta Kappan 69 (Oct., 1987): 104-109.

Joyce, B. and Showers, B. "The Coaching of Teaching." Educational Leadership. (Oct., 1982): 4-10.

Kesler, Jr., R. "Teachers' Instructional Behavior Related to Their Conceptions of Teaching and Mathematics and Their Level of Dogmatism: Four Case Studies." (Doctoral Dissertation, University of Georgia, 1985.) Dissertation Abstracts International (1985): AAC8524356.

Kinney, J. The Statistics Teacher Network. No. 25 (1990). Terre Haute, IN: American Statistical Association-National Council of Teachers of Mathematics Joint Committee on the Curriculum in Statistics and Probability, 1990. 1-10.

---. The Statistics Teacher Network. No. 27 (1991). Terre Haute, IN: American Statistical Association-National Council of Teachers of mathematics Joint Committee on the Curriculum in Statistics and Probability, 1991. 1-8.

Kouba, V. L.; Carpenter, T. P.; Swafford, J. O. Results from the Fourth Mathematics Assessment of the National Assessment of Educational Progress. Ed. J. J. Lindquist. Reston, VA: National Council of Teachers of Mathematics, 1989.

Krumlauf, J. M. "Program and Curriculum Development in Baccalaureate Nursing Education in the Church of the Nazarene: Program Histories and Descriptions and Critique of the Process of Curriculum Development." (Doctoral Dissertation, University of Kansas, 1985.) Dissertation Abstracts International (1985): AAC8608464.

Laforme Yoder, J. A. "The Relationship Among Personal and Psychological Factors and the Computer Literacy of Elementary Teachers." (Doctoral Dissertation, The University of Toledo, 1986.) Dissertation Abstracts International (1986): AAC8702382.

Landwehr, J. and Watkins, A. Exploring Data. Palo Alto, CA: Dale Seymour Publications, 1986.

Landwehr, J.; Swift, J.; Watkins, A. Exploring Surveys and Information from Samples. Palo Alto, CA: Dale Seymour Publications, 1987.

MacGraw-Hill Publishers. Business Week. Washington, D. C.: No. 3020. (September 19, 1988).

Marshall, C.; Rossman, G. B. Designing Qualitative Research. Newbury Park, CA: Sage Publications, 1989.

Mohammad, N. A. N. "The Study of Probability and Statistics at the High School Level." (Master's Thesis, Oklahoma State University, 1988.) Stillwater, OK: Oklahoma State University, 1988.

Moore, D. S. "Uncertainty." On the Shoulders of Giants: New Approaches to Numeracy. Ed. L. A. Steen. Washington, D. C.: National Academy Press, 1990. 95-137.

National Council of Supervisors of Mathematics. Essential Mathematics for the 21st Century. Minneapolis, MN: National Council of Supervisors of Mathematics, 1988.

National Council of Teachers of Mathematics. A History of Mathematics Education in the U.S. and Canada. 32nd Yearbook. Reston, VA: National Council of Teachers of Mathematics, 1970.

---. Curriculum and Evaluation Standards for School Mathematics. Reston, VA: National Council of Teachers of Mathematics, 1989.

---. Organizing Data and Dealing with Uncertainty. Reston, VA: National Council of Teachers of Mathematics, 1979.

---. Professional Standards for Teaching Mathematics. Working Draft. Reston, VA: National Council of Teachers of Mathematics, 1989.

---. Teaching Statistics and Probability. 43rd Yearbook. Reston, VA: National Council of Teachers of Mathematics, 1981.

---. The Agenda in Action. 45th Yearbook. Reston, VA: National Council of Teachers of Mathematics, 1983.

National Research Council. Everybody Counts: A Report to the Nation on the Future of Mathematics Education. Washington, D. C.: National Academy Press, 1989.

---. Reshaping School Mathematics: A Philosophy and Framework for Curriculum. Washington, D. C.: National Academy Press, 1990.

National Science Foundation. Educating Americans for the Twenty-first Century. Washington, D. C.: National Science Foundation, 1983.

Newman, C.; Obremski, T.; Scheaffer, R. Exploring Probability. Palo Alto, CA: Dale Seymour Publications, 1987.

Odum, M. K. "A Study of Teachers' Perceptions of Factors That Are Instrumental in Promoting Change in a School-Based Change Project." (Doctoral Dissertation, George Peabody College for Teachers of Vanderbilt University, 1985.) Dissertation Abstracts International (1985): AAC8611051.

Owens, J. E. "A Study of Four Preservice Secondary Mathematics Teachers' Constructs of Mathematics and Mathematics Teaching." (Doctoral Dissertation, University of Georgia, 1987.) Dissertation Abstracts International (1987): AAC8712686.

Patton, M. Q. How to Use Qualitative Methods in Evaluation. Newbury Park, CA: Sage Publications, 1987.

Paulos, J. A. Innumeracy: Mathematical Illiteracy and Its Consequences. New York: Hill and Wang, 1988.

Queue, Inc. Queue: The Best in Educational Sofware. Bridgeport, CT: Queue, Inc., 1991.

Scheaffer, R. L. "Why Data Analysis?" Mathematics Teacher. 83.2 (1990): 90-93.

Seymour, D. 1991 Catalog, K-8 Educational Materials. Palo Alto, CA: Dale Seymour Publications, 1991.

Sunburst Communications. Sunburst Educational Computer Courseware Catalog. Pleasantville, NY: Sunburst Communications, 1991.

Tanur, J.; Mosteller, F.; Kruskal, W.; Link, R.; Pieters, R.; Rising, G. Statistics: A Guide to the Unknown. Oakland, CA: Holden Day, Inc.

Thompson, A. G. "Teachers' Conceptions of Mathematics and Mathematics Teaching: Three Case Studies." (Doctoral Dissertation, University of Georgia, 1982.) Dissertation Abstracts International (1982): AAC8228729.

Travers, K.; Stout, W.; Swift, J.; Sextro, J. Using Statistics. Menlo Park, CA: Addison-Wesley, 1985.

U. S. Government Printing Office. A Nation At Risk. Washington, D. C.: U. S. Government Printing Office, 1983.

Woodrow Wilson National Fellowship Foundation. Focus on Statistics. Princeton, N. J.: Woodrow Wilson National Fellowship Foundation, 1984.

Worthen, B. R. and Sanders, J. R. Educational Evaluation: Alternative Approaches and Practical Guidelines. White Plains, NY: Longman Inc., 1987.

Weller, S. C. and Romney, A. K. Systematic Data Collection. Newbury Park, CA: Sage Publications, 1988.

Wiesner, M. B. W. "Concept Learning and the Learning of Strategies for Teaching Graphing, Probability, and Statistics Among Inservice Elementary and Secondary Mathematics Teachers." (Doctoral Dissertation, University of Houston, 1989.) Dissertation Abstracts International (1989): AAC8921592.

APPENDIXES

APPENDIX A

SURVEY TO STATE SUPERVISORS

September 5, 1990

Dear Mathematics Supervisor:

I am a fellow mathematics educator interested in certain aspects of your state's approach to implmentation of the NCTM's Curriculum and Evaluation Standards for School Mathematics. I am pursuing a doctorate in mathematics education at Oklahoma State University, and my dissertation is focusing on recommendations made in the Standards regarding statistics education in the secondary mathematics curriculum.

One part of my problem is to describe the current status of statistics education in the secondary mathematics classroom as it relates to the Standards. This is where I hope you will be able to help me. Accompanying this letter is a series of questions, the answers to which will help me formulate a picture of the current status of statistics education in the secondary schools in the U. S. Please complete the attached form, and return it to me in the enclosed self-addressed stamped envelope.

So that my summary is as comprehensive and complete as possible, please return the completed survey by the end of September. Thank you in advance for your assistance in gathering this information.

Sincerely,

Deborah Collum
Assistant Professor of Mathematics
Oklahoma Baptist University

Name____

Title____

Address____

____

_____________________________ Zip_______________

Please complete the following questions. Feel free to attach additional sheets, if necessary.

1. Does your state have mandated curriculum elements for statistics education at the secondary level?

   Yes________ No________

   Comments:

If you answered "No" to #1, please move to question 5. Otherwise, please continue.

2. Please attach a copy of your state's secondary statistics curriculum and a bibliography of the literature and research which influenced the structure of the curriculum which your state uses.

3. Identify the general process which your state is following (or plans to follow) in implementing the statistics education curriculum.

   a. As a separate course of study.
      Comments:

   b. Integrated into the existing mathematics curriculum.
      Comments:

   c. Other. Comments:

4. How consistently do you feel this implementation process is applied in the various districts throughout your state?

5. If your state does not have a mandated program in statistics education at the secondary level, please complete the following statements to the best of your knowledge.

   a. I would estimate that _____% of the secondary schools in my state do not consistently teach topics in statistics.

      Comments:

   b. Of the schools which do teach topics in statistics, I would estimate that

      _____% teach them in a course separate from traditional mathematics courses.

      _____% teach them as an integrated part of the existing mathematics curriculum.

      Comments:

6. For the following content areas, please indicate your impression as to whether they are generally included or not included in the mathematics curriculum of the schools in your state.

	Included	Not Included
Charts, tables, graphs of data	_________	_________
Measures of central tendency	_________	_________
Measures of variability	_________	_________
Statistical correlation	_________	_________
Designing and conducting a statistical experiment	_________	_________

7. For each of the following, identify the emphasis generally afforded them in the secondary classroom in your state. Use the following notation:

P (Primary emphasis)
M (Minor emphasis)
N (No emphasis)

_____Mean, Median, Mode

_____Standard Deviation

_____Variance

_____Histograms

_____Pie Graphs

_____Bar Graphs

_____Line Graphs

_____Box-and Whisker Plots

_____Central Limit Theorem

_____Standard Error of the Mean

_____Interval Estimate of the Mean

_____Hypothesis Tests About Means

_____Hypothesis Tests About Proportions

_____Analysis of Variance

_____Linear Regression

_____Linear Regression

_____Prediction

_____Other (List)

____

____

____

____

8. What changes, if any, do you foresee in the near future for statistics education in your state?

APPENDIX B

RESEARCH INTERVIEW

ATTITUDES TOWARD STATISTICS EDUCATION

AS THEY AFFECT THE SECONDARY MATHEMATICS CURRICULUM

<u>Part I:</u> Interview Questions

1. How did you become interested in including topics in statistics in the secondary mathematics curriculum? Personal interest, influenced by someone else?

2. Describe the statistics "program" at your school. What does it consist of? Is it integrated throughout the mathematics curriculum, treated via unit(s), as a separate course, other?

3. Identify the outstanding feature(s) of the statistics education program at your school. What factors do you think make it work well? Are there components that you would like to see change?

4. Who has been most responsible for implementing concepts of statistics into the mathematics program at your school? Yourself, department chair, colleagues, administrators, others?

5. How were topics of statistics implemented into the mathematics curriculum of your school? Through inservice training, summer institute(s) and/or workshop(s), graduate courses, other?

6. Was any type of education campaign used to generate support of members of the mathematics faculty, of administrators, of parents, of community leaders, of leaders of business or industry, others? If so, describe the efforts.

7. What stages of implementation, if any, remain to be implemented?

8. What obstacles, if any, have you encountered in implementing the desired changes?

9. What, if anything, would you do differently if you had the implementation process to do over again?

10. What advice would you give to teachers in other school districts who want to implement concepts of statistics into their school's secondary mathematics program?

Part II: DIRECTIONS: Background information.

1. How many years have you taught secondary mathematics?

2. What is the highest academic degree you have earned? (Please check one.)

   Bachelor's_____ Master's_____ Doctorate_____

3. Approximately how many college mathematics credit hours have you completed?

4. Approximately how many college statistics credit hours have you completed? (This may include Tests and Measurements.)

5. Approximately how many students are in your school?

6. Have you ever served as chair of your department? (Please check one.)

   Yes_____ No_____ Does not apply_____

7. Including yourself, how many teachers are in your department?

8. In your opinion, is your school making a conscious effort to implement the standards recommended by the National Council of Teachers of Mathematics in the Curriculum and Evaluation Standards for School Mathematics? (Please check one.)

   Yes_____ No_____ Not familiar with them_____

9. For each of the following related to topics in your mathematics department's curriculum, identify whether the topic is included or not.

	INCLUDED	NOT INCLUDED
Charts, tables, graphs of data	________	________
Measures of central tendency	________	________
Measures of variability	________	________
Statistical correlation	________	________
Sampling procedures	________	________
Designing/conducting an experiment	________	________

APPENDIX C

SURVEY TO OKLAHOMA SECONDARY

MATHEMATICS TEACHERS

Dear Secondary Mathematics Teacher:

The following survey represents an effort to identify and attitudes of secondary mathematics teachers toward statistics education as they affect the secondary mathematics curriculum. The data from this project will be used as part of my dissertation research through the Department of Curriculum and Instruction at Oklahoma State University. Your Expertise as a secondary mathematics teacher is greatly valued in this statewide study.

The attached survey instrument has been tested with a sample of secondary school mathematics teachers and has been revised in an attempt to obtain the necessary data with a minimum of your time. Please return the completed form in the inclosed self-addressed stamped envelope at your earliest convenience.

Thank you for your willingness to participate in this effort.

Sincerely yours,

Deborah Collum

ATTITUDES TOWARD STATISTICS EDUCATION AS THEY AFFECT THE SECONDARY MATHEMATICS CURRICULUM

Part I Directions: For each of the following statements, circle the response, A (Agree) or D (Disagree), which more closely corresponds to your belief. There are five basic statement formats related to six content areas. Word such as "support" may be interpreted in terms of financial or philosophical support as you, the teacher, wish.

1.	Constructing and drawing inferences from charts, tables, and graphs to summarize data from real-world situations will be included in my secondary mathematics classes next year.	A	D
2.	The principal in my school supports the movement to include the study of various sampling procedures for gathering data in the secondary mathematics curriculum.	A	D
3.	The placement of the topic designing a statistical experiment to study a problem, conducting the experiment, and interpreting the results in the text (e.g., first chapter, last chapter) influences my decision whether or not to include this as a topic of study in my secondary mathematics classes.	A	D
4.	The mathematics curriculum which I am required to teach is too overcommitted to permit me to include measures of central tendency (such as mean, median, mode) in the mathematics courses I teach.	A	D
5.	The mathematics curriculum of my school can be (has been) structured to include statistical correlation (such as Pearson's r) as a topic of study for all secondary students.	A	D
6.	My students will have an opportunity to design a statistical experiment to study a problem, to conduct the experiment, and to interpret the results before they graduate from high school.	A	D
7.	The principal in my school supports the movement to include measures of central tendency (such as mean, median, mode) in the secondary mathematics curriculum.	A	D

8. The placement of the topic <u>constructing and drawing inferences from charts, tables, and graphs to summarize data from real-world situations</u> in the text (e.g., first chapter, last chapter) influences my decision whether or not to include this as a topic of study in my secondary mathematics classes. A D

9. The mathematics curriculum which I am required to teach is too overcommitted to permit me to include the construction of <u>charts, tables, and graphs to summarize data from real-world situations</u> in the mathematics courses I teach. A D

10. The mathematics curriculum of my school can be (has been) structured to include the study of <u>measures of variability</u> (such as range, standard deviation, variance) as a topic of study for all secondary students. A D

11. My students will have an opportunity to gain understanding of various <u>sampling procedures for gathering data</u> through my secondary mathematics classes. A D

12. The principal in my school supports the movement to include <u>measures of variability</u> (such as range, standard deviation, variance) in the secondary mathematics curriculum. A D

13. The placement of the topic <u>measures of variability</u> (such as range, standard deviation, variance) in the text (e.g., first chapter, last chapter) influences my decision whether or not to include this as a topic of study in my secondary mathematics classes. A D

14. The mathematics curriculum which I am required to teach is too overcommitted to permit me to include <u>designing a statistical experiment to study a problem, conducting the experiment, and interpreting the results</u> in the mathematics courses I teach. A D

15. The mathematics curriculum of my school can be (has been) structured to allow all secondary students to <u>design a statistical experiment to study a problem, to conduct the experiment, and to interpret the results</u> as a part of their secondary mathematics education. A D

16. My students will have an opportunity to gain understanding of <u>measures of central tendency</u> (such as mean, median, mode) through my secondary mathematics classes. A D

17. The principal in my school supports the movement to have all students <u>design a statistical experiment to study a problem, to conduct the experiment, and to interpret the results</u> as a component of the secondary mathematics curriculum. A D

18. The placement of the topic <u>statistical correlation</u> (such as Pearson's r) in the text (e.g., first chapter, last chapter) influences my decision whether or not to include this as a topic of study in my secondary mathematics classes. A D

19. The mathematics curriculum which I am required to teach is too overcommitted to permit me to include the study of <u>statistical correlation</u> (such as Pearson's r) in the mathematics courses I teach. A D

20. The mathematics curriculum of my school can be (has been) structured to include <u>measures of central tendency</u> (such as mean, median, mode) as a topic of study for all secondary students. A D

21. My students will have an opportunity to gain understanding of <u>measures of variability</u> (such as range, standard deviation, variance) through my secondary mathematics classes. A D

22. The principal in my school supports the movement to include the study of <u>statistical correlation</u> (such as Pearson's r) in the secondary mathematics curriculum. A D

23. The placement of the topic <u>measures of central tendency</u> (such as mean, median, mode) in the text (e.g., first chapter, last chapter) influences my decision whether or not to include this as a topic of study in my secondary mathematics classes. A D

24. The mathematics curriculum which I am required to teach is too overcommitted to permit me to include the study of measures of variability (such as range, standard deviation, variance) as a topic of study in my mathematics classes. A D

25. The mathematics curriculum of my school can be (has been) structured to include the study of various sampling procedures for gathering data. A D

26. My students will have an opportunity to gain understanding of statistical correlation (such as Pearson's r) through my secondary mathematics classes. A D

27. The principal of my school supports the movement to include constructing and drawing inferences from charts, tables, and graphs to summarize data from real-world situations in the secondary mathematics curriculum. A D

28. The placement of the topic sampling procedures for gathering data in the text (e.g., first chapter, last chapter) influences my decision whether or not to include this as a topic of study in my secondary mathematics classes. A D

29. The mathematics curriculum which I am required to teach is too overcommitted to permit me to include sampling procedures for gathering data as a topic of study in my mathematics classes. A D

30. The mathematics curriculum of my school can be (has been) structured to include constructing and drawing inferences from charts, tables, and graphs to summarize data from real-world situations for all secondary students. A D

Part II: DIRECTIONS: Please complete the following information.

1. How many years have you taught secondary mathematics?

2. What is the highest academic degree you have earned? (Please check one.)

   Bachelor's_____ Master's_____ Doctorate_____

3. Approximately how many college mathematics credit hours have you completed?

4. Approximately how many statistics credit hours have you completed? (This may include Tests and Measurements.)

5. Approximately how many students are in your school?

6. Have you ever served as chair of your department? (Please check one.)

   Yes_____ No_____ Does not apply_____

7. Including yourself, how many teachers are in your department?

8. In your opinion, is your school making a conscious effort to implement the standards recommended by the National Council of Teachers of Mathematics in the Curriculum and Evaluation Standards for School Mathematics? (Please check one.)

   Yes_____ No_____ Not familiar with them_____

9. For each of the following related to topics in your mathematics department's curriculum, identify whether the topic is included or not.

	INCLUDED	NOT INCLUDED
Charts, tables, graphs of data	________	________
Measures of central tendency	________	________
Measures of variability	________	________
Statistical correlation	________	________
Sampling procedures	________	________
Designing/conducting an experiment	________	________

APPENDIX D

TEACHER PROFILE

TEACHER PROFILE

Content Topics

Teacher Conceptions	CTG	Cen. Ten.	Var.	Corr.	Samp.	Exp.	
Statistics Topics Included in Mathematics Curriculum	1A	16A	21A	26A	11A	6A	0 1 2 3 4 5 6
Principal Support for Including Statistics Topics in Mathematics Curriculum	27A	7A	12A	22A	2A	17A	0 1 2 3 4 5 6
Including Statistics Topics as a Function of the Text	8D	23D	13D	18D	28D	3D	0 1 2 3 4 5 6
Mathematics Cruuiculum Too Overcommitted to Include Statistics Topics	9D	4D	24D	19D	29D	14D	0 1 2 3 4 5 6
Mathematics Curriculum as Capable of Being Structured to Include Statistics Topics	30A	20A	10A	5A	25A	15A	0 1 2 3 4 5 6
	0	0	0	0	0	0	
	1	1	1	1	1	1	
	2	2	2	2	2	2	
	3	3	3	3	3	3	
	4	4	4	4	4	4	
	5	5	5	5	5	5	

2

VITA

Deborah Hopkins Collum

Candidate for the Degree of

Doctor of Education

Thesis: A STUDY OF SELECTED ATTITUDINAL FACTORS OF SECONDARY MATHEMATICS TEACHERS TOWARD CURRICULUM CHANGE AND IMPLEMENTATION IN STATISTICS EDUCATION

Major Field: Curriculum and Instruction

Biographical:

Personal Data: Born in Shawnee, Oklahoma, June 15, 1951, the daughter of Hubert W. and E. Mable Hopkins.

Education: Graduated from Shawnee High School, Shawnee, Oklahoma, in May 1969; received Bachelor of Science Degree in Mathematics from Oklahoma Baptist University at Shawnee, Oklahoma in May, 1972; received Master of Science Degree in Mathematics from University of Tulsa at Tulsa, Oklahoma in June, 1975; completed requirements for the Doctor of Education Degree from Oklahoma State University at Stillwater, Oklahoma in July 1991.

Professional Experience: Junior High School Mathematics Teacher, Sapulpa Junior High School, Sapulpa, Oklahoma, 1972-73; Graduate Assistant, Mathematics Department, University of Tulsa, Tulsa, Oklahoma, 1973-75; Middle School Mathematics Teacher and Department Chair, Jenks Middle School, Jenks, Oklahoma, 1975-80; Junior High School Mathematics Teacher, Shawnee Junior High School, Shawnee, Oklahoma, January, 1980 to August, 1980; Instructor in Mathematics, Oklahoma Baptist University, Shawnee, Oklahoma, August, 1980 to August 1983; Assistant Professor of Mathematics, Oklahoma Baptist University, Shawnee, Oklahoma, August 1983 to Present; Graduate Assistant in Curriculum and Instruction, Oklahoma State University, Stillwater, Oklahoma, August, 1990 to August, 1991.