COMPARISON OF UNIVERSITY RESEARCHERS' AND STATISTICAL CONSULTANTS' DIAGNOSES AND APPLICATIONS ON RESEARCH PROBLEMS

by

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DISSERTATION

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DEDICATION

To the memories of my father, mother, and big brother: Osman, Saliha, and Enver Ozkan whom I miss at every moment of my life. Their dignity and values continue to inspire the best in me.

To my wife, Zuleyha, my daughter, Elif, and my sons, Samil and Burak, whose existence are the light of my life and a joy to behold.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1

INTRODUCTION

Background of the Study

There has been a growing belief in the statistical community that significant changes must be realized in the methodology of statistics education. Statistics education traditionally focused on developing knowledge and mastery, assuming students would naturally create comprehensive insight and understanding of the subject during the educational process. Apparently, however, this approach has not been successful. The fact that learning from the experiences by using statistical thinking combined with the learning from psychology and behavioral sciences in real life situations has brought about the search of new curricular goals and methodological reforms.

According to Federer (1978), "the gap between the statistics instructor's world and the real world of the experimenter has got larger and larger. An overemphasis on significance testing, hypothesis testing, and decision rules has led to a de-emphasis of statistical design" (p. 117). Hogg (1991) argued that improvements are badly needed in statistical education because there is a general feeling that students are not as well prepared for college-level science and mathematics courses as they were 20 to 30 years ago.

After emphasizing the importance of involving students more into to designing projects, setting goals beginning with the introductory statistics courses, and the role of instructors' attitude and capacity to prevent statistics being one of the most hated courses, Hogg (1991) pointed out that statistics should not be presented as a branch of mathematics at the beginning level because good statistics is not equated with mathematical purity but is more closely associated with careful and critical thinking. This, of course, would require a change in the graduate programs in statistics.

Federer (1978) discussed the need for tailoring the teaching methodology of statistics to fit in a changing world by developing the statistical materials to meet current needs rather than an overemphasis on significance and hypothesis testing. He noted that the works of the early famous statisticians such as Fisher, Neyman, Pearson, Wald, Jeffreys, and others since the early 1930s has had a pronounced effect on the role of significance testing, hypothesis testing, and decision making in statistical research methods and statistical education.

As a result, some courses and some books are devoted almost entirely to significance and/or hypothesis testing. "Some editors and major professors accepted only results that were significant at the five-percent level… Many statisticians and teachers of statistics *assume*, but do not *verify*, that they have a random sample from some prescribed population" (p. 117- 118).

Marquardt (1987) stated that the statistics was the generic field of technology, among all the disciplines that use the scientific method. From this perspective, all other fields were special cases for specific subject matter, and the shared concept was the scientific method. Once this generic field of technology role is accepted, the statistics education should begin with the general public throughout their educational experience in grades K-12 would learn a variety of statistical concepts and tools and would emerge from their school years fully able to use effectively many simple statistical tools, especially graphics tool, in daily life.

Statistical Consulting

Statistical consulting has been one of the very important units in research environments such as government, industry, and universities to support their research activities. It's been also an integral part of the responsibilities of many statisticians working as faculty at universities and colleges. The statistical consulting services in research environments, especially in research universities, have been provided under different structures (Gibbons and Freund, 1980):

1. Subject matter department expert(s)
2. Assigned responsibility (voluntary statistical consulting)
3. Providing consulting through computing services
4. Statistical consulting center. (pp.141-144)

Statistical consulting has become a very important area of discussion among applied statisticians during the last 40 years (Sahai & Khurshid, 1999). It's now widely agreed upon that the traditional applied statistics training alone is not enough to prepare the student to develop skills and background in dealing with the real world problems to assume the role of a consulting statistician. Several authors have provided some implemented project analyses and recommendations for the integration of teaching of statistical consulting and the training for consulting in an applied statistics program (Hunter, 1981; Kimball, 1957; McCullogh, 1985; Marquardt, 1987; Zahn & Isenberg, 1983).

Schield (2007), making "an evangelical calling for statistical educators", noted that students in majors that do not require a mathematics or statistics course are often unbelievers in the value and power of statistics:

> if statistical instructors were to meet the quantitative needs of these students, they must be evangelists to non-believers rather than being ministers to believers; they must focus on statistical literacy rather than on statistical competence. They must be called to help students see the value of statistics in everyday situations; They must measure teaching effectiveness based more on improvements in students' attitudes toward statistics than in students' knowledge of statistics. (p. 1)

This study is based on the background that emerged from the following area of discussions:

1. The issues and challenges with the statistics education
2. The importance and functions of statistical consulting as it has become a significant part of research institutions and university programs
3. An increasing need for developing statistical literacy throughout the pre-college education so that the more efficient instructional methodology could be implemented on higher statistical education.

In summary, the lack of pre-college statistical literacy as well as methodological issues with the college and graduate level statistics courses are the main difficulties that researchers have been experiencing in their real-life research activities and has been leading to misunderstanding of the problem as well as misuse of the statistical tools.

The Purpose of the Study

The purpose of this study is to determine the most frequent problems that the researchers have been experiencing during their research activities in order to develop strategies for practically more efficient statistical education methodology; This will be accomplished by analyzing research consulting records of The Research Consulting Service of Wayne State University over an 18-year period by comparing the researchers' and the statistical consultants' perspectives and applications on research problems through a list of statistical items by obtaining KAPPA coefficients for a measure of agreement and McNemar's test for differences as well as testing the observed proportions of the checklist items against hypothesized proportions of 50% and 20% by employing Binomial tests.

Significance of the Study

A review of the literature suggests that improvements on the pre-college statistical literacy and inclusion of statistical consulting education in the statistical education system would significantly contribute to the effectiveness of college and higher-level statistics education, and accordingly to the researchers on their research activities. This study aims to determine the most frequent problems that the researchers have been experiencing on their research design, sampling, measurement, data management, data analysis, and reporting as well as the statistical tools the most frequently they needed a statistical consultant's help. The findings of this study will bring about some evidence for the type of most common methodological problems with the actual research activities that have been done. Based on this evidence, suggestions will be made regarding on what specific methods, tools, and topics should be more emphasized and improved in statistics education.

Assumptions

This study is based on the following three assumptions:

1. After controlling the time effect (inclusion of a time variable with three 5-year period) and position effect (inclusion of the position variable with five levels), all the client records reflect a homogeneous statistical background because they belong to the same university community
2. The consulting records are made on actual research and analysis (not hypothetical data).
3. All the consulting records were closed (finished cases).

Limitations of the Study

The main limitations of this study as follows:

1. The consulting records are limited to a specific university.
2. The consulting records are not uniform over the 18-year period.
3. The consulting records are limited to academic and clinical research.

CHAPTER 2

REVIEW OF THE LITERATURE

The focus of this research is related to the ongoing topic of discussion in terms of developing a higher level of statistical literacy as a result of general statistics education – including pre-college education – and the increasing functionality of statistical consultancy in real life practice of statistics as a scientific discipline. The review of the related literature will be divided into two sections:

1. Issues and challenges in statistics education
2. Statistical consulting and training in research environments

Statistics Education: Issues and Challenges

Statistics is now becoming a regularly used tool in all areas of modern life; Statistics and statisticians have an increasing important role from research to production in both private and government sectors. In his article discussing the perceived lack of visibility and influence of statistics as a generic field of technology, Marquardt (1987) defined statistics as:

> Mankind has been doing applied statistics for thousands of years. When faced with a problem—almost any problem—people can be observed deciding what data are needed and are practical to collect; then obtaining the data, analyzing the data, developing a conceptual frame-work that is consistent with the data (a predictive model, if you will); and then choosing a course of action based—at least in part—upon the data. Statistics has been a recognizable discipline for several centuries. That is, there has been some generalized theoretical basis and some form of documentation. In fact, the discipline of statistics is older than many of the other major disciplines we know today. (p. 1)

Public awareness of a discipline follows academic recognition very closely. Although there is a tremendous market for statistics in industrial, business, government, or research organizations, Minton (1983) stated "the job market for statistics is not the same as the job market for statisticians" (p. 285).

In general, statistics is a science of collecting, analyzing — using statistical tools — and interpreting the numerical facts of everyday life events as well as scientific inquiry such as weather condition estimates, sports statistics, political polls, economic indicators, etc.

Issues and Challenges in Statistics Education

Curricular Issues

An emphasis on need for changing the nature of statistical education has begun since 1979 through activities of the American Statistical Association (ASA) Section of Statistical Education by forming the Committee on Preparing Statisticians for Careers in Industry and expanded the efforts through the 1980s and into 1990s. Although this growing trend was necessary and much needed but progress was too slow. What is missing for speeding up the process of improving statistical education was the students, whose enrollments had been declining because math, science, and statistics were not popular subjects. A call for help from behavioral science has been emerged to create value for statistical thinking and a necessity for changing the content and delivery of statistical education (Snee, 1993). Increased computational power via existing sophisticated software, powerful personal computers, information and automated data collection available through internet allow the educators to develop and implement methods that were only dreamed of a few years ago (Hahn, 1989). The challenge for academia is to decide which of the many new things that could be covered in the statistical education curriculum, should be included so that a change from the current paradigm to a new paradigm as such the statistics education could be successfully incorporated into the other disciplines can take place (Bryce, 2005).

Gal and Garfield (1997, p. 2-5) provided a broad vision of currently accepted learning goals for students in statistics courses, which include:

1. Understanding the purpose of logic of statistical investigations: Students should understand the big ideas behind the statistical investigations that are conducted.
2. Understanding the process of statistical investigations: Recognizing how, when, and why existing statistical tools can be used to help an investigative process.
3. Mastering procedural skills: Need to master the component skills that may be used in the process of a statistical investigation.
4. Understanding mathematical relationships: Being able to connect the main mathematical ideas that underlie statistical procedures and concepts.
5. Understanding probability and chance: Gaining understanding of key ideas from experiences with chance behavior starting with devices (e.g., coins and dice) and progressing to computer simulated applications.
6. Developing interpretative skills and statistical literacy: Being able to make sense of results from analyses and surveys posing critical and reflective questions such as measurement, reliability, representativeness of samples, etc.

7. Developing ability to communicate statistically: Strong writing and speaking skills with respect to statistical and probabilistic terminology to effectively communicate about statistical investigations.
8. Developing useful statistical dispositions: Developing an appreciation for the role of chance and randomness in the world and for statistical methods in the face of uncertainty regarding real life events; Learning to adopt a questioning stance.

Gal & Garfield (1997) also noted:

> Educators are further challenged by the need to make sure that students understand the real-world problems that motivate statistical work and investigations, and by the need to help students become familiar with the many nuances, considerations, and decisions involved in generating, describing, analyzing, and interpreting data and in reporting findings. (p. 5)

According to Burril (2005) "given that statistics is often taught as part of the mathematics curriculum, one of the issues a curriculum development framework must address is the difference between mathematics and statistics" (p. 59). Mathematics is about reasoning, patterns, proof and abstractions. Statistics is also about numbers; However, understanding, measuring, and describing real world processes are integrated with application. The real value of statistical methodology lies in its ability in solving a problem of interest, not in any property that can be proved (Burrill, 2005).

It was suggested that college level core courses include at least five courses in statistics, covering data production, applied modeling, and statistical theory. The methodology for teaching those areas should emphasize real data and real life applications, and include exercises with statistical computing for data analysis and modern computer intensive methods like the bootstrap using one or more software packages used by professional statisticians, and encourage synthesis of theory, methods, and applications, with emphasis on statistical reasoning and problem solving, and also provide opportunities to develop communication skills with group work, class projects, presentations, and writing assignments based on statistical analysis (Tarpey, Acuna, Cobb, & Veoux, 2002).

Statistical Consulting and Training in Research Environments

Statistical consulting is one of the most important applications of the method of statistics. It is a way to improve research by contributing to the quality of the statistical aspects of research: design, analysis, and the interpretation of results. A large number papers in the statistical literature and many sessions on statistical consulting held by the major statistical societies may be the indicators of the importance of statistical consulting (Sahai & Khurshid, 1999).

Emphasizing the importance of methodology to the sciences — particularly the applied sciences — Gibbons and Freund (1980) reported the following observation:

> We noted that 28 of the 30 papers in the March/April 1978 issue of the *Agronomy Journal* used formal statistical methodology...The statistical methodology used in these 28 papers was often poorly documented or incomplete and occasionally inappropriate. 32 of 62 reports appearing in the *British Medical Journal* from January to March 1976 contained errors in the use of statistics. (p. 140)

Kimball (1957) pointed out the necessity for statistical consulting education fifty years ago by introducing a new kind of statistical error: "error of the third kind", in addition to the first and second kind of errors that are very well-known by any introductory level statistics student. His definition of this kind of error was, in simple terms:

> The error committed by giving the right answer to the wrong problem...There is no way of knowing how many of us, particularly in our early years as consultants, were guilty of errors of the third kind...Many of us, in good faith, have helped research workers make *t*-tests, or computed analyses of variance, or design experiments thinking we were giving the right answer to the right problem; and usually we do give the right answer to the question that is asked. Unfortunately it often happens that the question asked has little bearing on the real problem, and we are led into committing the third kind of error. (pp. 134-135)

Because graduate students in their statistical education are given very little — if any — preparation for actual consulting, they are unguarded to commit errors of the third kind, many of which could be avoided if they were properly trained .

Cox (1968) criticized the methodology of training of statistical consultants that was mainly based on empirical case studies in his time, alternatively recommending to consider the development of specific, systematized, course-wise training for the consultants. Encouraged by Cox (1968), Florida State University's Statistics and Biometrics departments added a "Principles and Practices of Statistical Consulting" course to their curriculum in the early 1970s to include training in statistical consulting in their graduate program; They have gradually added more components from various disciplines to the consulting course to help students bridge the gap between academia and statistical practice. McCulloch, Boroto, Meeter, Polland , and Zahn (1985) argued that the need for a fully systematic teaching program for statistical consulting rather than adding a course to the curriculum seemed eminent after observing the consulting students had deficiencies in both the statistical and non-statistical aspects of consulting.

In addition to the most common roles that statistical consultants are expected to have such as helper, leader, data - blesser, collaborator, and teacher, the graduate programs in statistics gave little attention to the human side of consulting as described by Kirk (1991):

1. Negotiating for a desired consulting role
2. Influencing the direction of a consultation
3. Consulting on a wide range of research problems
4. Working with clients having varied statistical backgrounds
5. Cleaning up the mess
6. Surviving in academe. (pp. 30-33)

Kenett and Thyregod (2006) demonstrated, through original examples, different aspects of the full statistical consulting cycle as problem elicitation, data collection, formulation of findings, and presentation of findings, which indicated that effective statistical consulting is not just properly implementing statistical methods; It is a collaborative venture whose success depends on the effectiveness of the communication between the statistical consultant and the client.

Jeske, Lesch, and Deng (2007) reported that the department of statistics at the university of California at Riverside formally established a Statistical Consulting Collaboratory in the Fall of 2003 to contribute effectively to the academic objectives of the Statistics Department. The establishment is uniquely directed to do this contribution through the development and application of statistical methods to real world problems. It was observed that the project not only functioned to solve client problems, but also significantly enhanced the ability to teach students statistical consulting skills.

Statistical Literacy

Schield (2005) defined the statistical literacy as "the ability to read and interpret data, and the ability to use statistics as evidence in arguments" (p. 1). He further defined three kinds of statistical literacy such as chance-based, fallacy-based, and correlation-based based on the perspectives with respect to the needs of employees, consumers, and citizens (Schield, 2001). The development of statistical literacy skills has been recognized as one of the instructional goals of statistics education at various levels. Rumsey (2002) included statistical literacy in the instructional goals besides developing research scientist skills, competence or understanding of the basic ideas, terms, and language of statistics, and finally, chain of statistical information.

Many papers published and presented on the statistical literacy reveals that the phrase statistical literacy is not consistently or uniquely defined. It is clear that while all of these definitions apply to the goals, the use of the phrase "statistical literacy" is too broad. In different studies quantitative literacy, or statistical competence, or statistical citizenship are also used to define the same concept (Jordan & Haines, 2006).

CHAPTER 3

METHODOLOGY

The purpose of this study was to determine the most frequent problems that the researchers have been experiencing during their research activities in order to develop strategies for practically more efficient statistical education methodology; It was accomplished by analyzing research consulting records of The Research Consulting Service of Wayne State University over an 18-year period by comparing the researchers' and the statistical consultants' perspectives and applications on research problems through a list of statistical items by obtaining KAPPA coefficients for a measure of agreement and McNemar's test for differences as well as testing the observed proportions of the checklist items against hypothesized proportions of 50% and 20% by employing Binomial tests.

This chapter contains the methods that were implemented to collect and analyze the data needed to test the statistical hypotheses that have been developed for this study. The topics addressed in this section are: participants, research design, instrumentation, evaluation of the instrument's reliability and validity, sampling plan, data collection, data analysis techniques, and probable limitations of this study.

Study Site

The Research Consulting, formerly known as *The Research Support Laboratory*, was established in 1990 under the coordination of Dr. Elaine Hockman, and sponsored by the Planning and Support Services of the Computing and Information Technology, a division of

Wayne State University to assist the Wayne State research community in any phase of their research. The services provided by the Research Consulting have been:

1. Consultation to the Wayne State University research community in matters concerning the conduct of their research. Areas of consultation have included design, implementation, analysis, and reporting of research. Although statistical analysis has comprised the majority of the consulting activity, emphasis has been placed on the use of computing technology in any phase of the research.
2. A second responsibility of the Research Consulting has been to provide training in the use of computing technology as it relates to research functions.
3. A third responsibility of the Research Consulting has been to provide a well-equipped facility in which the university researchers –whether faculty, staff or students—can complete the computing tasks necessary for their research.
4. A fourth responsibility of the Research Consulting has been to provide its facilities for research-related classes taught by members of the Wayne State University community.

Participants

The targeted population of this study was about 1,468 consulting records of the graduate students (doctorate and master's level), faculty, and staff of Wayne State University who have acquired help from a research consultant at Research Consulting Services regarding research design, statistical data analysis using the necessary software, and interpreting and reporting the results since 1990 to present as related to:

1. Master's theses
2. Dissertations
3. Clinical experiments
4. Grant proposals
5. Paper publications
6. Corrections based on journal reviewers' suggestions
7. Satisfaction surveys.

The records generally included the information regarding the client's name, department, status or position at Wayne State, date, the medium of consultation, i.e., via phone, e-mail, or in person, consultation topic, and result. However, the clients' names, positions, and departments were not used in any stage of this analysis.

Instrument

Three kinds of documentation comprised the instrument:

1. The consulting reports kept by the various consultants during the early years of Research Support Laboratory,
2. The personal records of consultants related to their clients such as notes, personal clients' folders, archived consulting messages via e-mail,
3. "The Research Consulting Information Form" (Appendix A.)

The following items were determined as main research consulting issues through all three kinds of consulting records mentioned above:

1. Appropriate setup of design of experiment
2. Identification of variables
3. Scale of measurement
4. Design of instrument or survey
5. Instrument reliability of proper type (i.e., internal consistency, test-retest)
6. Instrument validity of proper type (i.e., content, predictive, construct)
7. Appropriate formation of research question
8. Statistical hypothesis based on research question
9. Sampling strategy, power, and sample size determination
10. Appropriate setup of data for the statistical software intended to be used
11. Data manipulation (computing, recoding, conditional selection, etc.)
12. Usage of statistical software for the proposed analysis
13. Handling missing values
14. Selection of statistical techniques with respect to research questions
15. Issues regarding Type I and Type II errors
16. Issues regarding experiment-wise error rate
17. Handling violation of underlying assumption(s)
18. Implementation of the proposed statistical analysis
19. Implementation of nonparametric statistics when appropriate
20. Interpretation of analysis results

21. Reporting Findings – Words
22. Reporting Findings – Tables
23. Reporting Findings – Charts/Graphs

Data Collection

The twenty-three items of the consulting check-list from each client record were coded as "0" for "Not Applicable" and "1" for "Applicable. There were twenty-three dichotomous variables in addition to the variables that were consist of the row-wise sum scores that have reflected the total number of applicable items per client record.

Potential Sources of Errors

Two main sources of error may be confounded in the analyses based on the following factors:

1. Time: The clients' records that were kept over a long time period – longer than 18 years– may be confounded by many changing factors such as a methodology shift in statistics education, changing research methods, changing requirements in various kinds of research, changing conditions that facilitate new research, changing research technology and literacy such as drastically improving personal-computer technology, introduction of many specialized and professional statistical software, the inclusion of recent statistical analyses by the most popular programs that were not available in their previous versions,

changing awareness and increasing avoidance against the methodological flaws by academic advisors and journal editors, etc.

2. Background or status of client: The fact that graduate students, staff, and faculty had different level of statistical and research methodology knowledge.

Controlling Potential Sources of Error

A time period variable with two levels of approximately 10-year periods and a client's status variable with five levels of positions such as faculty, staff, doctoral student, master's student, and researcher were included in the statistical analyses to test their effects on the outcome variables.

Sampling Strategy and Sampling

A stratified sampling strategy was implemented based on the proportionality of two 10-year periods and the clients' positions to a total population of about 1,468 consulting records. The resulting sample size was 718 consulting records.

Scales of Measurement and Input Data Format

The data were entered as polytomous and dichotomous nominal variables and interval variables based on the total scores for the sub-scales as illustrated in Table1.

Research Questions

1. Do the instrument items significantly and meaningfully determines the factors such as design and sampling, measurement, data management, statistical analysis, and reporting?
2. Is probability of need for a consulting on each check-list item significantly greater than 50 % for researchers?
3. Is probability of need for a consulting on each check-list item significantly greater than 20 % for researchers?
4. Do clients' and consultants' diagnoses on the research problems, i.e., through the twenty-three consulting items, significantly differ?

The research hypotheses, statistical hypotheses, variables, and statistical analysis pertaining to these four research questions are depicted in Table 2.

Table 1: Projected Sub-Scale Groupings for the Consulting Check-List Items

Sub-Scales				
Design and Sampling	Measurement	Data Management	Statistical Analysis	Reporting
Design of experiment	Variable identification	Data setup	Choice of statistical techniques	Interpretation
Design of Instrument	Scale of measurement	Software usage	Implementation of statistics	Reporting- Words
Research problem	Reliability	Data manipulation	Type I and II errors	Reporting- Tables
Statistical hypothesis	Validity		Experiment-wise error rate	Reporting- Charts/Graphs
Sample size and power			Missing values	
			Underlying assumptions	
			Nonparametric statistics	

Table 2: The Research Hypotheses and Corresponding Statistics

Research Hypotheses	Statistical Hypotheses	Variables	Statistics
H_1 : The Confirmatory factor model Illustrated in Figure1 1 fits to the sampled data.	CFI, TLI, and RMSEA Fit indices >.90	Indicators: Item1 through Item23 (Nominal scale) Factors (Latent variables): 1. Design and Sampling 2. Measurement 3. Data management 4. Statistical Analysis 5. Reporting	Confirmatory factor analysis based on the diagram illustrated in Figure 1.
H_{2_i}: The probabilities of need for consulting help on each consulting check-list items significantly greater than %50 for researchers.	H_{2i}: $\pi_i > \pi_0$ where π_0=.50 and $i = 1, 2, \ldots, 23$	Item1 through Item23 (Nominal scale)	Binomial Test based on Z distribution
H_{3_i}: The probabilities of need for consulting help on each consulting check-list items significantly greater than %20 for researchers.	H_{3i}: $\pi_i > \pi_0$ Where π_0=.20 and $i = 1, 2, \ldots, 23$	Item1 through Item23 (Nominal scale)	Binomial Test based on Z distribution
H_{4_i}: The clients' and consultants' diagnoses on the research problems, i.e., through the twenty-three consulting items, significantly different from each other.	H_{4i}: $\pi_{CLI} \neq \pi_{CON}$ Where π_{CLI} and π_{CON} are the proportion the clients' and consultants' responses in different categories $i = 1, 2, \ldots, 23$	Item1 through Item23 (Nominal scale)	Kappa Coefficient & McNemar's test based on Z distribution

Underlying Assumptions

Estimation procedures in structural equation modeling assume multivariate normality. This also implies univariate normality and linearity and homoscedasticity on all combination of relationships (Kline, 1998.)

The binomial test assumes binomial distribution, which is one of the best known of the various discrete distributions (Wonnacott, 1977). The standard normal distribution, or z-distribution, is mostly used as a proxy to the binomial distribution (Conover, 1980.) The binomial test assumes the variables are dichotomous with levels that are mutually exclusive and exhaustive for all cases. McNemar's test is non-parametric which does not require assumptions about the shape of the underlying distribution. The test statistic, which is the signed square root of McNemar's chi-square statistic, is approximately normal for large samples (Agresti, 2002). Random sampling is assumed.

Nominal Alpha

The nominal alpha level was set to $\alpha=.05$ level for testing the hypotheses given in Table 2.

Statistical Power

For the Confirmatory Factor Analysis (CFA), the proposed sample size met the recommended ratio of at least 10-20:1 between the number of subjects and the number of parameters (Kline, 1998, p. 210-211). This was based on the fact that the model has had fifty-six free parameters to have fair to high power.

Table 3 and Table 4 give the estimates of power levels under alternative hypothesized proportions and proportion differences with respect to Binomial and McNemar's tests, respectively. The power projections given in Table 3 and Table 4 were obtained by using PASS 2001, Power and Sample Size Software (NCSS).

Table 3: Power Analysis Results for Binomial Test (2-sided, α=.05)

Power	N	P_0	P_1	$P_1 - P_0$
0.2371	50	0.5	0.6	0.1
0.4621	100	0.5	0.6	0.1
0.7868	200	0.5	0.6	0.1
0.9291	300	0.5	0.6	0.1
0.9937	500	0.5	0.6	0.1
0.9999	800	0.5	0.6	0.1
0.7822	50	0.5	0.7	0.2
0.9790	100	0.5	0.7	0.2
0.9999	200	0.5	0.7	0.2
1.0000	300	0.5	0.7	0.2
1.0000	500	0.5	0.7	0.2
1.0000	800	0.5	0.7	0.2
0.9937	50	0.5	0.8	0.3
1.0000	100	0.5	0.8	0.3
1.0000	200	0.5	0.8	0.3
1.0000	300	0.5	0.8	0.3
1.0000	500	0.5	0.8	0.3
1.0000	800	0.5	0.8	0.3

Table 4: Power Analysis Results for McNemar's Test (2-sided, α=.05)

Power	**N**	**P_{10}**	**P_{01}**	**Difference (P_{10}-P_{01})**	**Proportion Discordant**
0.97360	300	0.15	0.05	0.1	0.2
0.99497	400	0.15	0.05	0.1	0.2
0.99915	500	0.15	0.05	0.1	0.2
0.99987	600	0.15	0.05	0.1	0.2
0.99998	700	0.15	0.05	0.1	0.2
1.00000	800	0.15	0.05	0.1	0.2
0.87357	300	0.2	0.1	0.1	0.3
0.95132	400	0.2	0.1	0.1	0.3
0.98261	500	0.2	0.1	0.1	0.3
0.99404	600	0.2	0.1	0.1	0.3
0.99805	700	0.2	0.1	0.1	0.3
0.99938	800	0.2	0.1	0.1	0.3
0.76056	300	0.25	0.15	0.1	0.4
0.87510	400	0.25	0.15	0.1	0.4
0.93804	500	0.25	0.15	0.1	0.4
0.97028	600	0.25	0.15	0.1	0.4
0.98628	700	0.25	0.15	0.1	0.4
0.99381	800	0.25	0.15	0.1	0.4
0.66299	300	0.3	0.2	0.1	0.5
0.79220	400	0.3	0.2	0.1	0.5
0.87676	500	0.3	0.2	0.1	0.5
0.92900	600	0.3	0.2	0.1	0.5
0.96017	700	0.3	0.2	0.1	0.5

Data Analysis

The frequency distributions of consulting check-list items in form of counts and percentages and their corresponding descriptive statistics were reported as general tables. The same tables were also reported as the two periods, 1990-2000 and 2001-2008, and by clients' positions.

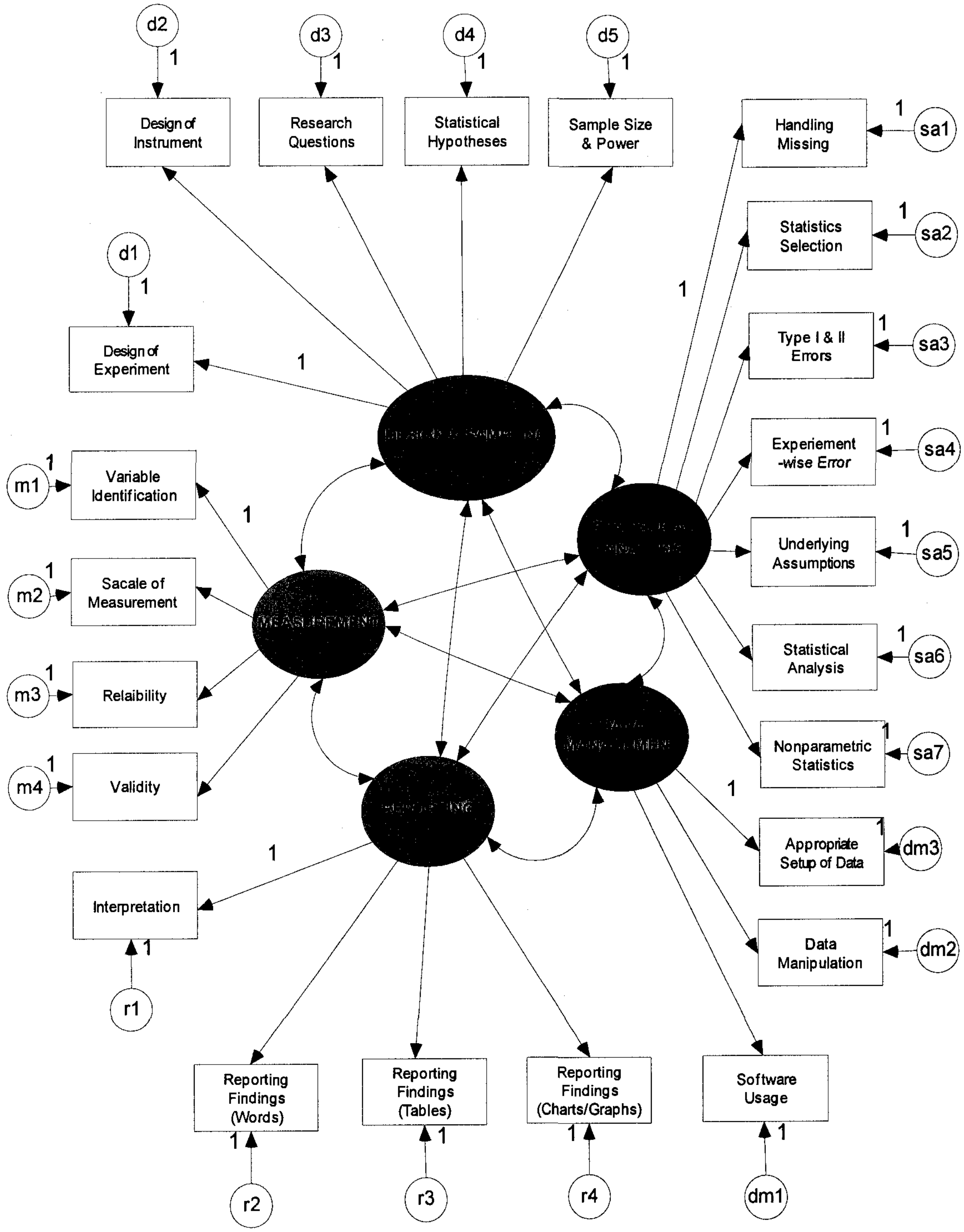
The confirmatory factor analysis as modeled in Figure 1 was tested in terms of goodness-of-fit based on five factors and their twenty-three indicator variables. To handle potential complications regarding the multivariate normality assumptions with the dichotomous data, the mean and variance-adjusted weighted least-squares method (WLSMV) rather than maximum likelihood method (ML) was implemented based on a tetrachoric correlation matrix as suggested by Bollen (1989) and Muthén (1984) using the WLSM method available in MPLUS software (Version 5) as illustrated by Muthén & Muthén (1998) for the categorical outcomes.

The Binomial Test procedure compares the observed frequencies of the two categories of a dichotomous variable to the frequencies that are expected under a binomial distribution with a specified probability parameter. First, the probability parameter for both groups (coded as 0 and 1) was set to 0.50. The next step was changing the probability setting as a test proportion for the first group (coded as 1) was set to 0.20. The probability for the second group was 1 minus 0.20 resulting 0.80.

The Kappa coefficient, a measure of agreement between two observers taking into account agreement that could occur by chance (Landis & Koch, 1977) and McNemar's test was employed to measure the similarities and differences between the clients' and consultants' checked items.

The analyses were conducted using SPSS (Version 16.0) software and the results were reported in tables, diagrams, and charts.

Figure 1: The Confirmatory Factor Analysis Model



CHAPTER 4

RESULTS

Sampling Method of the Consulting Records

Based on the sample size determination in order to have at least 90% power under alternative hypothesized proportions and proportion differences with respect to Binomial and McNemar's tests, a total of 718 records out of 1,468 was selected implementing a systematically simple random method, i.e., selecting the first consulting-related record at every third page of the consulting log book so that an approximately 40% of the records could be selected for the first two terms, 1990-2000 and 2001-2007, over the period of 1990 through 2008. All of the consulting records which belonged to the first 4 months of 2008 were included in the sample because they were kept in the most detailed way in terms of the consulting items as illustrated in *The Research Consulting Information Form* in Appendix A. The sampling method of the records is shown in Table 5.

Table 5: The Sampling Method of the Consulting Records Over 1990-2008

PERIODS	Total Number of Records (N)	% Selected	Sample (n)
1990 - 2000	600	40	240
2001 - 2007	650	40	260
2008	218	100	218
Total	1468		718

Table 6: The Frequency and Percentage of Clients by Their Colleges at WSU Over the Periods

Colleges	1990 - 2000		2001 - 2008	
	Count	%	Count	%
College of Education	66	30.4	273	57.7
College of Engineering	1	.5	28	5.9
Medical School	45	20.7	60	12.7
College of Nursing	17	7.8	17	3.6
Liberal Arts & Sciences	23	10.6	45	9.5
Fine, Performing & Communication Arts	1	.5	14	3.0
Science	7	3.2	.	.
Pharmacy	8	3.7	8	1.7
Business Administration	17	7.8	12	2.5
WSU Institutions & Divisions	32	14.7	10	2.1
Other	.	.	6	1.3
Total	217	100.0	473	100.0

As it is shown in Table 6, The College of Education researchers used the Research Consulting Services the most frequently over the both periods: Their usage percentage increased in 2001-2008 period (n=273, 57,7%) compared to the 1990-2000 period (n=66, 30.4%). The Medical School researchers were the second most frequent users of this service, (n=45, 20.7%) over 1990-2000 and (n=60, 12.7%) over 2001-2008, showing a decline over the second period. The Liberal Arts & Sciences departments' researchers used this service about the same level in both periods: (n=23, 10.6%) and (n=45, 9.5%), respectively. This service was also used by the other departments over the periods in the following frequency and percentage levels: the university institutions and divisions (n=32, 14.7%) and (n=10, 2.1%), the College of Nursing (n=17, 7.8%) and (n=17, 3.6%), the Business Administration (n=17, 7.8%) and (n=12, 2.5%), College of Engineering (n=1, 0.5%) and (n=28, 5.9%), Pharmacy (n=8, 3.7%) and (n=8, 1.7%), Science (n=7, 3.2%) in the first period, and other non-Wayne State University researchers (n=6, 1.3%) in the second period. The detailed list of the departments under the colleges over the whole period given in Table 5 is presented in Appendix B.

The positions of the researchers at the Wayne State University who have acquired the consulting service over the periods are shown in Table 7.

The majority of the researchers who used the consulting service was constituted by doctoral students in both periods, respectively: (n=61, 35.0%) and (n=193, 40.6%), followed by the Master's students (n=30, 17.0%) and (n=170, 35.8%), and the faculty (n=44, 25.0%) and (n=67, 14.1%). The researchers those who were with the other positions acquired this service in the following frequencies and percentages: The research assistants (n= 20, 12.0%) and (n=27, 5.7%), the staff (n=17, 10.0%) and (n=9, 1.9%), the academic administrators (n=7, 1.5%) in the second period, and finally the non-WSU researchers (n=1, 1.0%) in the first period.

Over the whole period, 1990-2008, the majority of the researchers who used the consulting service was constituted by doctoral students (n=254, 39.1%), followed by the Master's students (n=200, 30.9%) and the faculty (n=111, 17.1%). 7.3% of the research assistants (n= 47), 4.0% of the staff (n=26), 1.1% of the academic administrators (n=7), and finally 0.3% of the non-WSU researchers (n=1) also acquired the service.

Table 7: The Frequency and Percentage of Researchers by Their Position at WSU by Periods

Researcher's Position	1990 - 2000		2001 - 2008		1990 - 2008	
	Count	%	Count	%	Count	%
Master's Student	30	17	170	35.8	200	30.9
Doctoral Student	61	35	193	40.6	254	39.1
Faculty	44	25	67	14.1	111	17.1
Academic Administrator	.	.	7	1.5	7	1.1
Research Assistant	20	12	27	5.7	47	7.3
Research Associate	.	.	2	.4	2	.3
Staff	17	10	9	1.9	26	4.0
Other	1	1	.	.	1	.2
Total	173	100.0	475	100.0	648	100.0

The main way of consultation was face to face consulting (n=622, 86.8%) followed by the consultation via e-mail messaging (n=90, 12.6%) as they are shown in Table 8. It was observed that e-mail consultations have been taken place mostly for follow-up questions after the first session of consulting.

Table 8: The Frequency and Percentage of Consulting Activity as Type

Consulting Type	Frequency	Percent
In Office	622	86.8
Via E-Mail	90	12.6
Via Phone	1	0.1
Seminar/Workshop	4	0.6
Total	717	100.0

Table 9 shows the frequency and percentages for the main topics of the consulting activities (the checklist items) for the first period, 1990-2000.

As Table 9 shows, in 1990-2001 period, the main subject of the research consulting services was about the usage of statistical software such as SPSS, SAS, AMOS, LISREL (n=138, 24.4%) while it was a second main subject for the 2001-2008 period (n=172, 8.4%). The appropriate setup of data (n=84, 14.9%), the implementation of statistical analysis (n=83, 14.7%), the data manipulation (n=57, 10.1%), the selection of statistical techniques (n=39, 6.9%), and the interpretation of statistical analysis results (n=33, 5.8%) were the other most frequent research consulting subjects in 1990-2000 period.

In 2001-2008 period, the most frequent consulting subjects were regarding the interpretation of statistical analysis results (n=337, 16.4%), followed by the implementation of statistical analysis (n=322, 15.7%), the reporting of results in words (n=227, 11.0%), the usage of statistical software (n=172, 8.4%), and the selection of statistical techniques (n=114, 5.5%).

Table 9: The Frequency and Percentage of Consulting Topics in 1990-2008 Period

Research Consulting Subject	1990 - 2000		2001 - 2008	
	Count	Period %	Count	Period %
Design of experiment	31	5.5	55	2.7
Identification of variables	4	0.7	36	1.8
Scale of measurement	11	1.9	53	2.6
Design of instrument or survey	14	2.5	37	1.8
Instrument reliability of proper type	11	1.9	27	1.3
Instrument validity of proper type	1	0.2	15	0.7
Appropriate formation of research question	2	0.4	24	1.2
Statistical hypothesis	4	0.7	20	1.0
Sampling strategy, power, and sample size	5	0.9	35	1.7
Appropriate setup of data	84	14.9	56	2.7
Data manipulation	57	10.1	77	3.7
Usage of statistical software	138	24.4	172	8.4
Handling missing values	11	1.9	26	1.3
Selection of statistical techniques	39	6.9	114	5.5
Issues regarding Type I and Type II Errors	1	0.2	31	1.5
Issues regarding experiment-wise error rates	1	0.2	25	1.2
Handling violation of underlying assumption(s)	3	0.5	29	1.4
Implementation of statistical analysis	83	14.7	322	15.7
Implementation of nonparametric statistics	1	0.2	29	1.4
Interpretation of statistical analysis results	33	5.8	337	16.4
Reporting Findings - Words	8	1.4	227	11.0
Reporting Findings - Tables	11	1.9	174	8.5
Reporting Findings - Charts/Graphs	12	2.1	135	6.6

The frequency and percentage of the identification of consulting subject between the researchers and the consultant for 2001-2008 period are shown in Table 10. The consulting records of the 1990-2000 period were excluded from the table because there were not enough number of records in which the clients' views of the research consulting problems have been noted.

As Table 10 shows, the highest percentages of the absolute discrepancies between the researchers' and the consultant's perspectives of the research problem were about the formation of statistical hypothesis (difference=76.4%), the issues regarding experiment-wise error rates (difference=74.6%), the handling violation of underlying assumptions (difference=74.6%); The smallest percentage differences were regarding the reporting findings in charts (1.8%) and tables (3.8%) and words (15.2%) while it was the usage of statistical software (22.2%) as one of the analysis-related items.

Table 10: The Frequency and Percentage of the Proposed Consulting Subjects by the Researchers and the Consultant in 2001-2008 Period

Consulting Subjects	Researcher		Consultant		Absolute Difference	
	Count	Row %	Count	Row %	Count	%
Design of experiment	55	27.0%	149	73.0%	94	46.0
Identification of variables	36	22.1%	127	77.9%	91	55.8
Scale of measurement	53	22.6%	182	77.4%	129	54.8
Design of instrument or survey	37	37.8%	61	62.2%	24	24.4
Instrument reliability of proper type	27	20.5%	105	79.5%	78	59.0
Instrument validity of proper type	15	18.5%	66	81.5%	51	63.0
Appropriate formation of research question	24	16.8%	119	83.2%	95	66.4
Statistical hypothesis	20	11.8%	150	88.2%	130	76.4
Sampling strategy, power, and sample size	35	24.8%	106	75.2%	71	50.4
Appropriate setup of data	56	26.7%	154	73.3%	98	46.6
Data manipulation	77	28.1%	197	71.9%	120	43.8
Usage of statistical software	172	38.9%	270	61.1%	98	22.2
Handling missing values	26	26.0%	74	74.0%	48	48.0
Selection of statistical techniques	114	36.5%	198	63.5%	84	27.0
Issues regarding Type I and Type II Errors	31	15.4%	170	84.6%	139	69.2
Issues regarding experiment-wise error rates	25	12.7%	172	87.3%	147	74.6
Handling violation of underlying assumption(s)	29	13.3%	189	86.7%	160	73.4
Implementation of statistical analysis	322	59.1%	223	40.9%	99	18.2
Implementation of nonparametric statistics	29	15.7%	156	84.3%	127	68.6
Interpretation of statistical analysis results	337	57.7%	247	42.3%	90	15.4
Reporting Findings - Words	227	57.6%	167	42.4%	60	15.2
Reporting Findings - Tables	174	51.9%	161	48.1%	13	3.8
Reporting Findings - Charts/Graphs	135	49.1%	140	50.9%	5	1.8

Hypothesis Testing

The confirmatory factor model shown in Figure 1 in Chapter 3 was implemented to fit the whole sample (n=718) using M*plus* software version 5.1 because of its capability of handling binary factor indicators using a robust weighted least squares method (WLSM) as the default estimator for this type of analysis. With WLSM estimator, probit regressions for the factor indicators regressed on the factors are estimated (Muthen & Muthen, 2007.)

The confirmatory factor analysis estimates, factor inter-correlations , and item R^2 and residual variances are given in Table 11, 12, and 13, respectively.

As it is shown in Table 11, all five factors were significantly indicated by all the items; The highest indicating items were those that were in reporting and design and sampling groups.

Table 11: Confirmatory Factor Analysis with Binary Indicators Estimates for 1990-2008 (n=718)

Factors	Items	Binary Data Proportions Category 0	Category 1	Estimate	Critical Ratio
Design & Sampling	Design of Experiment	.88	.12	1.00	
	Design of instrument	.93	.07	0.99	10.16***
	Appropriate Research Question	.96	.04	1.24	16.21***
	Statistical Hypothesis	.97	.03	1.48	15.83***
	Sample Size & Power	.94	.06	1.27	17.40***
Measurement	Variable Identification	.94	.06	1.0	
	Scale of Measurement	.91	.09	0.93	11.51***
	Reliability	.95	.05	0.99	10.64***
	Validity	.98	.02	1.18	11.35***
Data Management	Appropriate Setup of Data	.80	.20	1.0	
	Data Manipulation	.81	.19	0.63	6.46***
	Usage of Statistical Software	.57	.43	0.64	6.61***
Statistical Analysis	Handling Missing Values	.95	.05	1.0	
	Selection of Statistical Techniques	.79	.21	1.1	5.78***
	Type I & II Errors	.95	.05	1.27	5.16***
	Experiment-Wise Errors	.96	.04	1.19	5.06***
	Violation of Underlying Assumptions	.95	.05	1.01	4.65***
	Statistical Analysis	.45	.55	1.53	6.0***
	Nonparametric Statistics	.95	.05	0.94	5.10***
Reporting	Interpretation of Results	.48	.52	1.0	
	Reporting – Words	.67	.33	0.84	28.61***
	Reporting - Tables	.74	.26	0.73	22.51***
	Reporting – Charts/Graphs	.80	.20	0.72	20.50***

*** $p < .001$, $\chi^2(44) = 317.49^{***}$, $df = 44$, CFI=0.78 , TLI=0.82, RMSEA=0.09, Estimator=WLSM.

The inter-correlations between the five factors are listed in Table 13. The largest positive and significant correlation was between the “design - sampling “ and “measurement” ($r = .47$, $p < .001$) while the largest negative and significant correlation was between the “data management“ and “reporting” ($r = -.37$, $p < .001$). The “design- sampling “ and “data management“ had no significant correlation ($r = .10$, $p > .05$).

Table 12: The Factor Inter-Correlations

Factors	1	2	3	4	5
1. Design & Sampling					
2. Measurement	.47***				
3. Data Management	.10	.17**			
4. Statistical Analysis	.24***	.20***	.17***		
5. Reporting	-.24***	.15*	-.37***	.42***	

*$p < .05$, **$p < .01$, ***$p < .001$

The item R^2 and residual variances based on the probit regressions of each item on the factors and their residual variances are listed in Table 13. The largest R^2 coefficients generated by "instrument validity of proper type" ($R^2 = .83$), "sampling strategy, power, and sample size" ($R^2 = .80$), "appropriate formation of research question" ($R^2 = .7$), and "reporting-words" ($R^2 = .72$), while the smallest ones generated by "implementation of nonparametric statistics" ($R^2 = .20$), "data manipulation" and "handling missing values" ($R^2 = .22$), and "usage of statistical software" and "handling violation of underlying assumptions" ($R^2 = .23$).

Table 13: Item R^2 and Residual Variances

Items	R^2	Residual Variance
Design of experiment	.50	.50
Identification of variables	.60	.40
Scale of measurement	.51	.49
Design of instrument or survey	.49	.51
Instrument reliability of proper type	.58	.42
Instrument validity of proper type	.83	.17
Appropriate formation of research question	.77	.23
Statistical hypothesis [a]	.	.
Sampling strategy, power, and sample size	.80	.20
Appropriate setup of data	.56	.44
Data manipulation	.22	.78
Usage of statistical software	.23	.77
Handling missing values	.22	.78
Selection of statistical techniques	.24	.76
Issues regarding Type I and Type II Errors	.36	.64
Issues regarding experiment-wise error rates	.32	.69
Handling violation of underlying assumption(s)	.23	.77
Implementation of statistical analysis	.52	.48
Implementation of nonparametric statistics	.20	.80
Interpretation of statistical analysis results [b]	.	.
Reporting Findings - Words	.72	.28
Reporting Findings - Tables	.54	.50
Reporting Findings – Charts/Graphs	.53	.47

[a, b] Undefined: The Residual Covariance Matrix (Theta) Is Not Positive Definite.

Table 14: The Binomial Tests for the Occurrences of the Research Consulting Subjects Tested Against the Hypothesized Proportions of 50% and 20% for the Periods of 1990-2000 and 2001-2008

Items	1990-2000 (N=240)			2001-2008 (N=478)		
	n	Observed Proportion (>50%)	Observed Proportion (>20%)	n	Observed Proportion (>50%)	Observed Proportion (>20%)
Design of experiment	31	0.13	0.13	55	0.12	0.12
Identification of variables	4	0.02	0.02	36	0.08	0.08
Scale of measurement	11	0.05	0.05	53	0.11	0.11
Design of instrument or survey	14	0.06	0.06	37	0.08	0.08
Instrument reliability of proper type	11	0.05	0.05	27	0.06	0.06
Instrument validity of proper type	1	0.00	0.00	15	0.03	0.03
Formation of research question	2	0.01	0.01	24	0.05	0.05
Statistical hypothesis	4	0.02	0.02	20	0.04	0.04
Power and sample size	5	0.02	0.02	35	0.07	0.07
Appropriate setup of data	84	0.35	0.35^{***}	56	0.12	0.12
Data manipulation	57	0.24	0.24^{***}	77	0.16	0.16
Usage of statistical software	138	0.58^{***}	0.58^{***}	172	0.36	0.36^{***}
Handling missing values	11	0.05	0.05	26	0.05	0.05
Selection of statistical techniques	39	0.16	0.16	114	0.24	0.24^{***}
Type I and Type II Errors	1	0.00	0.00	31	0.06	0.06
Experiment-wise error rates	1	0.00	0.00	25	0.05	0.05
Violation of underlying assumption	3	0.01	0.01	29	0.06	0.06
Implementation of statistics	1	0.35	0.35^{***}	322	0.67^{***}	0.67^{***}
Nonparametric statistics	33	0.00	0.00	29	0.06	0.06
Interpretation	8	0.14	0.14	337	0.71^{***}	0.71^{***}
Reporting Findings - Words	11	0.03	0.03	227	0.47	0.47^{***}
Reporting Findings - Tables	12	0.05	0.05	174	0.36	0.36^{***}
Reporting Findings – Charts/Graphs	12	0.05	0.05	135	0.28	0.28^{***}

*** $p < .001$, the significances of the statistics are based on Z distribution.

Table 14 indicates that the only significantly supported alternative hypothesis that has tested the observed proportion of consulting activity subjects against the hypothesized proportion of .50 in 1990-2000 period was about "usage of statistical software" ($P = .58$, $p < .001$), while the significant ones were about "interpretation of statistical analysis results" ($P = .71$, $p < .001$), and "implementation of statistical techniques" ($P = .67$, $p < .001$) in 2001-2008 period where P denoted the observed proportion.

When the same hypotheses tested against the hypothesized proportion of .20, the supported alternatives were about "usage of statistical software" ($P = .58$, $p < .001$), "appropriate setup of data" and "implementation of statistical techniques" ($P = .35$, $p < .001$), and finally "data manipulation" ($P = .24$, $p < .001$) in 1990-2000 period. In 2001-2008 period, the supported alternatives against $P=.20$ have belonged to "interpretation of statistical analysis results" ($P = .71$, $p < .001$), "implementation of statistical techniques" ($P = .67$, $p < .001$), "reporting findings-words" ($P = .47$, $p < .001$), "usage of statistical software" and "reporting findings-tables" ($P = .36$, $p < .001$), "reporting findings-charts/graphs" ($P = .28$, $p < .001$), and finally "selection of appropriate statistical techniques" ($P = .24$, $p < .001$).

The consulting subjects of which observed proportions were significantly greater than the hypothesized proportion of .20 were "usage of statistical software" and "implementation of statistical techniques" in both periods.

The Kappa coefficients for measurement of agreement and McNemar test for differences between the clients and the consultant for the 2001-2008 period are listed in Table 15. The first period, 1990-2000, consulting records were not included in the analysis because the comparisons of the consultants' and clients' aspects of the research problem were mostly unavailable.

Table 15: The Kappa and McNemar's Statistics for Testing the Rate of Agreement and Differences Between the Clients and the Consultant on Research Consulting Subjects for 2001-2008 Period (N=478)

Consulting Subjects	Measure of Agreement (KAPPA)	Approximate t-value for testing KAPPA (H_0: K=0)	McNemar's Test for difference *p-value*
Design of experiment	.34	8.93***	.000
Identification of variables	.31	8.80***	.000
Scale of measurement	.25	7.15***	.000
Design of instrument or survey	.71	16.05***	.000
Instrument reliability of proper type	.32	9.13***	.000
Instrument validity of proper type	.31	9.07***	.000
Formation of research question	.23	7.28***	.000
Statistical hypothesis	.15	5.77***	.000
Power and sample size	.39	10.24***	.000
Appropriate setup of data	.35	9.12***	.000
Data manipulation	.35	9.16***	.000
Usage of statistical software	.46	11.31***	.000
Handling missing values	.43	11.14***	.000
Selection of statistical techniques	.54	12.81***	.000
Type I and Type II Errors	.18	6.20***	.000
Experiment-wise error rates	.10	3.85***	.000
Violation of underlying assumption	.16	6.09***	.000
Implementation of statistics	.56	13.45***	.000
Nonparametric statistics	.22	7.57***	.000
Interpretation	.48	11.41***	.000
Reporting Findings - Words	.71	16.08***	.000
Reporting Findings - Tables	.76	16.97***	.085
Reporting Findings – Charts/Graphs	.60	13.05***	.653

*** $p < .001$, McNemar's significance values are based on Binomial Distribution.

As the McNemar's test results indicate in Table 15, there were statistically significant differences between the clients' and the consultant's diagnoses on research problems presented by the consulting subjects, except for the items "reporting findings-tables" and "reporting findings-charts/graphs" ($p > .05$).

The measure of agreement coefficients (KAPPA) indicated that the strongly and significantly agreed diagnoses were regarding the three reporting findings items, "reporting findings-words" ($K = .76$, $t = 16.97$, $p < .001$), "design of instrument" and "reporting findings-words" ($K = .71$, $t = 16.0$, $p < .001$), "reporting findings-charts/graphs" ($K = .60$, $t = 13.05$, $p < .001$), "implementation of statistics" ($K = .56$, $t = 13.45$, $p < .001$), and "selection of statistical techniques" ($K = .54$, $t = 12.81$, $p < .001$).

However, the weakly and significantly agreed diagnoses between the clients and the consultant were "issues related to experiment-wise error rates" ($K = .10$, $t = 3.85$, $p < .001$), "appropriate formation of statistical hypothesis" ($K = .15$, $t = 5.77$, $p < .001$), "issues related to Type I-Type II error rates" ($K = .18$, $t = 6.20$, $p < .001$), "handling the violation of underlying assumptions" ($K = .16$, $t = 6.09$, $p < .001$), and "appropriate formation of research question" ($K = .23$, $t = 7.28$, $p < .001$).

CHAPTER 5

CONCLUSIONS

Overview

The main purpose of this study was to investigate if there were statistically significant differences between the researchers' and the statistical consultants' diagnoses and applications on research problems in a university through a list of statistical items.

In specific terms, the main purpose of the present study was to determine the most frequent problems that the researchers of a higher education institution at different positions such as faculty, graduate students and staff have been experiencing on their research design, sampling, measurement, data management, data analysis, and reporting as well as the statistical tools that the most frequently they needed a statistical consultant's help. The findings of this study were expected to bring about some evidence for the type of most common methodological problems with the actual research activities that have been done.

The data population were consisted of the 1468 research consulting logs (about 1,000 records were excluded because of their irrelevance to a statistical matter or insufficient information) kept by the different consultants who have worked for the Research Consulting Services (formerly known as the Research Support Laboratory) of the Computing and Information Technology of the Wayne State University through the period of 1990-2008. A total of 718 records were drawn out of the total of 1468 to test the hypotheses in the form of:

1. Fitting a confirmatory factor analysis (CFA) model to the sampled data,

2. Testing the observed proportions of the listed research problems against the hypothesized proportions of 50% and 20% to identify the most frequent research problems that the researchers have faced,
3. Testing the degree of agreement and difference between the researchers' and consultants' perspectives of the identification and solution of the research problem during the consulting sessions.

Discussion and Recommendations

Implications of Some Descriptive Statistics

The majority of the researchers who have received the research consulting help over the whole period were from the College of Education (n=339, 49.1%), School of Medicine (n=105, 15.2%), and Liberal Arts and Sciences departments (n=68, 9.9%.)

The majority of the researchers who have acquired the research consulting help were the doctoral students (n=254, 39.1%), the Master's students (n=200, 30.9%), and the faculty (n=111, 17.1%.) This order was prevailed in both periods, 1990-2000 and 2001-2008.

The vast majority of the consulting activity has been taken place as face to face (in office) sessions (n=622, 86.8%) followed by consulting via e-mail messaging which has shown a gradual increase over the years.

The highest percentage of research issue in 1990-2000 period was "usage of statistical software" (24.4%) while it was "interpretation of statistical analysis results" (16.4%) in 2001-2008 period. This indications should be consistent with the type, performance, and the availability of computer hardware and software in each period, i.e., the researchers were less familiar with the operating system environments such as Windows, MTS-CMS (main-frames) and the main software packages which have required more syntax-driven skills in 1990-2000 period while the researchers in 2001-2008 period were luckier in terms of the availability of the high-performance personal PC hardware and more user-friendly and menu driven software. The drastic advances in computing technology and computer literacy have placed the 'interpretation' skills in the first place, saving researchers a great deal of time that used to be spent on the operational problems with the software.

Implications of Hypothesis Testing Results

The present study implemented a confirmatory factor model (CFA) to determine whether the model fitted well to the sample. The findings showed that all 23 research consulting subject items significantly indicated the underlying factors such as design and sampling, scale of measurement, data management, statistical analysis, and reporting. The binary nature of the dependent variables required using a weighted least square method. The proposed model fitted fairly well (CFI = 0.78, TLI = 0.82, RMSEA = 0.09) to the sample underlying the factors meaningfully. However, because of the binary nature of the data, a larger sample size would improve the adjusted fit indices. In addition, the strongest positive correlation was between the factors "design and sampling" and "measurement" ($r = .47$, $p < .001$), followed by "statistical analysis" and reporting" ($r = .42$, $p < .001$), and "design and sampling" and "statistical analysis" ($r = .24$, $p < .001$).

The binomial tests for testing an observed proportion against a hypothesized proportion indicated that "usage of statistical software" was the only significant observed proportion tested against the 50% of the time in 1990-2000 period while "interpretation" and “implementation of statistics" were the significant consulting subjects more than 50% of time in 2001-2008 period. This result was consistent with the effects of the technological advancements in computing capabilities in research. Testing the observed proportions of the research consulting matters against the 20% of time also implied that there has been a shift between the periods from data manipulation and software usage issues to interpretation and reporting issues in terms of the frequency of their occurrences. This shift, again, can be explained by the improvement regarding the quality and comprehensibility of statistical software which resulted in inclusion of more recent theoretical methods into the software that has also required more familiarity with the literature, accordingly, more interpretation capabilities. In addition, increasing proportion of reporting issues such as reporting in words, tables, and charts and graphs, may have been stimulated by academically higher academic standards, i.e., more experienced and demanding advisors, journal editors, etc.

The McNemar's test for difference results indicated that the only consulting issues on which both the clients and the consultant had had the similar diagnosis were reporting in tables and charts. There were statistically significant differences between the clients and the consultant in terms of identification of consulting subject matters for the rest of the 21 items.

The Kappa measurement of agreement coefficients between the clients' and the consultants' perspectives with respect to the diagnoses of the 23 research problems listed were all significant at .001 Alpha level. The research problems such as reporting (in words, tables, and charts), interpretation, selection and implementation of statistical techniques had relatively the strongest agreement coefficients, the "experiment-wise error rates" and "handling violations of underlying assumptions", "issues regarding Type I and II error rates", and "implementation of nonparametric statistics" indicated the weakest agreement between the clients and the consultant in 2001-2008 period.

Specific implications for Statistics Classes at Universities

The results implied that the following issues should be emphasized more in statistics classes regardless of the field or major and working with representative samples for real-life research activities in form of case studies:

1. Deeper insight and practice on design, scale of measurement, reliability and validity of an instrument with field-specific case studies and projects.
2. Identification and adjustment methods of experiment-wise error rates when multiple comparisons are made.
3. Identification and adjustment methods when violations of underlying assumptions of either parametric or nonparametric statistics are in question.
4. Practice of formation of research and statistical hypotheses based on real-life oriented research problems so that they could be testable with the available methods in the most robust way.

5. Deeper insight and knowledge of nonparametric statistical alternatives that are as powerful as their parametric counterparts when the normality assumption is violated which is very common with the real life data especially in social fields, as Sawilowsky (1990) stated: "many nonparametric rank tests outperform their parametric counterparts under many nonnormal distributions... negating the argument that converting to ranks throws away important information" (p. 95.)
6. Involving more practice with the main statistical software by projects, case studies, and assignments, etc., to improve the students' computer and software literacy.
7. Giving the students the analyses results of case studies and asking them to interpret to improve their interpretative skills.

General Implications for Statistics Education

The classical teaching method for statistics provides the students with some familiarity with the statistical concepts in a way that those concepts are never satisfactorily internalized into the disciplines. The departments should determine their priorities and goals in teaching statistics so that it would offer students the necessary and specific tools that they can confidently use in their research activities rather than using the statistics courses to satisfy the academic requirements. Especially the introductory level statistics courses should focus on the process of learning how to collect data effectively in that particular field, how to summarize and interpret that information, and how to understand the limitations of statistical inference.

Having known that a sufficient mathematical background is essential, teaching should not be stereotyped into a mathematical proof only methodology; An optimum balance should be kept between mathematical and numerical manipulations for especially introductory level statistics courses.

Statistical consultancy should be included in the statistical education curriculum as it has been implemented by many major universities in the last decade in order to improve the statistical quality of research activities. For a beginning, professional statistical consultants who have theoretical background of the fields in question should be hired by the departments which intensively involved with research by their faculty and graduate students. The main functions of the statistical consultants should be:

1. Helping the faculty and graduate students with their research.
2. Teaching graduate level statistical consultancy courses specific to the departments' fields in a way that the content would meet the field-specific needs and knowledge for research.
3. Make their classes a meeting place for the student consultants and researchers as a part of the course objective to provide their students with the consulting experience as well as meeting the researchers' needs.

Implications for Future Research

First, this study should be repeated with a well-balanced sample drawn from all the fields or departments to assess the needs of the researchers in terms of the research problems that were included in the present study to identify field-specific needs in a more detailed framework for a more efficient statistical education.

Second, a similar study should be done utilizing more detailed consulting records to get deeper insight of the researchers' needs as well as more specific suggestions for improving the statistical education.

Third, an extension of this study in form of a meta-analysis involving the similar studies done by the statistical consultancy units of different research universities would be of interest to test the consistency of the problems and/or suggestions.

APPENDIX A

The Research Consulting Information Form

Print Form   Submit by Email

Research Consulting
Academic Technologies and Customer Services - C&IT
Wayne State University

Please take a moment to fill in the form. The information you provided will be used solely for the planning and improvement purposes for this service, and not be shared by anyone / institution.

Today's Date ______ **Semester** ______

Name ______

E-mail ______ **Phone** ______

Department/College ______

Your current position at Wayne State University (please check all that apply):

- ☐ Faculty
- ☐ Staff
- ☐ Researcher
- ☐ Doctoral Student
- ☐ Master's Student
- ☐ Undergraduate Student
- ☐ Other (Please specify) ______

Is this your first visit to the Research Consulting? ○ Yes ○ No

If no, when was the last time you visited the Research Consulting?

- ○ Few days ago
- ○ Few weeks ago
- ○ Few months ago
- ○ More than a year ago
- ○ Do not remember

Which of the following relates to your request for consultation (please check all that apply):

- ☐ Dissertation
- ☐ Thesis
- ☐ Paper
- ☐ Grant Proposal
- ☐ Clinical Experiment
- ☐ Class Project
- ☐ Software Usage
- ☐ Software Technical Support
- ☐ Other (Please specify) ______

Research Consulting
Academic Technologies and Customer Services - C&IT
Wayne State University

On which of the following topics, you intend to get consulting (please check all that apply):

1. ☐ Design of experiment
2. ☐ Identification of variables
3. ☐ Scale of measurement
4. ☐ Design of instrument or survey
5. ☐ Instrument reliability of proper type (i.e., internal consistency, test-retest)
6. ☐ Instrument validity of proper type (i.e., content, predictive, construct)
7. ☐ Appropriate formation of research question
8. ☐ Statistical hypothesis based on research question
9. ☐ Sampling strategy, power, and sample size determination
10. ☐ Appropriate setup of data
11. ☐ Data manipulation (computing, recoding, conditional selection, etc.)
12. ☐ Usage of statistical software for the proposed analysis (please check all that apply):

    Software: ☐ SPSS ☐ SAS ☐ AMOS ☐ HLM ☐ Power & Sample Size ☐ Other ☐

13. ☐ Handling missing values
14. ☐ Selection of statistical techniques with respect to research question(s)
15. ☐ Issues regarding Type I and Type II Errors
16. ☐ Issues regarding experiment-wise error rates
17. ☐ Handling violation of underlying assumption(s)
18. ☐ Implementation of statistical analysis
19. ☐ Implementation of nonparametric statistics when applicable
20. ☐ Interpretation of statistical analysis results
21. ☐ Reporting Findings - Words
22. ☐ Reporting Findings - Tables
23. ☐ Reporting Findings - Charts/Graphs
24. ☐ Other (please specify):

THANK YOU.

APPENDIX B

The Frequency of Consulting Records by Departments

College/Department

	Frequency	Valid Percent
Audiology/Speech Pathology	9	2.4
Business School-Finance	28	7.4
College of Engineering-Biomedical Engineering	22	5.8
College of Engineering-Mechanical Engineering	5	1.3
Center Peace/Conflict	2	.5
COE- Administration	28	7.4
COE-Career and Technical Education	8	2.1
COE-Curriculum & Instruction	33	8.8
COE-Educational Leadership & Policy	5	1.3
COE-Educational Psychology	35	9.3
COE-Instructional Technology	24	6.4
COE-Math Education	2	.5
COE-Multicultural Education	12	3.2
COE-School and Community Psychology	32	8.5
COE-Secondary Education	24	6.4
College of Nursing	34	9.0
Davenport University	2	.5
Fine, Performing & Comm. Arts-Comm.	15	4.0
Liberal Arts & Sciences-Political Science	13	3.4
Liberal Arts & Sciences-Psychology	13	3.4
Lifelong Learning	9	2.4
Pharmacy-Occupational Theraphy	11	2.9
COE-Physical Education	7	1.9
Registrar/Recors/Registration	1	.3
School of Medicine- Genetic Counseling	1	.3
School of Medicine-Anatomy	2	.5
Total	377	100.0

College/Department (continued)

	Frequency	Valid Percent
School of Medicine-Genetic Counseling	23	7.3
School of Medicine-Pediatrics	8	2.5
School of Medicine - Cancer Institute	3	.9
School of Medicine	59	18.6
Liberal Arts & Sciences - Sociology	11	3.5
Liberal Arts & Sciences - Theology	12	3.8
COE-Theoretical & Behavioral Foundations	10	3.2
Liberal Arts & Sciences - Nutrition & Food Sciences	7	2.2
University of Detroit	4	1.3
Fashion Design and Merchandising	1	.3
Center for Urban Studies	10	3.2
Liberal Arts & Sciences - Criminal Justice	1	.3
COE-Reading, Language & Literature	1	.3
COE-Teacher Education	5	1.6
COE	101	31.9
C&IT	3	.9
Social Work	4	1.3
Chemistry	1	.3
Liberal Arts & Sciences-Economics	5	1.6
Library Science	3	.9
Geography	3	.9
Anthropology	2	.6
COE-Elementary Education	5	1.6
College of Engineering-Industrial Engineering	2	.6
Liberal Arts & Sciences	6	1.9
Pharmacy	5	1.6
CULMA	4	1.3
COE-Science Education	7	2.2
Development Office	1	.3
WSU Division	8	2.5
Math	2	.6
Total	317	100.0

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ABSTRACT

COMPARISON OF UNIVERSITY RESEARCHERS' AND STATISTICAL CONSULTANTS' DIAGNOSES AND APPLICATIONS ON RESEARCH PROBLEMS

by

BULENT OZKAN

August 2008

Advisor: Dr. Shlomo S. Sawilowsky

Major: Evaluation and Research

Degree: Doctor of Philosophy

There has been a growing belief in the statistical community that significant changes must be realized in the methodology of statistics education. Statistics education traditionally focused on developing knowledge and mastery, assuming students would naturally create comprehensive insight and understanding of the subject during the educational process. Apparently, however, this approach has not been successful. The lack of pre-college statistical literacy as well as methodological issues with the college and graduate level statistics courses are the main difficulties that researchers have been experiencing in their real-life research activities and has been leading to misunderstanding of the problem as well as misuse of the statistical tools.

The purpose of this study was to determine if there were statistically significant differences between the researchers' and the statistical consultants' diagnoses and applications on research problems in a university through a list of research problem items.

A random sample of 718 was drawn from approximately 1500 research consulting records that have been logged by the statistical consultants of the Research Consulting Services of the Computing and Information Technology over the 1990-2008 period.

A confirmatory factor analysis with five underlying factors such as design and sampling, scale of measurement, data management, statistical analysis, and reporting was implemented and it fitted fairly well to the sampled data with significant indicators.

Binomial tests were conducted to test the observed proportions of the recorded research problems against hypothesized proportions of 50% and 20% separately for 1990-2000 and 2001-2008 periods.

Finally, Kappa measure of agreement coefficients and McNemar's tests were used to analyze the agreements and differences between the researchers' and consultants' perspectives of the diagnosis on the listed research problems.

AUTOBIOGRAPHICAL STATEMENT

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PROFESSIONAL EXPERIENCE

2000–2008 Research Consultant		Research Consulting Services, Academic Computing and Customer Services, C&IT, Wayne State University Detroit, MI
1996–1999 Statistical Consultant		Research Support Laboratory, Planning & Support Services, C&IT, Wayne State University Detroit, MI
1986–1990 Instructor		College of Economics and Admin. Sciences, Cukurova University Adana, TURKEY
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EDUCATION

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