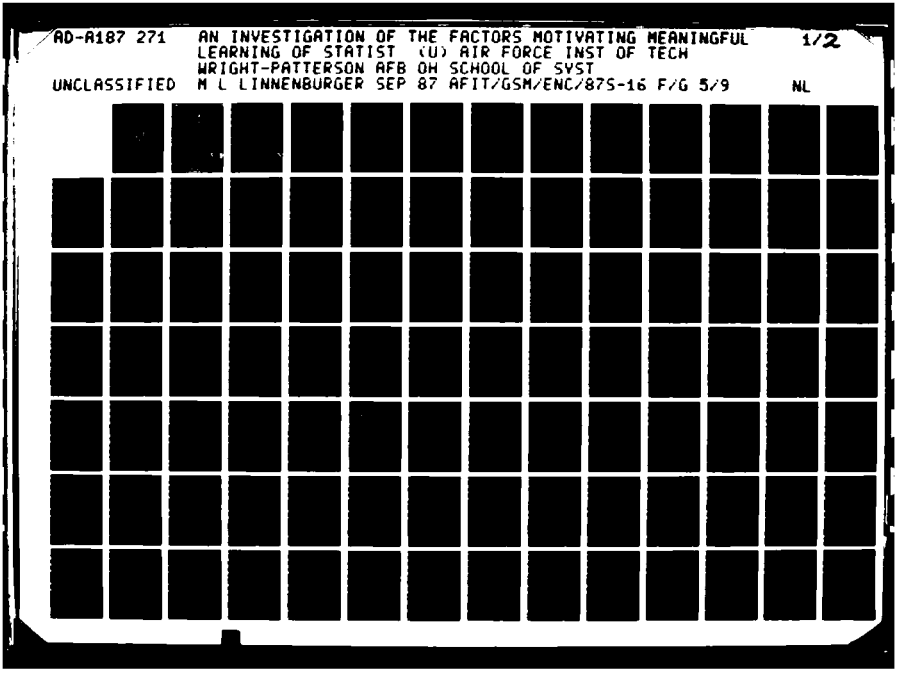
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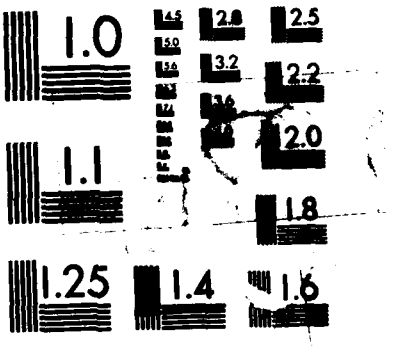

AN INVESTIGATION OF THE FACTORS MOTIVATING MEANINGFUL LEARNING OF STATISTICS BY GRADUATE SYSTEMS MANAGEMENT STUDENTS AT AFIT

THESIS

Michael Lee Linnenburger
Captain, USAF

AFIT/GSM/ENC/87S-16

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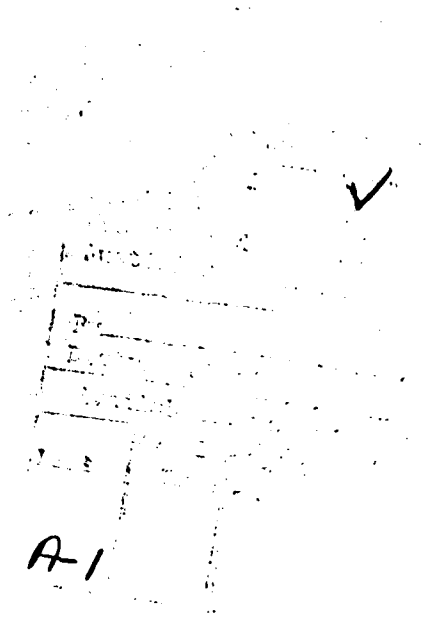

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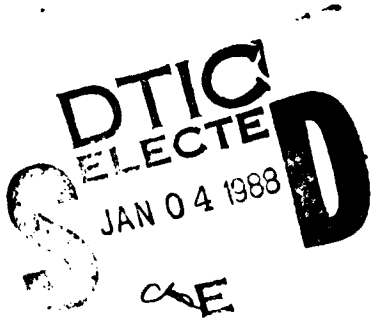

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AFIT/GSM/ENC/87S-16

AN INVESTIGATION OF THE FACTORS MOTIVATING MEANINGFUL LEARNING OF STATISTICS BY GRADUATE SYSTEMS MANAGEMENT STUDENTS AT AFIT

THESIS

Presented to the Faculty of the School of Systems and Logistics
of the Air Force Institute of Technology
Air University
In Partial Fulfillment of the
Requirements for the Degree of
Master of Science in Systems Management

Michael Lee Linnenburger, B.S.E.E.
Captain, USAF

September 1987

Preface

The purpose of this thesis was to collect basic information on the statistical concept base potential GSM students usually bring to AFIT and to determine which statistical concepts are used by acquisition managers. The specific application of Ausubel's Learning Theory and Johnson's Curriculum Model was to statistics, even though both can be applied to other disciplines.

In performing the research and writing of this thesis I have received a great deal of help and support from others. I am deeply indebted to my advisor, Dan Reynolds, for his assistance when I was lost. I also wish to thank all of the people manning the AFIT computer centers for putting up with my endless computer runs and re-runs. Finally, I wish to thank my wife Barbara for her understanding and concern on those many nights when I was else where with thesis work.

Michael Lee Linnenburger

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Abstract

The purpose of this thesis was to collect basic information on the statistical concept base potential GSM students usually bring to AFIT and to determine which statistical concepts are used by acquisition managers. The specific application of Ausubel's Learning Theory and Johnson's Curriculum Model was to statistics, even though both can be applied to other disciplines.

In order to accomplish this purpose the following objectives were developed: (1) to collect data on statistical background and work experience of acquisition managers so an inference could be made concerning the statistical concept base of entering GSM students; (2) to determine the job functions being performed by acquisition managers so that problems and exercises for statistical courses can be developed to represent the types of situations GSM students can be expected to encounter upon graduation from AFIT.

Three conclusions were reached and these were; (1) while there are indications that statistics is needed by acquisition managers, the current survey results show that the acquisition managers are not using any of the identified statistical course/concepts in their work; (2) while the top ranked task functions are primarily quantitative in nature, the courses most used are qualitative with little or no quantitative nature; (3) while the response was good to the survey, the use of this survey to try and infer the concepts entering acquisition management GSM students would bring to AFIT produced unclear results. Any attempt to infer an association among the statistical concepts with the activity job groups will most likely require personal interviews of selected field personnel.

AN INVESTIGATION OF THE FACTORS MOTIVATING MEANINGFUL LEARNING OF STATISTICS BY GRADUATE SYSTEMS MANAGEMENT STUDENTS AT AFIT

I. Introduction

General Issue

Faced with acquiring large and complex systems for the national defense, the Department of Defense (DOD) has committed vast resources to the implementation of project management as the most viable and effective method of managing the procurement of weapon systems. As part of the overall implementation plan, the Air Force Institute of Technology (AFIT) has been tasked by HQ USAF to provide the systems management student with an education that meets the needs of the Air Force. As a result, AFIT's coordinator for the Graduate Systems Management (GSM) Program is charged with providing a curriculum that is responsive to field requirements and which encourages the introduction of state-of-the-art problem solving technologies in the classroom. AFIT's teaching staff's greatest challenge, therefore, is to foster a *meaningful learning environment* that motivates students to study technology, in particular quantitative technologies, and to apply these upon graduation from AFIT.

In his book, ***Educational Psychology: A Cognitive View***, David P. Ausubel presents a theory of learning that declares meaningful learning can take place:

> (1) if the student employs a meaningful learning set (a disposition to relate new learning material meaningfully to his existing structure of knowledge), and (2) if the learning task itself is potentially meaningful (if it itself consists of plausible and sensible material and if it can be related in a nonarbitrary and substantive fashion to the particular student's cognitive structure) (2:4).

Meaningful learning of quantitative material, especially statistical material, will take place at AFIT, if courses are designed to (1) accommodate students' need to link new statistical concepts to those they bring with them and (b) foster a meaningful learning set by introducing applications of statistics that students perceive as useful.

Previous research confirmed the utility of the statistical courses taken by GSM students (13:31), but failed to uncover any evidence of wide spread use of statistics by the 27XX's in the field (8:77). Neither Speck nor Koble attempted to identify the relationship between specific statistical techniques and job tasks assigned to 27XX personnel. To date, no research has been carried out to assess what statistical concepts the entering GSM students can be expected to possess (8; 13).

If GSM students are to encounter learning tasks that are potentially meaningful and a learning environment that fosters a meaningful learning set. The statistical concept base they bring to AFIT and the relationship statistical technologies maintain with critical acquisition functions, especially those performed by 27XXs, must be ascertained.

Problem Statement

The problem is, at AFIT; (1) there is no formal procedure to assess the statistical maturity of entering GSM students, and (2) there is a general lack of knowledge concerning how statistical technology is or could be related to tasks performed by practicing acquisition managers.

Justification

AFIT has provided selected officers and Air Force civilians undergraduate and graduate level education since 1954 (15:2). Longstanding tradition and past

results require AFIT to produce highly educated personnel to perform the tasks of acquiring new weapon systems for use by the operational commands of the United States Air Force. Recently, the management systems created for such procurement activities have come under attack because "weapon systems take too long and cost too much to produce" (12:xxii). Clearly, a "better job of determining requirements and estimating costs [is] needed at the outset of weapons development" (12:xxiii).

In order to meet this requirement the Air Force has instituted a management discipline known as project management. This initiative has received the support of the Blue Ribbon Commission on Defense Management, which proposed the establishment of *Centers of Excellence.* Such Centers of Excellence are populated by project teams that have been commended for their ability to develop and produce new weapons systems "rapidly, efficiently, and with high quality performance" (12:42). The fact is, however, this form of project management requires the project managers to be very knowledgeable in project performance and possess the ability to recognize immediately when a problem requires their attention (3:365; 1:34-45; 9:21-22; 12). Such skills can only be exercised by someone who has acquired and mastered a broad range of analytical skills, including the corpus of concepts identified within the field of applied statistics.

Confirmation of this fact was obtained by Captain Roger D. Koble in his MS Thesis, *Applications of Computers as an Aid to Decision-Making in Air Force System Program Offices*, Koble found that project managers routinely needed to know how to establish sampling schemes, to estimate system performance parameters, and to forecast future procurement activities. It appears such statistical tools are the *sine qua non* for evaluating costs, schedules and technical performance of projects (8:28-30). Lt Ernest E. Speck in his MS Thesis, *Perceived Utility of the AFIT Graduate Systems Management Program*, after sampling AFIT graduates, found 57.9 percent of the respondents stated they definitely needed managerial statistics on the job. Most, 80.3 percent, felt the level of presentation of statistics

at AFIT was correct. More importantly, 67.6 percent stated they felt more practical applications of statistical technology, directly related to the job functions of AFIT graduates, should be included in the AFIT statistical curriculum. Interestingly enough, few respondents, 16.2 percent, felt more theory should be included in coursework (13:31).

Such research findings lead one to believe acquisition managers have a growing requirement for practical applications of statistics in the education and training. Indeed, the definition of statistics provided by Sam Kash Kachigan in his book, *Statistical Analysis: An Interdisciplinary Introduction to Univariate & Multivariate Methods*, almost sounds like the job description of an acquisition manager. He proposes the following definition for statistics:

> Observations of the world are converted into numbers, the numbers are manipulated and organized, and then the results are interpreted and translated back to a world that is now hopefully more orderly and understandable than prior to the data analysis. This process of *drawing conclusions and understanding more about the sources of our data* is the goal of statistical analysis in its broadest sense.
>
> More specifically, we can view the data manipulation and organization as achieving one or more of three basic objectives: (1) *data reduction*, (2) service as an *inferential measuring tool*, and (3) the *identification of associations or relationships* between and among sets of data (7:5).

Acquisition managers have responsibilities for meeting all three objectives. Quantifying project activities for purposes of data reduction and display are part of their daily routine. Making inferences about system parameters based on day to day inputs from other project personnel and trying to identify causal relationships among variables that create the problems of weapons system acquisition are routine acts for every acquisition manager (3; 1; 9; 12).

If the tasks performed by the acquisition managers can be clearly linked to specific statistical analysis techniques, and the statistical concept base required to meet all three objectives in the field can be identified, scenarios can be constructed

that will be perceived as useful by AFIT's GSM students. Furthermore, if job functions are clearly documented and their relationship to specific statistical technologies is identified, AFIT faculty will have a much clearer understanding of the statistical knowledge base entering students can be expected to bring with them to AFIT. Both of these posibilities served to motivate the goals of this study: to determine the functions performed by acquisition managers and to assess the statistical background of entering students in order to facilitate a meaningful learning environment for statistics.

Research Objectives

In order to identify the statistical concepts entering students can be expected to possess and in order to facilitate an environment for meaningful learning this thesis sought to meet two objectives:

Objective 1. To collect data on statistical background and work experience of acquisition managers, so an inference could be made concerning the statistical concept base of entering GSM students.

Objective 2. To determine the job functions being performed by acquisition managers, so that problems and exercises for statistical courses can be developed to represent the types of situations GSM students can be expected to encounter upon graduation from AFIT.

Research Questions

To meet *objective 1* the following research questions were addressed:

1. What coursework and, more specifically, what exposure to statistical concepts via academic and/or Professional Continuing Education study have potential

GSM students received?

2. What statistical concepts have found application in the environment of potential GSM students?

To meet *objective 2* the following research questions were addressed:

3. What particular job functions are currently being accomplished by Acquisition Managers?

4. Given a particular job function, what statistical technologies are being used to help solve management problems associated with that job function?

Scope

This research studied the population of systems acquisition managers in the United States Air Force. Data pertinent to this study were collected from a sample of personnel in the field of system acquisition management. These personnel were selected only from military systems acquisition managers, AFSCs 2716 and 2724. The population of interest is the military systems acquisition managers, AFSCs 2716 and 2724, with and without an AFIT Systems Management Degree. The sampling plan involved the use of a stratified sampling model. The survey was structured to collect data on job functions performed and statistical technologies used by any of the strata identified. It gathered information from individuals from the rank of 2nd Lieutenant (2d Lt) to Colonel (Col). The data were analyzed for current and possible applications of statistical technologies.

Limitations

This study did not include data from any source outside of the system acquisition management career field nor information from individuals below the rank of 2d Lt or above Col. In addition, only individuals within the continental United States (CONUS) were surveyed.

Assumptions

It was assumed that system acquisition managers had a basic knowledge of system management tools and understood how to apply them to their particular job. Since all officers hold at least a bachelors degree, and only replies from individuals who had at least six months experience in systems acquisition management were retained, this assumption seemed to be reasonable.

Definitions

Cognitive Structure. Cognitive structure is "the total content and organization of a given individual's ideas; or, in the context of subject–matter learning, the content and organization of his or her ideas in a particular area of knowledge" (2:625).

Concepts. Concepts are "objects, events, situations, or properties that possess common criterial attributes (despite diversity along other dimensions or attributes) and are designated by some sign or symbol, typically a word with generic meaning" (2:625).

Curriculum. Curriculum is "a logically connected set of conceptually and pedagogically analyzed knowledge and value claims" (6:109).

Discovery Learning. Discovery learning is "that kind of learning in which the principal content of what is to be learned is not given (or presented), but must be discovered by the learner before he can assimilate it into his cognitive structure" (2:626).

Educating. Educating is the process of "changing the meaning of human experience" (6:124).

Governance. Governance is "the power in a social setting which is required to bring together teaching, curriculum, and learning. Governance controls the meaning that controls the effort" (6:153-154).

Learning. Learning is the process of "the active reorganization of an existing pattern of meaning" (6:124).

Meaningful Learning. Meaningful learning is "the acquisition of new meanings; it presupposes a meaningful learning set and a potentially meaningful learning task (that is, a task that can be related in nonarbitrary, substantive fashion to what the learner already knows)" (2:628).

Meaningful Learning Set. Meaningful learning set is "a 'disposition' on the part of a learner to relate a learning task nonarbitrarily and substantively to relevant aspects of his or her cognitive structure" (2:628).

Progressive Differentiation. Progressive differentiation is a "part of the process of meaningful learning, retention, and organization that results in further hierarchical elaboration of concepts or propositions in cognitive structure from 'the top downwards'" (2:629).

Program Manager (PM). The single Air Force manager (system program director, program or project manager, or system or item manager) during any specific phase of the acquisition life cycle (14:2).

Reception Learning. Reception learning is "that kind of learning in which the entire content of what is to be learned is presented to the learner in more or less final form" (2:629).

Rote Learning. Rote learning is "the acquisition of arbitrary, verbatim associations in learning situations where either the learning material itself cannot be nonarbitrarily and substantively related to cognitive structure (that is, does not possess 'logical meaning') or where the learner exhibits a nonmeaningful learning set" (2:629).

Subsumptive Learning. Subsumptive learning is when "learning the meaning of a new concept or proposition that can be subsumed under a relevant, *more* inclusive particular idea(s) in cognitive structure; includes *derivative* and *correlative* subsumption" (2:630).

Teaching. Teaching is the process of "achievement of shared meaning in the context of educating" (6:62).

The Four Commonplaces of Educating. The four commonplaces of educating are teaching, learning, curriculum, and governance. These are the processes, expectations, and controls of the educating experience (6:25).

Overview of Thesis

Chapter II will summarize the theoretical basis for the survey conducted by this research. Chapter III will outline the methodology used to collect data needed to answer the research questions posed by the thesis. Chapter IV will present survey results concerning the job functions performed by acquisition managers and

make inferences about the statistical concept base GSM students can be expected to bring with them to AFIT. Chapter V will state the conclusions of the thesis and make specific recommendations for future research.

II. A Theoretical Model for Curriculum and Instructional Design

Introduction

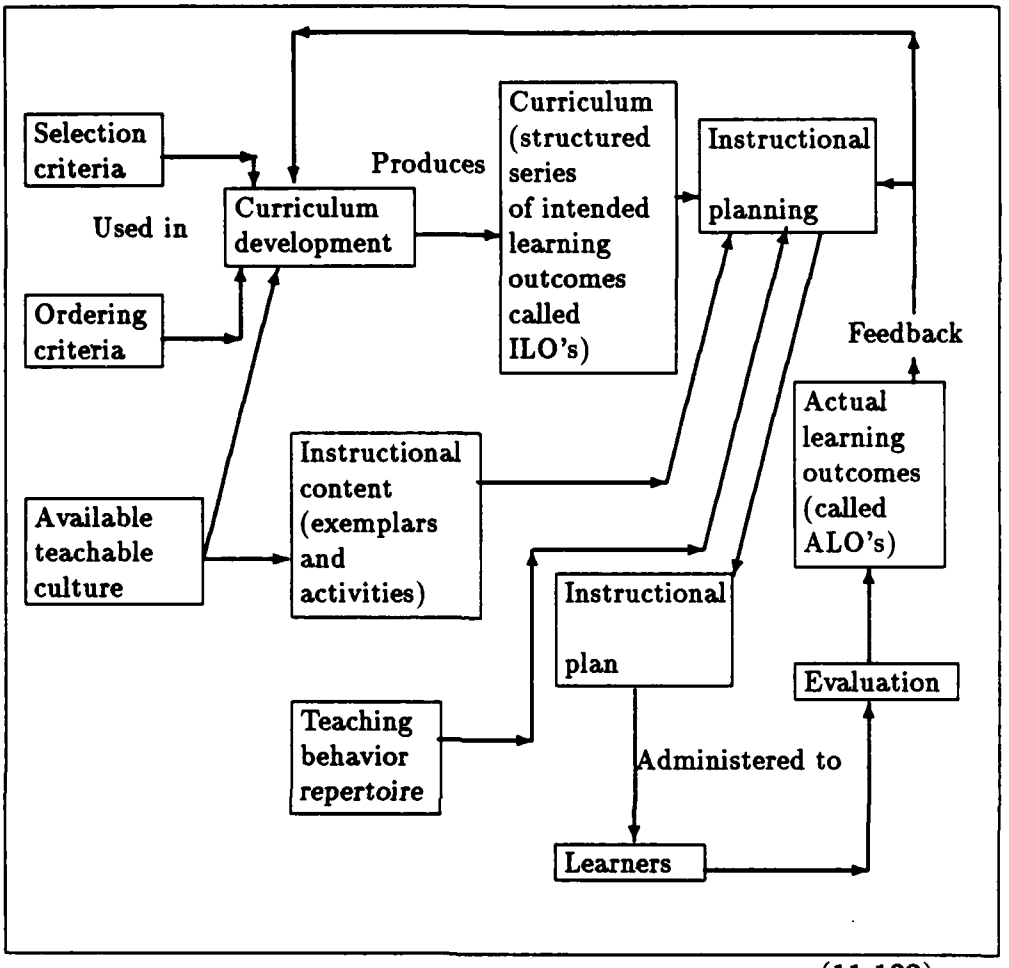
Establishing a meaningful learning environment ultimately requires decisions be made concerning ***what is to be taught*** and ***how it is to be taught.*** Educators must answer these two questions when performing the two major tasks of any course design: *Curriculum Development* and *Instructional Planning.* When the time came to develop a methodology to answer the research questions posed in Chapter I of this thesis, it became obvious that a model would be required to guide the development of the survey questionnaire.

Model Selection

After a review of many learning theories and models for course development, the model for Curriculum Development and Instruction proposed by Mauritz Johnson in a seminal paper entitled ***Definitions and Models in Curriculum Theory*** (10) was selected. Figure 1 displays the fundamental components of the model and provides a clear indication of the central roles played by what Johnson labels the Curriculum Development System and the Instructional System.

For purposes of this research, attention was focused on the boxes labeled Selection Criteria and Ordering Criteria and the two cells dealing with the product of Curriculum Development, the structured series of intended learning outcomes (ILOs) and the product of Instructional Planning, the Instructional Plan. ILOs were conceived of as a hierarchy of progressively differentiated concepts, implying that the curriculum should address the most general concepts of statistics first, and deal with the more refined notions embedded within each later.

> Although Johnson does not specify the form of ILO's, Ausbel's theory would indicate that these should be concepts to be learned, for



(11:132)

Figure 1: Johnson's (1967) model for curriculum and instruction

with them we effect meaningful learning. In other words, Johnson's "curriculum matrix" produced by the curriculum development system should be a matrix of concepts. To the extent possible, this matrix should suggest hierarchical and subordinate relationships between concepts, although this feature is in part confounded with the sequence in which concepts are taught and the specific exemplars used in instruction. Skills, attitudes, and values should be considered especially as they bear on learning of the concepts specified (11:138).

Development of a revised statistics curriculum mandates careful selection of concepts to be taught and formal assessment of linkages between the specific aspects of the discipline of statistics and the real world activities of GSM students.

This requirement provided the rational for posing the first two research questions of this thesis and, more generally, for proposing the two objectives of the research effort: to acquire data on the statistical background of entering students and to determine the major job functions performed by practicing acquisition managers. Unless the management culture of the entering GSM student is clearly defined, it will be impossible to divine what type of conceptual base he can be expected to bring to AFIT or what type of concepts should be taught once he arrives. Selection criteria proposed by Johnson's model document the need to carefully choose, from a vast array of concepts, those concepts that will satisfy GSM students' desire for new material as well as for material that takes into consideration the conceptual base each student brings to class. In Ausubelian terms, only if the new concepts to be taught find subsumption within the more familiar cognitive structure of the student can any schooling begin to facilitate the criteria established by Ausubel in the quote of Chapter I for "potentially meaningful learning tasks." Indeed, one of the things that made Johnson's model so attractive was that it graphically inspires one to fulfill David P. Ausubel's major dictum:

> If I had to reduce all of educational psychology to just one principle, I would say this: The most important single factor influencing learning is what the learner already knows. Ascertain this and teach him accordingly (2:preface).

The long term goal of several ongoing research efforts is to provide a formal matrix of specific statistical concepts for the curriculum of GSM students and to develop the instructional materials that foster applications of statistics that can be perceived as useful by GSM students. Thus, it was very reassuring to read in Joseph Novak's book, *A Theory of Education*, the following endorsement for Johnson's model's ability to facilitate completion of the goal of this thesis effort: to build a data base that can provide the information required to select the concepts of statistics to be taught and to build the scenarios that will illustrate the application of statistics in acquisition management.

> If learning is to be meaningful, then new knowledge to be learned must have relevant anchoring concepts available in the learner's cognitive structure. Since an enormous array of information is to be learned in any discipline, only the most general, most inclusive concepts are likely to provide anchorage in a wide variety of learning situations. Johnson's stress on selection criteria for curriculum planning can be related to Ausubel's stress on subsumption, starting with the most general, most inclusive concepts. And Johnson's equal emphasis on ordering criteria can be linked to Ausubel's description of progressive differentiation of concepts in cognitive structure (10:137).

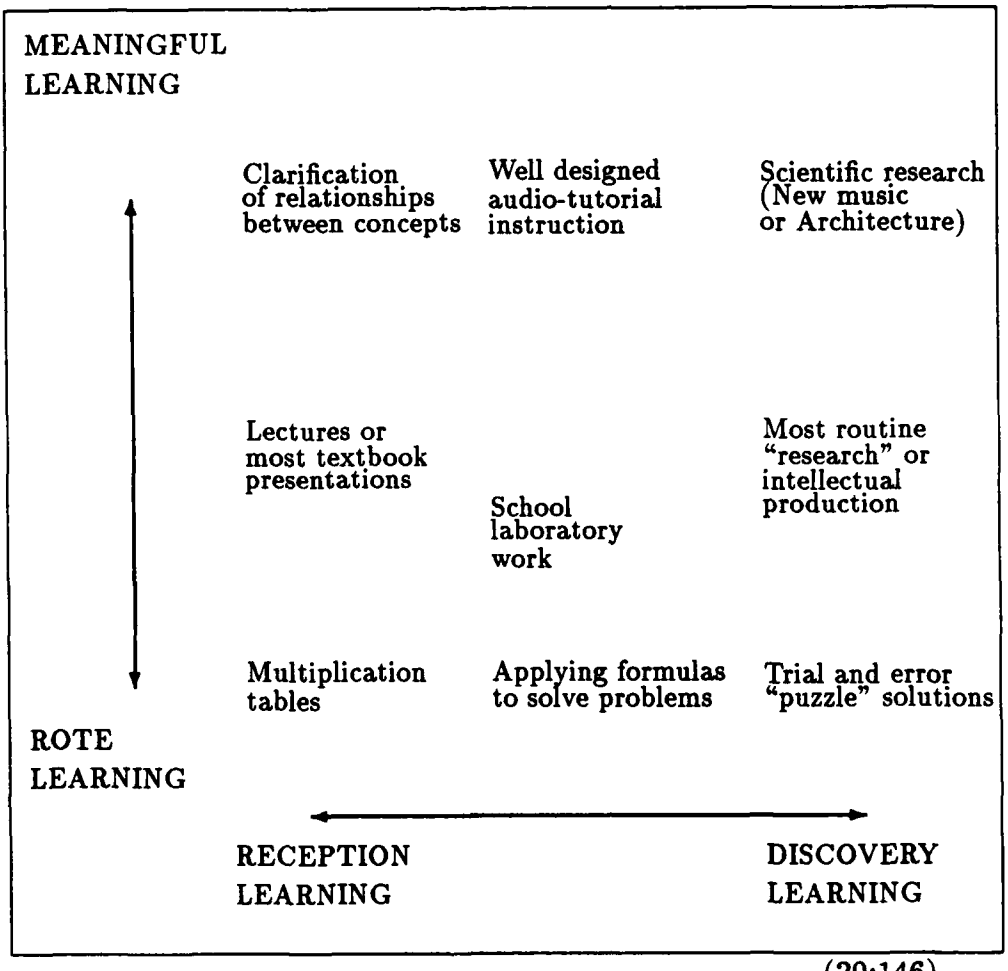
The Ultimate Goal: Meaningful Reception Learning

Before moving to Chapter III and a full discussion of the methodology proposed to meet the objectives of this research effort Johnson's model, and indeed, the whole effort of curriculum development and instructional planning, need to be seen as merely one facet of the educating process. It seems the best way to do this is to point out that, while this thesis was able to address problems encountered in three out of the four commonplaces of education: Teaching, Learning, and Curriculum, the fourth: Governance, which may be the most important factor of all in trying to obtain a *meaningful learning environment*, was simply inaccessible to influence or investigation. Most importantly, the entire effort was conducted in light of the modes of learning proposed by David Ausubel.

Dimensions of Learning

Ausubel declares that two independent dimensions of learning create an opportunity for four different types of learning experience for the student. Figure 2 lays out these dimensions graphically.

Whereas *meaningful learning* implies subsumption of new concepts by concepts in a students current cognitive structure, *rote learning* leads to arbitrary inclusion of such concepts. Whereas, *reception learning* implies receiving ex-



(20:146)

Figure 2: Dimensions of Learning

clusively from someone else, *discovery learning* involves becoming aware of a concept or major insight without outside help. Although there are four extreme combinations: ROTE/RECEPTION, ROTE/DISCOVERY, MEANINGFUL/RECEPTION, and MEANINGFUL/DISCOVERY. Ausubel makes it very clear which he believes takes priority in the classroom:

> As shown in Figure [2], neither meaningful nor discovery learning is an absolute. Rather, each can be located on the rote-meaningful and reception-discovery continua. For logistical reasons, most classroom learning, especially in older pupils, is meaningful reception learning.

> However, for certain kinds of learning, and in younger learners, some degree of rote and discovery learning is indicated ... (2:4).

Summary

At AFIT, it appears that because of time constraints and an enormous course overload most learning is *rote/reception.* Numerous testimonies of students and faculty reveal that while the desire is present on the part of both faculty and students for elevation to a *meaningful/reception* mode during classroom periods and *meaningful/discovery* mode during research quarters, the domination of the Governance, which so far chooses to impose overwhelming workloads and scheduling constraints resulting in too few quarters for study of too much material, has virtually precluded any reasonable progress toward the worthy goal of creating a meaningful learning environment at AFIT.

On the other hand, as results of this thesis reveal, many innovative and creative changes can be made *in the commonplaces* of the Teaching and Learning, and most importantly, to the Curriculum. If any one of these innovations succeed, the chances for a more meaningful involvement of students with statistics, in particular, and with the education process, in general, will rise drastically.

Therefore, while the goal of this thesis was very ambitious, the limitations imposed on this particular attempt at producing a more meaningful learning environment were severe. Forever optimistic that a small change can sometimes initiate a large–scale transformation, the thesis objectives were diligently pursed. And, as will be be reported in later chapters, while it appears the major thrust of the statistical program is consistent with the needs of the field, a great deal more effort must be given to designing a curriculum that fully acknowledges the conceptual maturity of each student and which makes a supreme effort at addressing specific examples of applications that demonstrate the utility of applying statistics to the student. Only with such salesmanship can powerful successes within the

commonplaces of Teaching and Learning have any hope of perturbing Governance to a new center of gravity.

With Johnson's Model and Ausubel's Learning Theory in hand, the research effort proceeded to develop a survey that was ultimately submitted to the field of 27XX acquisition managers for completion. Specific questions posed by the survey instrument and the data analysis used to evaluate the questionnaire are outlined in Chapter III. The survey's findings are fully documented by Chapter IV.

III. Methodology

Introduction

As discussed in Chapter II, the establishment of a meaningful learning environment requires decisions be made concerning ***what is to be taught*** and ***how it is to be taught.*** The methodology presented in this chapter was developed to discover the conceptual base potential students can be expected to bring to AFIT and to identify the statistical concepts they should be taught in statistical courses they take at AFIT. The chapter itself is divided into four major sections; survey sample population identification, survey instrument development, survey administration, and statistical analysis of survey data.

Survey Sample Population Identification

The population of interest included military acquisition systems managers with the 27XX AFSC. In order to meet the research objectives and answer the research questions, it was determined that this population should be divided into four groups as follows: AFSCs 2716 and 2724 with and without an AFIT Systems Management Masters Degree. This is illustrated in Figure 3. The sample population was selected using a modified four-way stratified sampling model. The sampling of acquisition managers (AFSCs 271X and 272X) without an AFIT masters degree was accomplished on a proportional basis, while the sample of acquisition managers (AFSCs 271X and 272X) with an AFIT masters degree involved an attempt at taking a full census. The survey collected data on job tasks performed and statistical technologies used by each strata of interest.

Personnel were identified by strata from data contained in the ATLAS data base maintained by the Air Force Manpower and Personnel Center (AFMPC). To be selected respondents had to be stationed in the CONUS area and hold a duty

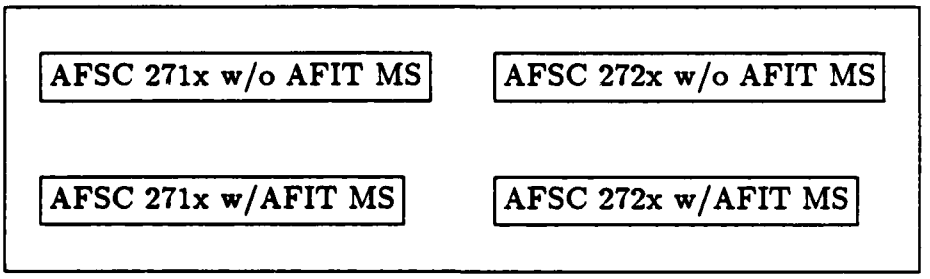


Figure 3: All Four AFSCs Strata Illustrated

AFSCs of 2711, 2716, 2721, or 2724. The distribution of ranks and number of personnel identified by ATLAS (16) are shown in Table 1 and the distribution of these personnel among the major commands identified from *Officer Authorizations Listing* (18) is shown in Table 2.

Table 1: Rank Distribution of Survey Population

	Total 27xx AFSC	AFSC 271x w/o AED	AFSC 271x with AED	AFSC 272x w/o AED	AFSC 272x with AED
2nd Lt	360	0	0	360	0
1st Lt	459	0	0	455	4
Captain	662	65	10	507	80
Major	441	333	43	57	8
Lt Col	475	410	61	2	2
Col	112	105	7	0	0
	2509	913	121	1381	94

Based on sampling statistics, a representative sample of each population was obtained. The following formula was used for determining the maximum sample size from a given finite population.

$$n = \frac{N(z^2) \times p(1-p)}{(N-1) \times (d^2) + (z^2) \times p(1-p)} \quad (1)$$

Table 2: MAJCOM and SOA Distribution of Population*

Organization	AFSC 271x	AFSC 272x	Total 27xx AFSC
AFSC	914	1067	1981
AFCC	8	5	13
SAC	7	0	7
TAC	3	11	14
MAC	7	3	10
AFLC	25	39	64
SPC	16	16	32
Other	55	35	90
Air Staff	83	11	94
HQ AF	126	120	246
SAF	4	0	4
	1248	1307	2555

* — NOTE: From *Officer Authorizations Listing*, as of EOM APR 8 (1986).

where n: sample size
N: population size
p: maximum sample size factor (0.50)
d: desired tolerance (0.10)
z: factor of assurance for confidence level (0.90)

Using Formula 1 the return sizes shown in Table 3 were required to achieve a 90 percent confidence level and ± 10 percent confidence interval (21). Based on an expected return rate of 60 percent, the calculated sample size was adjusted to account for expected non-returned surveys. This new sample size is shown in Table 4. More specific sample and return information is displayed in Table 5.

Survey Development

The data collection instrument for this survey was 27XX Systems Manager Survey, SCN 87-77, dated 8 June 1987. The survey developed to answer the re-

Table 3: Rank Distribution of Survey Sample for 90 percent Confidence Level

	Total 27xx AFSC	AFSC 271x w/o AED	AFSC 271x with AED	AFSC 272x w/o AED	AFSC 272x with AED
2nd Lt	59	0	0	59	0
1st Lt	78	0	0	75	3
Captain	165	15	7	83	60
Major	121	76	30	9	6
Lt Col	137	94	42	0	1
Col	29	24	5	0	0
	589	209	84	226	70

search questions contained five sections and can be found in Appendix A. The first, a background section, was designed to gather demographic information about the respondents. The second section contains a list of 61 task functions performed by personnel in the 27XX utilization field, these job task functions were designed to gather information about the level of involvement with decisions and actions concerning the respondents. The third section is composed of a list of 20 Professional Continuing Education (PCE) courses which could have been taken by entering AFIT Students. The fourth section contains a list of 10 academic courses, all of which are related to statistics and are available at all levels of education. These PCE and academic courses were selected to gather information about the level of completion and concept utilization relative to the respondent. The last section was for comments.

Demographics. In this part of the survey, the respondent was requested to provide information concerning his/her military and academic background and current job. These items were rank, duty AFSC, highest academic degree, in what field(s) were their bachelors (BS) in, if they had an AFIT Masters of Science

Table 4: Rank Distribution of Survey Sample

	Total 27xx AFSC	AFSC 271x w/o AED	AFSC 271x with AED	AFSC 272x w/o AED	AFSC 272x with AED
2nd Lt	98	0	0	98	0
1st Lt	128	0	0	124	4
Captain	254	25	10	139	80
Major	194	127	43	16	8
Lt Col	221	156	61	2	2
Col	54	47	7	0	0
	942	355	114	379	94

(MS), what major command they were assigned, what their current job was, how many people did they supervise, and how much experience as a 27xx did they have.

Survey Task Function. In the task function section of the survey, respondents were asked to rate each task on a 5-point scale indicating the relative amount of decision making or action taken on that task. The rating scale ranged from one (no role) to five (sole role), with a rating of three representing a moderate role in performing a task.

Factors. The job function areas of interest are listed in Table 6. These eleven areas are described in Air Force Regulation, Officer Air Force Specialty (AFR 36-1), for Acqisition Management Officer (AFSC 2716) and Acquisition Project Officer (AFSC 2724). These areas are as follows; overall program management, program office management, plans and manages acquisition programs, manages personnel subsystems function, performs data management, assists in configuration management, assists in program control performs test and deploy-

Table 5: Survey Sample Distribution

	Number	Percent
Total Personnel Assigned 27xx Duty AFSC*	2509	
Total Eligible Personnel Surveyed	942	
Percent of Assigned Personnel Surveyed		37.5
Total Surveys Returned	556	
Percent of Returned Surveys		59.0
Total Returned Undelieverable Surveys	28	
Percent Undelieverable Surveys		3.0
Total Removed From Returned Surveys**	13	
Percent Removed From Returned Surveys		1.4
Total Usable Surveys	515	
Percent Usable Surveys		54.6

* – As of 12 May 1987, ATLAS STAT SUMMARY INQUIRY 16575.
** – Excludes surveys from personnel with less than 6 months experance on the job and eliminations based on response errors.

ment operations, provides acquisition program integrated logistics support, staff functions, and acquisition program support (17:A10-31–A10-34).

Functions. These eleven areas can be reduced to six task functions; cost, budget, schedule, technical performance, logistics, and administration. The relationship of the job factors with the task functions is shown in Table 7. The question grouping being used for the reduction of the job factors to the six function areas can be seen in Table 8.

Variables. The questions selected for the job task function section are the variables. These questions were selected and designed to be a cross section of the duties performed by the personnel making up the 27xx AFSC. The types of duties included were related to the eleven areas shown in Table 6.

Table 6: Acquisition Management Job Factor Areas

Number	AFSC	Job Factor
1	2716	Overall Program Management
2	2716	Program Office Management
3	2716/2724	Plans and Manages Acquisition Programs
4	2716/2724	Manages Personnel Subsystems Function
5	2716/2724	Performs data management
6	2716/2724	Assists in Configuration Management
7	2716/2724	Assists in Program Control
8	2716/2724	Performs Test and Deployment Operations
9	2716/2724	Provides Acquisition Program Integrated Logistics Support
10	2716	Staff Functions
11	2716	Acquisition Program Support

Professional Continuing Education (PCE) Courses. In the third section of survey, respondents were asked to answer "if they had completed a particular PCE course," and if the response was "YES," to answer the next part. This part of the question asked "if they had found use for the course material in their current duties," and if so, to mark the response which was correct in their case. The purpose of these questions was to identify which courses an entering GSM student can be expected to have taken before entering AFIT and whether or not he has used the concepts covered by such courses. Courses for which a double positive response occurred were used to identify the applicability of PCE courses entering GSM students had previously taken. This information was also used to help construct the expected *PCE course* background of these students. A number of relevant courses were left out, because they are not normally available to company grade officers (i.e., Defense Systems Management College's Program Management Course).

Table 7: Acquisition Management Job Factor Areas verses Task Function

Job Factor	Cost	Budget	Schedule	Technical	Logistics	Administration
1	X	X	X	X	X	X
2	X	X	X	X	X	X
3	X	X	X	X	X	X
4			X	X	X	X
5				X	X	X
6				X		X
7	X	X	X			
8			X	X	X	X
9	X	X		X	X	X
10		X				X
11			X	X	X	X

Academic Statistical Courses. In the fourth section of the survey respondents were asked to complete the same type of questions as in the third section. These questions were designed to identify which statistical courses an entering GSM student could be expected to have taken before attending AFIT and whether or not he had used the concepts covered by the course. As was done with the PCE courses, academic courses for which a double positive response occurred were used to identify the applicability of ***statistical courses*** entering GSM students had previously taken. This information was also used to help construct the expected statistical course background of these students. The statistical course topics included in the survey were selected with the availability of the courses to field personnel in mind.

Comments. The last section of the survey was for comments. This is where the respondent could address any topic he felt needed to be addressed either because of an omission of an important item in the survey or because he/she just wanted to make a personal observation.

Table 8: Survey Items Categorized by Task Functions

Job Task Function	Survey Item Number
Cost	10, 18, 32, 34, 36, 38, 41, 49, 55, 60, 63, 65
Budget	17, 20, 22, 24, 26, 30, 40
Schedule	25, 29, 45, 57, 62
Technical Performance	11, 16, 35, 39, 42, 43, 48, 54, 58, 64, 66, 68
Logistics	13, 14, 21, 28, 31, 51, 59, 67, 69
Administration	12, 15, 19, 23, 27, 33, 37, 44, 46, 47, 50, 52, 53, 56, 61, 70

Survey Administration

From June 1987 through August 1987, 27XX Systems Manager Surveys were administered to a randomly selected group of personnel in the field of system acquisition management (AFSC 27XX). The surveys were distributed to the subjects through the mail using the BITS system whenever possible. The subjects were sent the survey by name through their organization of record. The package the subjects received contained the survey and a return envelope. The survey contained instructions on how to fill out the survey and how to return the survey. The surveys were returned by mail to AFIT/LSG by the individual subject in the provided envelopes. When the survey arrived at AFIT/LSG there was no way to identify the returned survey with any of the individuals sent surveys. This way

the individual was granted anonymity. The surveys were then coded on to optical scan forms for data processing.

Statistical Analysis of Survey Data

Surveys returned from the field were entered into the AFIT computer at Wright-Patterson AFB by optical scanning. The Statistical Analysis System (SAS) was then used to analyze the data. The SAS program is capable of producing a variety of computer printouts based on survey respondent ratings on tasks, PCE courses, and academic courses, and background information.

Reliability Check. Cronback's alpha was calculated in order to make a task function question reliability check. Questions 10 through 70 were run through the reliability check. It was decided that an alpha value greater than or equal to 0.8 would consistute an adequate reliability coefficient.

Format Used for Developing the Research Questions. The following format is used in developing all of the research questions methodology. The topics discussed in each question area are the population of interest, research hypothesis, statistical test selection or descriptive procedures, test statistic if needed, assumptions, focus if the null is rejected, and limitations. In the following sections on the research questions the specific methods of analysis will be discussed.

Research Questions 1 and 2. The first two research question that needed to be answered were,

Research Question 1: ***What coursework and, more specifically, what exposure to statistical concepts via academic and/or Professional Continuing Education study have potential GSM students received?*** and

Research Question 2: *What statistical concepts have found application in the environment of potential GSM students?*

Population of Interest. The population of interest in both cases was the 27xx without an AFIT masters degree and holding a grade of major or below. This subset of the survey data was selected because it is representative of the population of the potential students for the GSM program.

Research Hypothesis The research hypothesis for both of these questions was that there is an association between whether a person takes a course and whether he is able to use that course.

Statistical Test Selection. The statistical test selected was a Test for Independence. An example of the table used is shown in Figure 4. The research hypothesis was converted to the following set of statistical hypotheses.

$$H_o : p_{ij} = p_i \cdot p_j; \qquad \text{for} \quad i = \text{YES, NO} \quad \text{and} \quad j = \text{YES, NO} \tag{2}$$

$$H_a : H_o \text{ is not true} \tag{3}$$

Where p_{ij}: is the probability for that cell
p_i: is the probability for the category of completed course
p_j: is the probability for the category of used course on the job

Test Statistic. χ^2 was used as the test statistic for this test. Its use requires that probability values for each cell must be found. The values of $p_{i.}$ and $p_{.j}$ are not readily available, therefore must be estimated. Devore derives the "estimated expected cell count" (5:550) and presents the following proposition:

QXXA(Completed course)

QXXB(Used course)

FREQUENCY PERCENT	YES	NO	TOTAL
YES	NN yy.yy	NN yy.yy	MM kk.kk
NO	NN yy.yy	NN yy.yy	MM kk.kk
TOTAL	PP qq.qq	PP qq.qq	XX sss.ss

FREQUENCY MISSING = QQQ

STATISTICS FOR TABLE OF QXXA BY QXXB

STATISTIC	DF	VALUE	PROB
CHI-SQUARE	N	x.xxx	z.zzz

Figure 4: Two–Way Contingency Table Example

When the null hypothesis of independance of factors is true and $\hat{E}_{ij} \geq 5$ for all i, j, the statistic

$$\chi^2 = \sum_{i=1}^{I} \sum_{j=1}^{J} \frac{(N_{ij} - \hat{E}_{ij})^2}{\hat{E}_{ij}}$$

has approximately a chi-squared distribution with $(I-1)(J-1)$ degrees of freedom (ν). A test for H_o versus H_a which has approximate level α consists of rejecting H_o if $\chi^2 \geq \chi^2_{\alpha,(I-1)(J-1)}$ (5:551).

An alpha of 0.05 was used to establish the critical value for the test statistic.

According to Devore the formula for degrees of freedom (ν) is,

$$\nu = (I-1)(J-1) \tag{4}$$

In this situation, ν is

$$\nu = (2-1)(2-1) = 1 \tag{5}$$

Where I: is 2
J: is 2

Using this information and a statistical table for χ^2, the critical value of $\chi^2_{\alpha,(I-1)(J-1)}$ was found to be 3.843.

Decision Rule. If $\chi^2 \geq 3.843$ reject H_o in favor of H_a.

Assumptions. The statistical and practical assumptions for this test are discussed below.

Statistical. The statistical assumptions were as follows;

1. An independent random sample has been taken.
2. The expected frequency of each cell is at least five (5).
3. Each respondent belongs to one and only one of the I categories for *completed course* and one and only one of the J categories for *used course on the job.*

Practical. The practical assumption was that the individuals surveyed understand at least enough about acquisition management to make statements concerning course application to their current duties.

Focus, if the Null is Rejected. Only if the *Yes/Yes* response in the table was found to exceed 70 percent of the total responses, was the course considered important enough to be included in the set of courses that would be used to answer research questions 1, 2, and 4.

Limitations. The data used to answer research questions 1 and 2 was garnered under the following constraints:

1. The data could not be used to predict an estimate statistical concept structure of any particular entering GSM student, but instead would be an indicator of the typical cognitive structure brought to AFIT by entering acquisition management GSM students.

2. Due to the limitation of space and respondents time the number of courses was restricted to twenty PCE and ten statistical courses.

Research Question 3. The research question was, *What particular job functions are currently being accomplished by acquisition managers?*

Population of Interest. The population of interest in this case was the entire sampled 27xx population.

Research Hypothesis. The research hypothesis for this question was that the functions could be ranked based on their mean task function scores.

Statistical Test Selected. The statistical test selected was an analysis of variance (ANOVA). The research hypothesis was converted to the following set of statistical hypotheses:

$$H_o : \mu_{cost} = \mu_{budget} = \mu_{schedule} = \mu_{techn} = \mu_{log} = \mu_{admin} \quad (6)$$

$$H_a : \mu_{cost} \neq \mu_{budget} \neq \mu_{schedule} \neq \mu_{techn} \neq \mu_{log} \neq \mu_{admin} \quad (7)$$

ANALYSIS OF VARIANCE PROCEDURE

DEPENDENT VARIABLE: XXXX

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE
MODEL	$I-1$	$\frac{1}{J}\sum_{i=1}^{I} X_{i\cdot}^2 - \frac{1}{IJ}X_{\cdot\cdot}^2$	$\frac{\frac{1}{J}\sum_{i=1}^{I} X_{i\cdot}^2 - \frac{1}{IJ}X_{\cdot\cdot}^2}{(I-1)}$
ERROR	$I(J-1)$	$\sum_{i=1}^{I}\sum_{j=1}^{J}(X_{ij} - \bar{X}_{i\cdot})^2$	$\frac{\sum_{i=1}^{I}\sum_{j=1}^{J}(X_{ij}-\bar{X}_{i\cdot})^2}{I(J-1)}$
CORRECTED TOTAL	$IJ-1$	$\sum_{i=1}^{I}\sum_{j=1}^{J} X_{ij}^2 - \frac{1}{IJ}X_{\cdot\cdot}^2$	
MODEL F =		$\frac{\frac{1}{J}\sum_{i=1}^{I} X_{i\cdot}^2 - \frac{1}{IJ}X_{\cdot\cdot}^2}{(I-1)}$ / $\frac{\sum_{i=1}^{I}\sum_{j=1}^{J}(X_{ij}-\bar{X}_{i\cdot})^2}{I(J-1)}$	PR > F = x.x

Figure 5: Analysis of Variance Illustration

where μ_{cost}: is the sample mean of the cost task function area.

μ_{bud}: is the sample mean of the budget task function area.

μ_{sch}: is the sample mean of the schedule task function area.

μ_{techn}: is the sample mean of the technical performance function area.

μ_{log}: is the sample mean of the logistics task function area.

μ_{admin}: is the sample mean of the administration task function area.

H_a is to be read as *at least one group mean is different from another.* The *null* hypothesis is that the means are the same, while the *alternate* hypothesis is th .t at least two means are different. An example of the ANOVA output used is shown in Figure 5.

Test Statistic. The F test was used as the test statistic for this test. To use the F test, two variances must be estimated. These variances are denoted by $\hat{\sigma}_B^2$ for the between-sample estimator and $\hat{\sigma}_W^2$ for the within-sample estimator. The formula for the $\hat{\sigma}_B^2$ is

$$\hat{\sigma}_B^2 = JS_{\bar{X}}^2 = \frac{\sum_{i=1}^{I}\sum_{j=1}^{J}(\bar{X}_{i\cdot} - \bar{X}_{\cdot\cdot})^2}{I-1} \tag{8}$$

and the formula for $\hat{\sigma}_W^2$ is

$$\hat{\sigma}_W^2 = \frac{\sum_{i=1}^{I} S_i^2}{I} = \frac{\sum_{i=1}^{I}(X_{ij} - \bar{X}_{i\cdot})^2}{I(J-1)} \tag{9}$$

The F test then used the formulas above in the form shown below,

$$F = \frac{\hat{\sigma}_B^2}{\hat{\sigma}_W^2} \tag{10}$$

In order to use the formula for F to find the critical value of F for this test the value of α, the numerator degrees of freedom (ν_1), and the denominator degree of freedom (ν_2) must be identified and found. A value of 0.05 was selected for α. The value of ν_1 is found using the formula,

$$\nu_1 = I - 1 = 6 - 1 = 5 \tag{11}$$

The value of ν_2 is found using the following formula,

$$\nu_2 = I(J-1) = 6(515-1) = 3084 \tag{12}$$

With the above values and an F table (5:624-625) for F, the critical value of $F_{\alpha,I-1,I(J-1)}$ was found to be 2.21 (5:343-353).

Decision Rule. The decision rule for the F test is to reject H_o in favor of H_a if $F \geq 2.21$.

Assumptions. The statistical and practical assumptions for this test are discussed below.

Statistical. The statistical assumptions were as follows;

1. "The variables $X_{ij}(i =, \ldots, I$ and $j = 1, \ldots, J)$ are independent of one another with $E(X_{ij}) = \mu_i$, $Var(X_{ij}) = \sigma^{2}$" (5:347).

2. Each X_{ij} is a normally distributed variable, if all I populations were normal populations (5:348).

Practical. The practical assumption was that the individuals surveyed understand at least enough about acquisition management to make statements concerning course application to their current duties.

Focus, if the Null is Rejected. If H_a was rejected, the Tukey procedure was to be used to establish the ranking of the functions based on the mean task function scores.

Limitations. The information gathered to answer research question 3 is unsuitable for developing an estimation of the job task structure in any given program/project, but is instead is an indicator of the relative job task structure used by acquisition managers.

Research Question 4. The fourth research question was, ***Given a particular job function what statistical technologies are being used to help solve management problems associated with that job function?***

Population of Interest. The population of interest in this case was the entire 27xx population.

Activity Group	Task Function Correlation	Course 1 YES/YES	... YES/YES	Course n YES/YES	Row Totals YES/YES
Program/ Project Manager	Positive	NN	...	NN	MM
	Unclear	NN	...	NN	MM
	Negative	NN	...	NN	MM
Functional Manager	Positive	NN	...	NN	MM
	Unclear	NN	...	NN	MM
	Negative	NN	...	NN	MM
Others (i.g., HQ AF, PEMs)	Positive	NN	...	NN	MM
	Unclear	NN	...	NN	MM
	Negative	NN	...	NN	MM
All	Positive	NN	...	NN	MM
	Unclear	NN	...	NN	MM
	Negative	NN	...	NN	MM

Figure 6: Course Job Factor/Task Correlation Description Illustration

Motivation for Research Question 4. The motivation for this question was to discover if a relationship between statistical courses/statistical concepts and specific functions could be inferred.

Descriptive Procedure. The end result of the procedure established to answer the research question 4 was a table of counts in the form of Figure 6. Each respondents ranking of the six task functions was correlated with the populations ranking of the functions and then used to categorize each individual into a task correlation group within one of three activity groups. Then for each respondent an accounting was made of any course containing a double positive response if the course had been identified during the resolution of research questions 1 and 2 as containing a significant number of double positive responses. A large number of individuals in a high positive correlation task function group and course cell would be taken as sufficient evidence to support an inference that concepts taught in the course were being widely applied by 27xxs in that activity group.

Summary

In this chapter, the methodology has been developed that was used to discover the conceptual base potential students can be expected to bring to AFIT and to identify the statistical concepts that should be taught in statistical courses they will take at AFIT. Chapter IV will present the results of application of the methodology proposed by this chapter.

IV. Analysis of Survey Results

Introduction

This chapter analyzes the findings and results of the survey conducted by this thesis effort. It is divided into two major sections:

1. Presentation and analysis of demographic data, and
2. Presentation and analysis of answers provided by the survey to each research question.

Presentation and Analysis of Demographic Data

The surveys were mailed to 942 personnel assigned the duty AFSC of 271x or 272x. Overall 556 surveys were returned. Of the 556 surveys received, 28 were returned unopened and 13 were unusable (due to personnel not having more than six months experience as a 27xx and response errors). This left 515 surveys to build the research data base with (54.3 percent response rate).

Findings and Analysis. The respondent supplied the following information concerning his military and academic background and current job; rank, duty AFSC, highest academic degree, in what field(s) were their bachelors (BS) in, if they had an AFIT Masters of Science (MS), what major command they were assigned, what their current job was, how many people did they supervise, and how much experience as a 27xx did they have.

The "typical" acquisition manager can be described by using the modal categories of the demographic questions, shown in Table 9. He is a captain with a 2724 AFSC. He possesses a bachelors degree in engineering/technology and a non-AFIT masters degree. Assigned to the Air Force Systems Command (AFSC)

he performs the duties of a program/project manager that require supervision of himself or one other person. He typically has two to four years of acquisition experience. The demographic information from the data base is displayed in Appendix C (in Figures 7 through 16).

Table 9: Summary of Demographic Data

Question # and Topic	Modal Response	Percent Response
Q1 – Rank	Captain	28.9
Q2 – AFSC	2724	52.2
Q3 – BS/MS/PhD	MS	62.1
Q4 – BS Major	Engineering/Technical	59.8
Q5 – AFIT Graduate or not	Non-AFIT Graduate	69.1
Q6 – Major Command	AFSC	79.0
Q7 – Duty Title	Program/Project Manager	46.6
Q8 – Supervisor	0-1 people	58.4
Q9 – Acquisition Experience	2 years ¡ 4 years	31.8

Cronback's alpha reliability coefficient was used to assess the reliability of the survey (shown in Appendix A). Coefficient alpha and the standardized alpha were both greater than 0.97, hence well above the minimum value established for declaring attainment of sufficient reliability in chapter III. The coefficient of alpha for each question was found to be greater than 0.97. This information is also available in Appendix C in Table 17 through 18.

Presentation and Analysis of Answers Provided by the Survey

Research Question 1 and 2. The two research questions were,

1. ***What coursework and, more specifically, what exposure to statistical concepts via academic and/or Professional Continuing Education study have potential GSM students received?***

2. *What statistical concepts have found application in the environment of potential GSM students?*

Findings. The respondents used in this part supplied information concerning PCE course exposure and utilization. The data may be found in the summary table displayed in Appendix C (in Table 12). Courses listed below were found to meet the criteria of exceeding the statistical test critical value and of exceeding the level of 70 percent for the category taken and used as defined in chapter III. According to the data the "typical" potential student has taken the following PCE courses that he has found use for on the job; SAS 001/SYS 100/SYS 123, SYS 028, SYS 200/SYS 223, SYS 229, and DSMC CPM.

The following descriptions of the above courses are provided to show the concepts/content of the courses.

SAS 001/SYS 100/SYS 123. The courses SAS 001, Introduction to systems Command Acquisition Management; SYS 100, Introduction to Acquisition Mangement; and SYS 123, Fundamentals of Acquisition Mangement; are grouped together as they are very similar courses. These courses provide the following, "[c]urrent concepts of acquisition management (DoDD 5000.1 and AFR 800-2) and problem areas in the acquisition process" (19:51).

SYS 028. This course SYS 028, Introduction to Configuration Management provides the following, "basic philosophy and practices of configuration Management ... [relating to] the key areas of configuration management (namely identification, audits, change control, and status accounting) ... " (19:30).

SYS 200/SYS 223. The courses SYS 200, Acquisition Planning and Analysis and SYS 223, System Program Management provide the following,

"content in three management functional areas: planning, executing, and controlling ... such as generating a POM, writing a SOW, using cost estimating resources, analyzing contractor performance and developing planning networks" (19:69).

SYS 229. This course SYS 229, Test and Evaluation Management provides the following, "... test planning, test reporting, and special issues ... insight into test management and constraints, and difficulties ... in any T&E program" (19:85).

DSMC CPM. This course DSMC CPM, Defense Systems Management College; Contractor Performance Measurement provides the following, "instruction in analysis techniques [to] enable ... the student to determine current status, forecast performance trends, and estimate ... contract cost at completion" (4:5-F-5).

Respondents also supplied the information concerning academic statistic course exposure and utilization. According to the data the "typical" potential student appears to have not taken *and* used any of the statistics courses listed in the survey by the same criteria used above for acceptance of the course for consideration as defined in chapter III. This data may be found in the summary table displayed in Appendix C (in Table 13).

Analysis. The courses identified might refer to statistics theory but they do not directly teach statistical concepts. This leads to an inference that the potential acquisition manager GSM student has not had previous course work in statistics and the the exposure to applied statistics lacked the rigor of formal statistics courses. In spite of the fact that several written comments on the survey responses indicated a need for statistical education and application, it appears

that the "typical" potential student has not found any application for statistical courses he may have taken.

A further inference can be made that the acquisition managers do not use statistical techniques directly. On the other hand, while the 27xxs may not use or perform statistical calculations themselves, they do have occasions to use or interpret statistics presented by others. The following comment taken from one of the surveys returned supports this.

> ... More important ... than understanding the technical details of various statistical methods, the greatest value of statistical courses ... to me as an acquisition manager has been learning to question input parameters, assumptions and output sensitivities! (See Appendix B)

While the survey indicates statistics is not viewed as having great relevance, written comments confirm the vitial nature of statistical education to the practicing acquisition manager.

> Statistics are misapplied so often that everyone should know how statistics works. Specifically, in evaluating weapon system performance, it is critical to recognize the proper distribution to use, sample size, and where varying Test Conditions invalidate test results. Unfortunately, a high percentage of Air Force Testing appears to not [illegible] good sample. Cost of assets and the numerous variables needed to duplicate the operational environment (which create the need for large sample sizes) often causes the evaluation of a weapon system's performance to degenerate into subjective feelings and guesses rather than objective evaluation based on an adequate sample size in testing (See Appendix B).

Such comments together with the survey data results indicate that while statistics is presently not a major factor in performing the acquisition process to the 27XX, it should be.

Research Question 3. The third research question was, ***What particular job functions are currently being accomplished by acquisition managers?***

Findings. The ANOVA was run as set forth in the methodology, and the results can be found in Appendix C (in Table 15). The F value was found to be 69.24, which exceeded the critical value of 2.21 determined in chapter III. Therefore, the research hypothesis that the functions could be ranked based on their means was supported. Through the use of the Tukey process, it was found there were four distinct mean groupings. These are shown in Table 10. Also, shown in the table are the rankings of the functions in following order (based on mean score); schedule, administration, budget, technical performance, cost, and logistics. The starred lines indicate there is no clear distinction between the means of the functions in that grouping. The groups involved are logistics/cost and budget/administration. The analysis section will relate these findings to the research question.

Table 10: Summary of ANOVA and Tukey results for the six Task Functions Data

Rank:	6	5	4	3	2	1
Function:	Logistics	Cost	Technical	Budget	Administration	Schedule
Means:	1.730	1.801	2.127	2.311	2.321	2.574
	**********	**********		**********	**********	
	Non-Quant	Quant	Quant	Quant	Non-Quant	Quant

Analysis. This ranking reflects the relative level of decision making and/or action taking done by these managers. The judgemental functions (Non-Quant) do not have a need for the statistical methods, while the quantitative functions (Quant) do use analytical mathematical methods.

Based on the results, shown in the table, scheduling is the function performed most by acquisition managers, followed by administration, budget, and technical

performance. Thus three out of the four most highly ranked functions acquisition managers perform are quantitative in nature. This is a curious result considering the indication provided by responses to research questions 1 and 2 which imply the most useful courses are of a non-statistical/mathematical nature. The lack of statistical sophistication implied by these two findings may indicate why systems acquisition has experienced problems such as schedule delays and cost overruns.

Research Question 4. The fourth research question was, *Given a particular job function what statistical technologies are being used to help solve management problems associated with that job function?*

Findings. The descriptive procedure was run as set forth in the methodology. The results of this procedure can be found in Table 11. As shown in the table there were no respondents in the *negative correlation* category. While the remaining two categories received the rest of the respondents correlation scores, the largest portion went to the *unclear correlation* category, with 94.4 percent of the respondents in the data base. This left the *positive correlation* category with 5.6 percent of the survey populations. The only category with large numbers of counts in them were SAS 001, SYS 100, and SYS 200 and these counts were in the unclear range of the correlation categories. This would indicate that concepts of these courses get a great deal of use.

Analysis. Based on these cell counts, there appears to be no way to associate the statistical concepts to a particular activity job group. Indeed, there are simply no statistical courses represented at all.

Chapter V will present the conclusions drawn from answers to these four research questions and make recommendations for further research.

Table 11: Summary of Course Activity/Correlation Data

Activity Group	Task Function	Brooks SAS 001	AFIT SYS 028	AFIT SYS 100	AFIT SYS 123	AFIT SYS 200	AFIT SYS 223	AFIT SYS 229	DSMC CPM
	Correlation	YES/ YES	YES/ YES	YES/ YES	YES/ YES	YES/ YES	YES/ YES	YES/ YES	YES/ YES
Program/ Project Manager	Positive	2	0	0	0	2	0	0	0
	Unclear	84	25	99	14	87	25	16	19
	Negative	0	0	0	0	0	0	0	0
Functional Manager	Positive	2	2	4	1	4	0	0	0
	Unclear	49	18	54	6	33	17	14	14
	Negative	0	0	0	0	0	0	0	0
Others (i.e., HQ AF, PEMs)	Positive	2	1	4	0	6	3	2	3
	Unclear	16	9	43	11	25	20	13	13
	Negative	0	0	0	0	0	0	0	0
All	Positive	6	3	8	1	12	3	2	3
	Unclear	149	53	198	32	146	62	44	47
	Negative	0	0	0	0	0	0	0	0

Where Positive: $(0.5) \leq (1.0)$
Unclear: $(-0.5) \leq (0.5)$
Negative: $(-1.0) \leq (-0.5)$

V. Conclusions and Recommendations

Summary

The purpose of this thesis was to collect basic information on the statistical concept base potential GSM students might bring to AFIT and to determine which statistical concepts are used by acquisition managers. The specific application of Ausubel's Learning Theory and Johnson's Curriculum Model was to statistics, even though both can be applied to other disciplines. The Theory and the Model were discussed in Chapter II.

In order to identify the statistical concepts entering students can be expected to possess and in order to facilitate an environment for meaningful learning this thesis sought to meet the following objectives:

1. To collect data on statistical background and work experience of acquisition managers, so an inference could be made concerning the statistical concept base of entering GSM students,

2. To determine the job functions being performed by acquisition managers, so that problems and exercises for statistical courses can be developed to represent the types of situations GSM students can be expected to encounter upon graduation from AFIT.

In developing the methodology, in Chapter III, to meet *objective 1* the following research questions were addressed:

1. What coursework and, more specifically, what exposure to statistical concepts via academic and/or Professional Continuing Education study have potential GSM students received?

2. What statistical concepts have found application in the environment of potential GSM students?

And to meet *objective 2* the following research questions were addressed:

3. What particular job functions are currently being accomplished by Acquisition Managers?

4. Given a particular job function, what statistical technologies are being used to help solve management problems associated with that job function?

The surveys were mailed to 942 personnel assigned the duty AFSC of 271x or 272x. Overall 556 surveys were returned. Of the 556 surveys received, 28 were returned unopened and 13 were unusable (due to personnel not having more than six months experience as a 27xx or response errors). This left 515 surveys with which to build the research data base with (54.3 percent response rate). These surveys were analyzed and the results shown in chapter IV. The conclusions drawn from these results are discussed next.

Conclusions

Three conclusions were reached and these were,

1. While there are indications that statistics is needed by acquisition managers, the current survey results show that the acquisition managers are not using any of the identified statistical course/concepts in their work.

2. While the top ranked task functions are primarily quantitative in nature, the courses most used are qualitative with little or no quantitative nature.

3. While the response was good to the survey, the use of this survey to try and infer the concepts entering acquisition management GSM students would bring to AFIT produced unclear results. Any attempt to infer an association

among the statistical concepts with the activity job groups will most likely require personal interviews of selected field personnel.

Recommendations

The following three recommendations for future research are proposed,

1. The use of personal interviews of acquisition managers should be used to discover the real need of acquisition managers for various statistical disciplines.

2. A way to assess the cognitive structure of the entering GSM student upon entry to AFIT should be developed.

3. Serious consideration should be given to what concepts ought to be taught and to new ways to teach such concepts so the general lack of appreciation of the real world value of statistical technology in the acquisition management field can be overcome.

The fact is project management requires the project managers to be very knowledgeable in project performance and possess the ability to recognize immediately when a problem requires their attention (3:365; 1:34-45; 9:21-22; 12). Such skills can only be exercised by someone who has acquired and mastered a broad range of analytical skills, including the corpus of concepts identified within the field of applied statistics.

Appendix A. Survey

DEPARTMENT OF THE AIR FORCE
AIR UNIVERSITY
AIR FORCE INSTITUTE OF TECHNOLOGY
WRIGHT-PATTERSON AIR FORCE BASE OH 45433-6583

REPLY TO ATTN OF: ENC (Lt Linnenburger/AUTOVON 785-5435) 8 June 1987

SUBJECT: 27XX Systems Manager Survey, SCN 87-77

TO: Survey Participant

1. As an officer in the 27XX career fied, you have been randomly selected to participate in the Air Force research project that may have a significant impact on your future.

2. We request that you answer the questions in the attached survey to help us gather data needed to establish a profile of 27XX managers' statistical background and the post-graduation benefits of statistical courses taught to 27XX students who attend AFIT's Professional Continuing Education (PCE) or Graduate Systems Management programs.

3. Please return your completed survey in the enclosed envelope within one week of receipt. All participants in this survey will remain anonymous. Participation in the survey is voluntary.

4. If you are interested in receiving a summary of the results of this research, please write to:

AFIT/LS (Lt Linnenburger)
Wright-Patterson AFB OH 45433-6583

We thank you for your support of this research effort.

DAVID K. MILLER, Lt Col, USAF
Acting Head
Department of Mathematics
and Computer Science

2 Atchs
1. Survey
2. Envelope

27XX Systems Manager Survey

USAF Survey Number SCN 87-77

expires: 30 September 1987

GENERAL INFORMATION

The purpose of this questionnaire is to obtain data concerning:

1. The statistical concepts 27XX students can be expected to have encountered prior to entry into AFIT's Graduate Program in Systems Management, and
2. The applicability of specific statistical technologies in the day-to-day working environment of 27XX officers.

This data will be used to enhance our ability to create statistical courses that are responsive to the real world needs of 27XX officers.

Please be assured that all information you provide will be held in the strictest confidence. Your individual responses will NOT be provided to management or to any other agency. Feedback on the study's results will be presented to management only in terms of group responses describing what the "typical" system manager would say. In addition, when the results of this study are published, readers will NOT be able to identify specific individuals or work groups.

Thank you for your cooperation in participating in this study. If you have any questions, please contact the researcher at the following address:

Lt Michael Linnenburger
AFIT/LS
Wright-Patterson AFB, OH 45433
Telephone: AUTOVON 785-5435

KEYWORDS

The following are definitions of key words that recur throughout the questionnaire:

1. Supervisor: The person from whom you take direction.

2. Work Group: All persons who take direction from you or work with you.

INSTRUCTIONS

This questionnaire contains 99 items (individual "questions"). The items must be answered by filling in the appropriate response in the space provided. If for any item you do not find a response that fits your situation exactly, mark the one that is the closest to the way you feel.

Part I.

Demographics

The statements below request information about your military and academic background and current job.

1. What is your rank?

1. 2nd Lieutenant
2. 1st Lieutenant
3. Captain
4. Major
5. Lieutenant Colonel
6. Colonel

2. What is your current **DUTY** AFSC?

1. 2721
2. 2724
3. 2711
4. 2716

3. What is the highest academic degree you hold?

1. Bachelors Degree
2. Masters Degree
3. Doctorate Degree

4. In what field is (are) your bachelors degree(s) (Mark more than one if necessary)?

1. Arts
2. Business
3. Engineering
4. Sciences
5. Management
6. Math
7. Other (specify)

---

5. If you have a Masters Degree from AFIT, what education code identifies your degree?

1. Systems Management, 1ASY
2. Engineering Management, 1AGY
3. R& D Management, 1APY
4. Other (specify)

6. To which Major Command are you assigned?

1. AFSC
2. AFCC
3. SAC
4. TAC
5. MAC
6. AFLC
7. Space Command
8. Other (Please Specify)

_____

7. How would you classify the job function in which you currently work?

1. Program/Project manager
2. Test manager
3. Logistics manager
4. Financial manager
5. Configuration/Data manager
6. Project Engineer
7. Program Administration
8. Contract manager
9. Production/Manufacturing manager
10. Staff
11. Other (specify)

_____

8. How many people do you directly supervise? (i.e., those which you direct the action of)

1. 0–1
2. 2–3
3. 4–5
4. 6–8
5. 9–15
6. 16–50
7. 51–75
8. 76–100
9. 101–150
10. More than 151

9. How much experience do you have as a 27XX?

1. Less than 6 mos
2. 6 mos but less than 1 yr
3. 1 yr but less than 2 yr
4. 2 yr but less than 4 yr
5. 4 yr but less than 6 yr
6. 6 yr but less than 8 yr
7. 8 yr but less than 10 yr
8. 10 yr but less than 12 yr
9. 12 yr but less than 14 yr
10. 14 yr or more yrs

Part II.

Job Tasks

The statements in this part of the questionnaire are designed to help us understand the role you play in making decisions or taking actions in the performance of your job as a 27XX manager. Your responses should be based on your current job. Please use the following scale for your responses:

1. **I PLAY NO ROLE IN THE DECISION MAKING OR ACTION TAKEN TO ACCOMPLISH THIS TASK**
2. **I PLAY SOME ROLE THE IN DECISION MAKING OR ACTION TAKEN TO ACCOMPLISH THIS TASK**
3. **I PLAY A ROLE ABOUT HALF THE TIME IN THE DECISION MAKING OR ACTION TAKEN TO ACCOMPLISH THIS TASK**
4. **I PLAY A LARGE ROLE IN THE DECISION MAKING OR ACTION TAKEN TO ACCOMPLISH THIS TASK**
5. **I AM THE ONLY PLAYER IN THE DECISION MAKING OR ACTION TAKEN TO ACCOMPLISH THIS TASK**

1 (No Role) 2 3 (Half) 4 5 (Sole)

10. Approve or disapprove award fees 1 2 3 4 5

11. Perform site inspections to observe contractor or QAE performance 1 2 3 4 5

12. Approve or disapprove inputs to Memoranda of Understanding (MOU) or Memoranda of Agreements (MOA) 1 2 3 4 5

13. Develop Industrial Preparedness (IPP) plans 1 2 3 4 5

14. Determine training requirements 1 2 3 4 5

15. Approve or disapprove source selection 1 2 3 4 5

16. Approve or disapprove Acquisition Management Reviews 1 2 3 4 5

1 (No Role) 2 3 (Half) 4 5 (Sole)

17. Recommend approval or disapproval of contracts
1 2 3 4 5

18. Approve or disapprove Contract Management Reviews
1 2 3 4 5

19. Prepare/present formal/informal briefings
1 2 3 4 5

20. Analyze budgeting requirements
1 2 3 4 5

21. Analyze quality assurance problems
1 2 3 4 5

22. Approve or disapprove inputs to Five Year Defense Plan (FYDP) or Program Objective Memorandum (POM)
1 2 3 4 5

23. Evaluate effect of funding cuts on programs
1 2 3 4 5

24. Justify budget proposals to Program Review Committees
1 2 3 4 5

25. Coordinate with prime contractor on status of subcontracts
1 2 3 4 5

26. Monitor fund allocations
1 2 3 4 5

27. Determine status of action items
1 2 3 4 5

28. Review fund expenditures on materials, such as equipment or supplies
1 2 3 4 5

29. Compare progress reports with established or proposed schedules
1 2 3 4 5

30. Develop budgets or budget estimates
1 2 3 4 5

31. Approve or disapprove Production Readiness Review (PRR) plans
1 2 3 4 5

32. Analyze cost proposals
1 2 3 4 5

1 (No Role) 2 3 (Half) 4 5 (Sole)

33. Approve or disapprove management system review meetings
1 2 3 4 5

34. Analyze direct or indirect rates
1 2 3 4 5

35. Validate requirements
1 2 3 4 5

36. Analyze overhead or direct labor proposals
1 2 3 4 5

37. Develop Program Management Plans (PMP)
1 2 3 4 5

38. Develop cost forecasting models
1 2 3 4 5

39. Evaluate Engineering Change Proposals (ECP)
1 2 3 4 5

40. Develop overhead rate projections
1 2 3 4 5

41. Develop target price positions
1 2 3 4 5

42. Develop Statements of Work (SOW) or specifications
1 2 3 4 5

43. Analyze preliminary or critical designs for producibility
1 2 3 4 5

44. Approve or disapprove inputs to five-year plans
1 2 3 4 5

45. Determine status of milestones
1 2 3 4 5

46. Approve or disapprove budget planning or review meetings
1 2 3 4 5

47. Advise on system matters during negotiations
1 2 3 4 5

48. Review RFP/RFQs
1 2 3 4 5

49. Coordinate with customers or finance personnel on availability ot funds
1 2 3 4 5

1 (No Role) 2 3 (Half) 4 5 (Sole)

50. Develop business strategies for acquisitions

1 2 3 4 5

51. Prepare Contract Data Requirements Lists (CDRL)

1 2 3 4 5

52. Review cost analysis reports

1 2 3 4 5

53. Review PMDs

1 2 3 4 5

54. Review proposal evaluation reports, such as technical evaluations or price evaluations

1 2 3 4 5

55. Compare incurred rates with negotiated rates

1 2 3 4 5

56. Review recurring budget reports

1 2 3 4 5

57. Conduct contractor progress review or final review conferences

1 2 3 4 5

58. Conduct trade-off analyses

1 2 3 4 5

59. Coordinate with contractors on warranty work

1 2 3 4 5

60. Justify changes to budget allocations

1 2 3 4 5

61. Designate subcontracts as major or critical

1 2 3 4 5

62. Monitor delivery dates

1 2 3 4 5

63. Evaluate C/SCSC reports

1 2 3 4 5

64. Assist negotiation considerations for contractors' failure to perform

1 2 3 4 5

65. Evaluate contractors' requests for reimbursements

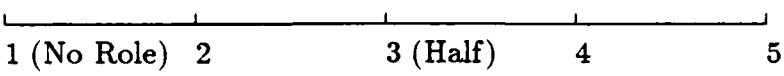
1 2 3 4 5

66. Assist negotiation with contractors on modification to contracts

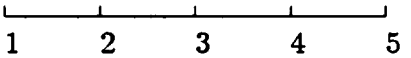
1 2 3 4 5

67. Identify alternate sources for terminated contractors

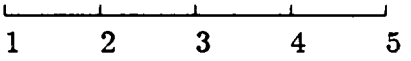
1 2 3 4 5



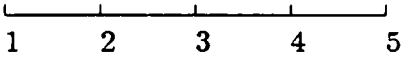
68. Assist negotiation considerations for specification deviations or waivers



69. Assist negotiation of spare parts prices or delivery schedules



70. Assist negotiation with contractor on contract change proposals



Part III.

PCE Courses

The statements in this part of the questionnaire are designed to help us understand the role the following courses play in decision making or action taking place during the performance of your job as a 27XX manager.

Tell us whether or not you completed the course. Then tell us whether you have been able to use the technologies covered in the course in your current job.

Complete the Used column **only** if Completed column is YES.

	Completed		Used	
71. Introduction to Systems Command Acquisition Management (SAS 001)	YES	NO	YES	NO
72. Introduction to Acquisition Management (AFIT SYS 100)	YES	NO	YES	NO
73. Acquisition Planning and Analysis (AFIT SYS 200)	YES	NO	YES	NO
74. Fundamentals of Acquisition Management (AFIT SYS 123)	YES	NO	YES	NO
75. Systems Program Management (AFIT SYS 223)	YES	NO	YES	NO
76. Introduction to Configuration Management (AFIT SYS 028)	YES	NO	YES	NO
77. Advanced Configuration Management (AFIT SYS 128)	YES	NO	YES	NO
78. Applied Configuration Management (AFIT SYS 228)	YES	NO	YES	NO
79. Intermediate Program Management (AFIT SYS 400)	YES	NO	YES	NO

	Completed		Used	
80. Test and Evaluation Management (AFIT SYS 229)	YES	NO	YES	NO
81. Reliability and Maintainability in Systems Acquisition (AFIT QMT 335)	YES	NO	YES	NO
82. Contractor Performance Measurement (DSMC)	YES	NO	YES	NO
83. Contract Finance for Program Managers (DSMC)	YES	NO	YES	NO
84. Contract Overhead Monitorship (AFIT QMT 355)	YES	NO	YES	NO
85. Cost Improvement Analysis (AFIT QMT 180)	YES	NO	YES	NO
86. Quantitative Techniques for Cost & Price Analysis (AFIT QMT 345)	YES	NO	YES	NO
87. Introduction to Life Cycle Costing (AFIT QMT 353)	YES	NO	YES	NO
88. Cost/Schedule Control System Criteria (AFIT SYS 362)	YES	NO	YES	NO
89. Surveillance of Cost & Schedule Control Systems Criteria (AFIT SYS 361)	YES	NO	YES	NO
90. Advanced Cost & Economic Analysis (AFIT QMT 551)	YES	NO	YES	NO

Part IV.

Academic Courses

The statements in this part of the questionnaire are designed to help us understand the role the following courses play in decision making or action taking place during the performance of your job as a 27XX manager.

Tell us whether or not you completed the course. Then, tell us whether you have been able to use the technologies covered in the course in your current job.

Complete the Used column **only** if Completed column is YES.

	Completed		Used	
91. Applied Probability	YES	NO	YES	NO
92. Applied Statistics (Descriptive Statistics and Hypothesis Testing)	YES	NO	YES	NO
93. Applied Statistics (Regression and Analysis of Variance)	YES	NO	YES	NO
94. Time Series Analysis	YES	NO	YES	NO
95. Multivarate Analysis (Factor Analysis, Canonical correlation, MANOVA)	YES	NO	YES	NO
96. Categorical Data Analysis (Contingency Tables)	YES	NO	YES	NO
97. Applied Decision Analysis (Baysian Statistics)	YES	NO	YES	NO
98. Design of Experiments	YES	NO	YES	NO
99. Non-Parametric Statistics	YES	NO	YES	NO

Thank you for completing this survey. We invite any comments you have on the subject of this survey and/or the survey itself. Space for comments has been provided on the following page.

Appendix B. Survey Comments

NOTE: The use of the symbol ¶ is to indicate the start of a selected individuals comment.

¶— Application of management principles and sense of teamwork gained in the operational career fields is important to those of us who career broaden into program management. Descision making techniques learned in SOS and ACSC also are of great importance to the program manager.

¶— It makes a big difference if you have had some experience before taking an AFIT course.

¶— I see little use for an elaborate statistical background. In the real world, that's not how decisions are made.

¶— I have taken 18hrs on MBA and use the statistics and management everyday. I would be more then willing to take the PCE courses you outlined. I have asked for DSMC and been recommended by my bosses for the last four years. But as you are aware that is a hard school to get into.

¶— I have had no use for statistics in my job.

¶— I've used the thought processes taught in economic analysis in my decision making processes. Decisions in acquisition management must also consider utility and marginal value. These can be considered in theory using empirical analysis; however, the program manager doesn't have the resources or data bases, normally, to do in-depth empirical studies to determine a decision. This leaves the manager with following his intuitive judgement. Some people have a good intuition, some don't. Generally those who can do an excellent empirical analysis can't for the life of them understand the underlying issues that could steer a decision away from the numbers. Conversely, those who have a good intuition can't understand the empirical approach when confronted with sound quantitative facts to go a certain way with a decision, policy or contrast.

¶— Part IV. — More importantly than understanding the technical details of various statistical methods, the greatest value of statistical courses (ESP, Applied Statistics) to me as an acquisition manager has been learning to question input parameters, assumptions and output sensitivities!

¶— There are a lot of requirements from my job that could not be filled solely with AFIT courses. Some AFIT courses do not prepare you for real life experiences. Most of the emphasis is on ideal situations and not on reality. AFIT usually focuses on major programs and SPOs without considering small programs and laboratory efforts.

¶— There must be a way/course (i.e., 2 to 3 months) to teach an individual new to the acquisition business the big picture without being fed piece meal in two week periods spread over 2 to 3 years!

We have a concentrated training program for pilots, engineers, maint officers, missile

officers, but not AFSC SPO acquisition officers. Therefore the people developing the operational equipment make mistakes at everyone else's expense!

¶— In my present job, I use very little math. I feel that an introductory – very basic – class on statistical/mathematical techniques could be useful to me. However, a highly technical class would be a waste of time.

¶— Your study has made me realize how little that I did know and more importantly how much I don't do. My background is ops – and I believe that that Education speaks for itself and using that background I have been able to interpret AFSC into English (and stay productively employed for 40 hrs per week). Hopefully after AFIT sees fit to schedule more of your classes I can truly become a productive member of society.

¶— Statistics are misapplied so often that everyone should know how statistics works. Specifically, in evaluating weapon system performance, it is critical to recognize the proper distribution to use, sample size, and where varying Test Conditions invalidate test results. Unfortunately, a high percentage of Air Force Testing appears to not be a good sample. Cost of assets and the numerous variables needed to duplicate the operational environment (which create the need for large sample sizes) often causes the evaluation of a weapon system's performance to degenerate into subjective feelings and guesses rather than objective evaluation based on an adequate sample size in testing.

¶— The best course that I have taken for program management was SYS 200. I thought it was very worthwhile and practical. If other courses could be structures more like that, I believe they would be of greater value.

¶— My PhD in *Economics* with emphasis in econometric has provided me with the education base to perform cost estimating C/SCSC, and budgetary functions. Prior Air Staff experience in DCS/PR has provided an opportunity to understand the internal workings of the Planning, Programming, and Budgeting process necessary building a good working relationship between Program Control and Command and Air Staff counterparts.

¶— As a 2716 with almost 20 years service it is difficult to respond to some of the questions regarding utility of various courses in my current job. Obviously many of the courses in III and IV have been directly used throughout my career. They may not enter directly into my job responsibility today but formed the basis for my being able to progress from a specific technical responsibility to a broadened management role at the headquarters (MAJCOM or Air Force).

¶— Statistics is of use to me only as it provides the ability to critically evaluate other's use of it.

¶— The questions in part II are highly skewed to contracts and cost estimating. There is no mention of the value of a background in statistics ...It's particularly helpful in understanding a contractors analysis, but is not used as a desk tool for me. I need the understanding, not the analytical skill.

¶— Applied probability and applied statistics are probably the most useful. I had the opportunity to do some number crunching in defining the reliabililty requirements for the ...program.

It's very difficult to communicate reliability concepts with an untrained person. The emphasis now is on reliability but we have very few trained managers in the Air Force

today who really understand those concepts and using applied statistics in defining test requirements.

In short, we need to develop a short course for the senior managers as well as workers to bring about a better understanding of those concepts. Why? Because of a lack of understanding we sometimes ask for things that are impossible or we end up with farless than optimum cost/benefit ratio.

You should do a sample-test survey on reliability concepts. Thank you.

¶— The only time I had any use of the AFIT stat course was at a design review. We were looking at RMA formulas that the contracts was using.

¶— My experiences as a program manager 2724 and 2711 have not required the use of any statistical analysis technics. My brief exposure to statistics at ...where I obtained my MBA, does not provide a clue to using statistical analysis techniques.

¶— Program Managers need training in: Program Management, Configuration Mgmt (ECP/CCP Processing), Financial Mgmt (Budget, Expenditure/Obligation), Test Mgmt (Facilities, Coordination), Contract Mgmt (Pricing Evaluation, Negotiation, CLIN Structure/Pricing), Logistics Mgmt (Outyear Requirement, Deployment Scheduling, Warranty Structure).

¶— -Even though I have not directly used statistics (#92-93) and analysis (#96), I feel they are overall beneficial - I lack experience in: "situations" to use them and "when" to use them - not really in "how " to use them.

-Also, I think 27xx's should have these AFIT classes more available to them. At my base, no one even Knows they exist or that they are available to us. They should be available as short courses?

¶— All PMs and Engineers NEED to understand statistical analysis as it applied to reliability. I don't know much but I've seen data misrepresented.

¶— I have an engineering Phd from ... with substantial statistical background/probability. I regard statistics as a key discipline for all officers doing program management for Systems Command.

¶— I had QMT 576 which was 50% statistics. Used somewhat as R&M engineer but use no statistics in current 2724 position. Also had government course in statistical quality control - used in supervisory QA position and now when dealing with QA issues. Statistics courses would be low in my priority for anyone in 27XX career field.

¶— I feel statistics has been very useful in some aspects of my job because I acquire missile warning systems and we do have algorithm analysis. However, this work has not been hands on. It has been more in an advisory program management role (mostly because people know I do have this background).

I feel for the average 27xx who does not work with direct statistical systems on a daily basis, that courses oriented more toward the ops research side of statistics could be a lot more useful than "pure" statistics courses.

Personally, however, I would love to see you offer more probability and statistics courses.

¶— The use of most courses has been in general, permitting a more thorough understanding of contractor's reports, studies, etc.

While few AFIT courses were checked local in-house courses and DSMC courses also provide good source.

¶— As part of my Grad Log Degree I tool statistical and QDM courses. They are useful in my current job.

¶— I have had statistics and decision analysis in my undergrad and masters - I have used them - not extensively but when I do I'm glad I know the material.

Courses like SYS 200 are invaluable at the one yr point - we need more slots for these courses.

¶— Although I do not currently use these courses in my job, there are many times when the basics of statistics and probability have come into play. Setting test criteria often includes confidence levels. I do not do these calculations, but must understand them to make pass/fail decisions on test results.

¶— I like your purpose statement and have significant background and knowledge that would be of value to you. For instance, I have been a test engineer doing reliability testing with confidence levels, etc.

⋮

However, the real question is the real world needs of 27xx's for training in statistics — absolutely! Some needs are obvious, such as my duties with reliability testing, where detailed knowledge is required. At that same time, the design engineers, technical managers, program managers, and entire chain of command found themselves in the position of needing and/or wanting to understand the real significance of the test results - often with little background in statistics. Also, often with a great fear of statistics and statisticians!
...

¶— ...In considering the development of courses please stress application. Life out here is much different from academia and the learning of knowledge should be approached in a manner much different than typical courses. Application of probability and statistics to budget (BES/POM), Risk Analysis/Abatement, cost analysis, as well as more typical production related analyses would be helpful. Particular attention must be paid to validating assumptions and proper use of tools available ...use existing real life data from AFSC and various SPO's ...wide range of PC tools.

END OF SURVEY COMMENTS

Appendix C. Statistical Tables

Entire Survey Population Demographics

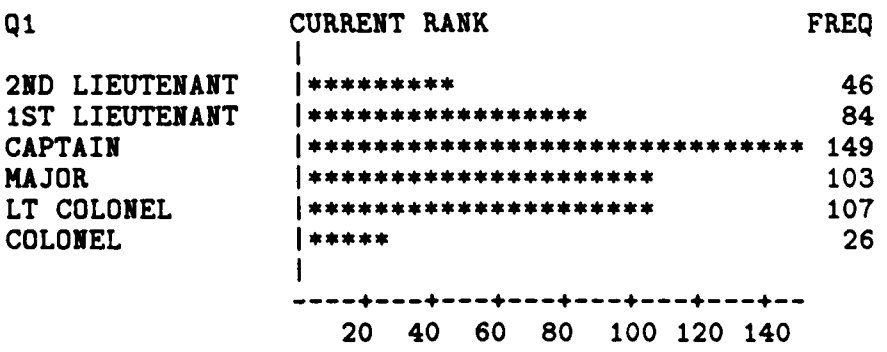


Figure 7: Q1 Current Rank; Entire Survey Population

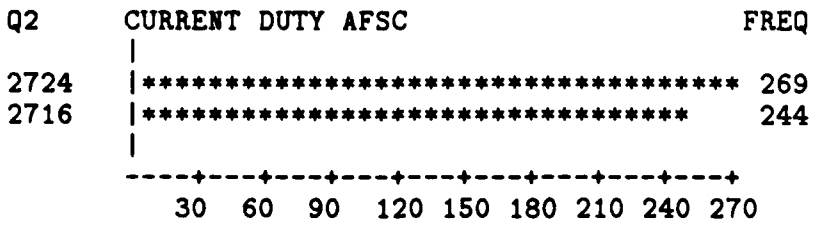


Figure 8: Current Duty AFSC; Entire Survey Population

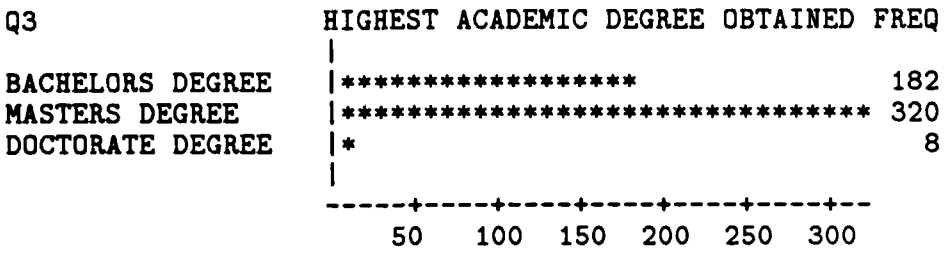


Figure 9: Q3 Highest Academic Degree Obtained; Entire Survey Population

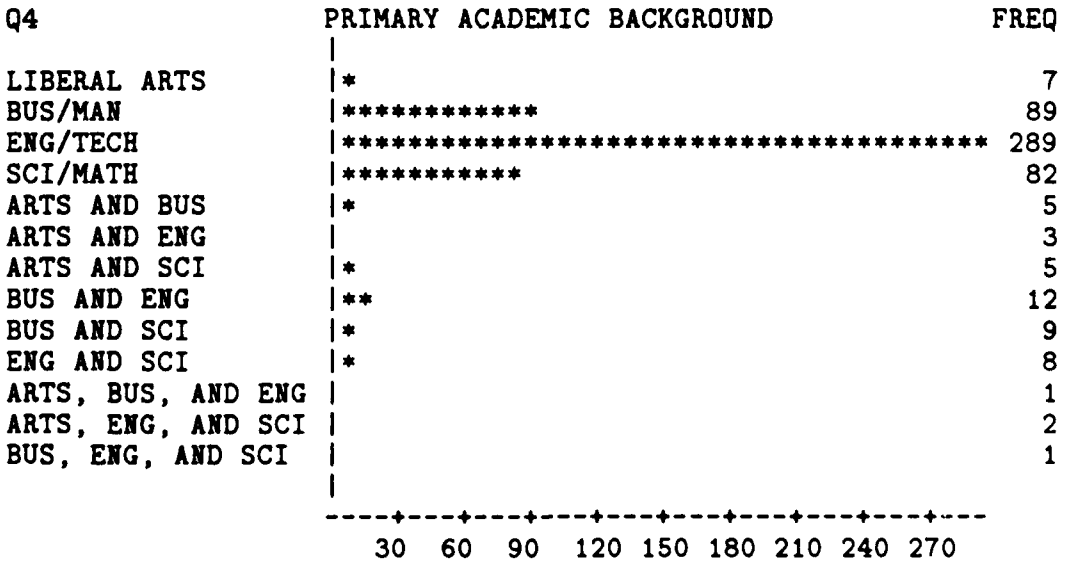


Figure 10: Q4 Primary Academic Background; Entire Survey Population

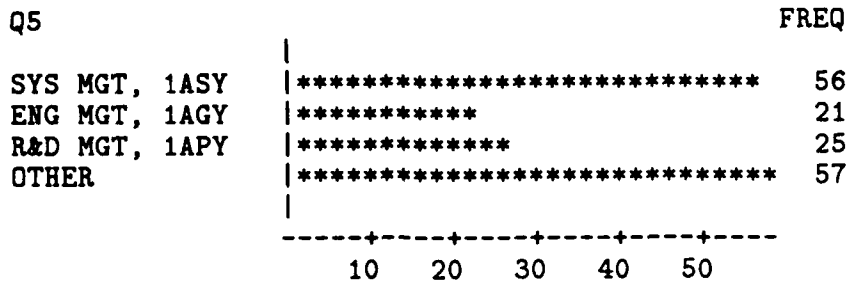


Figure 11: Q5 Education Code for MS from AFIT; Entire Survey Population

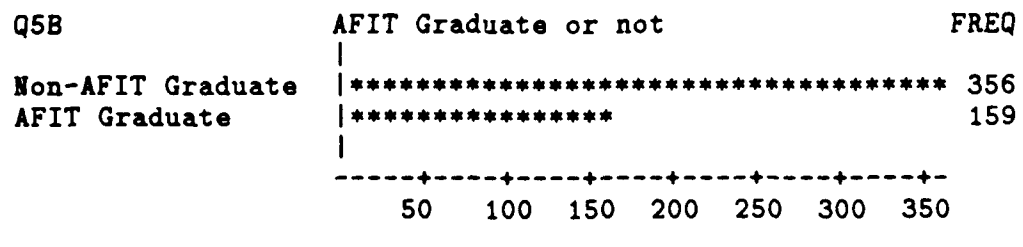


Figure 12: Q5b AFIT Graduate or not; Entire Survey Population

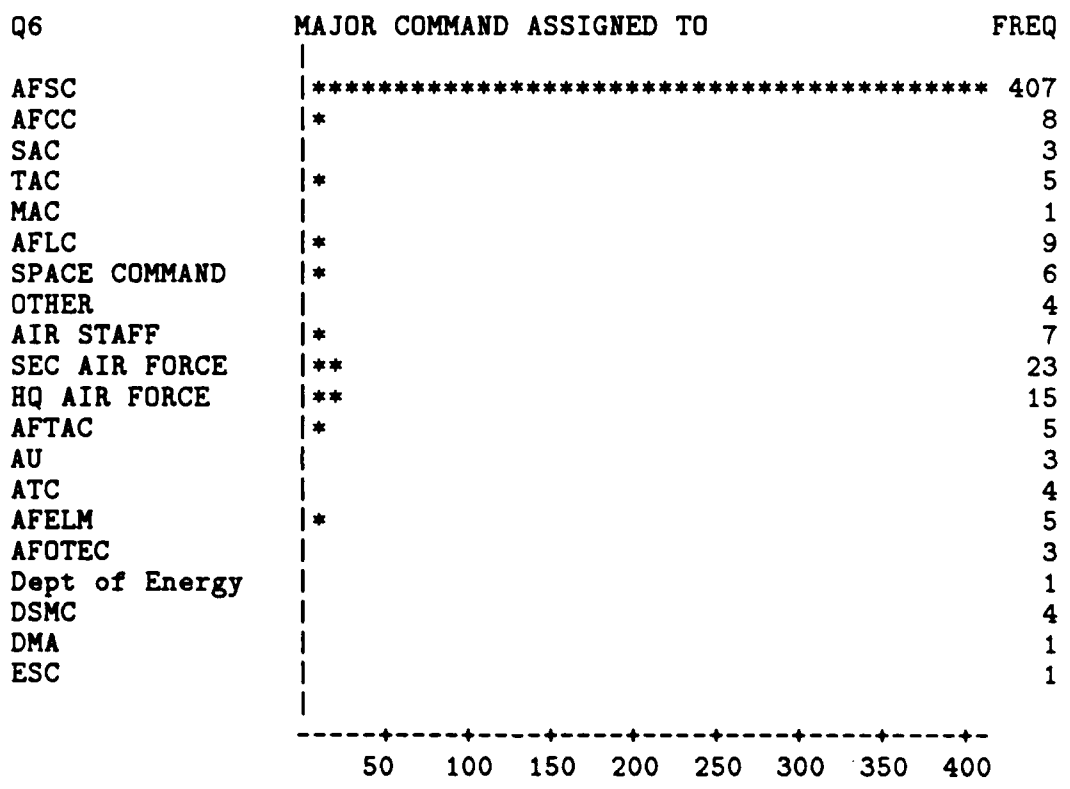


Figure 13: Q6 Major Command Assigned to; Entire Survey Population

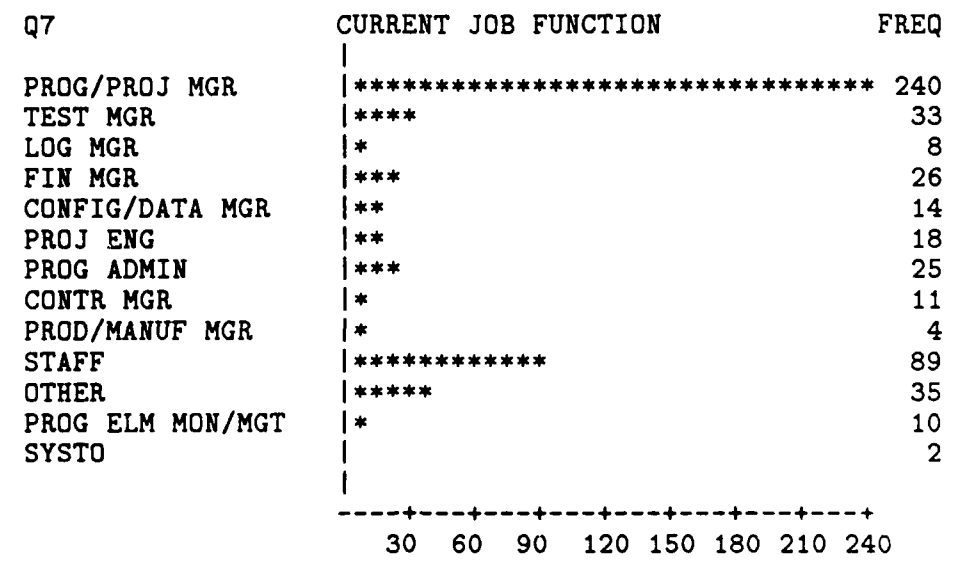


Figure 14: Q7 Current Job Function; Entire Survey Population

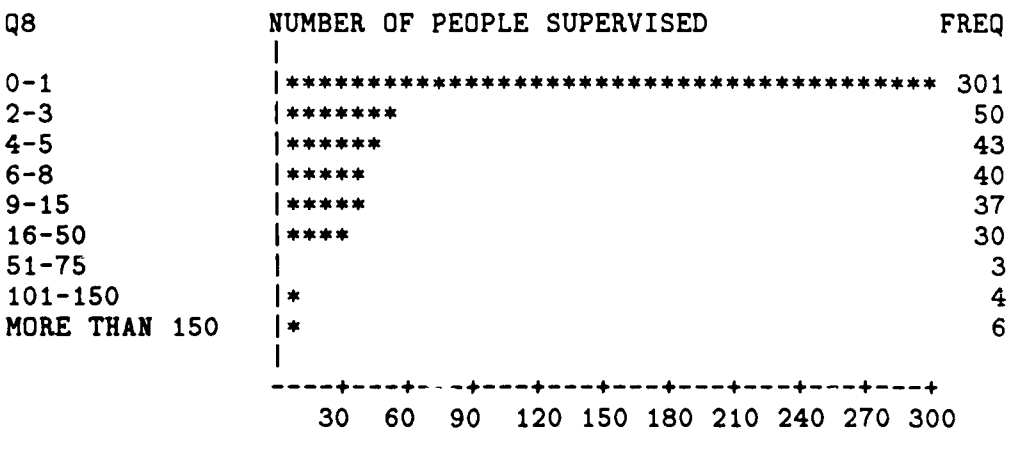


Figure 15: Q8 Number of People Supervised; Entire Survey Population

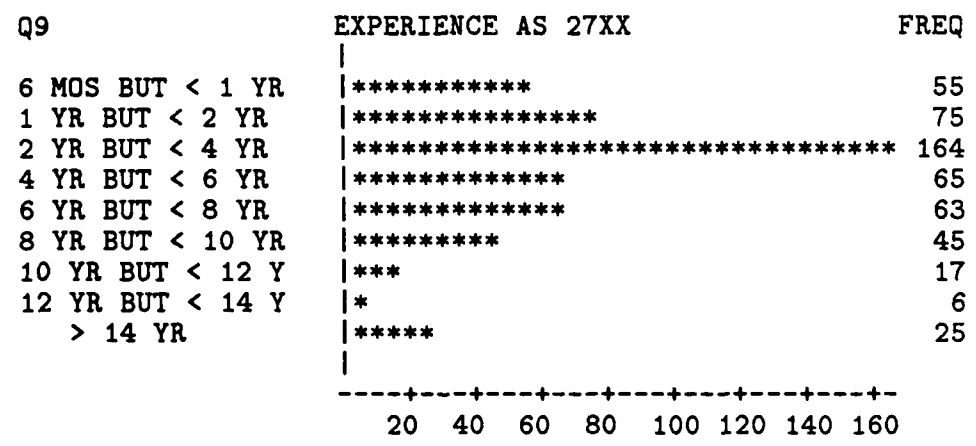


Figure 16: Q9 Experience as 27XX; Entire Survey Population

Potential Acquisition Manager GSM Students

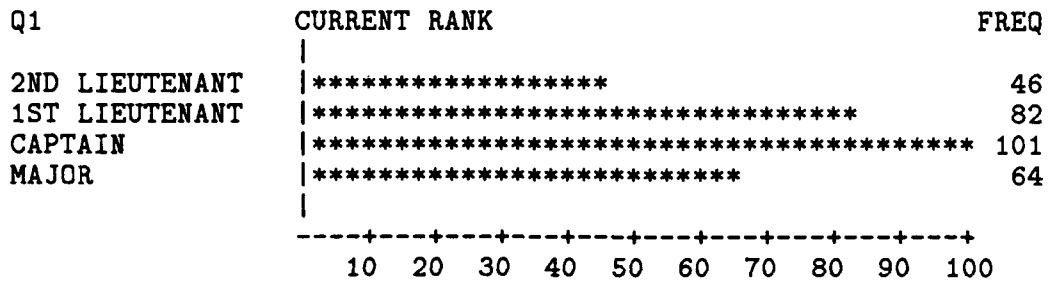


Figure 17: Q1 Current Rank; All Potential GSM Students from 27xx AFSC

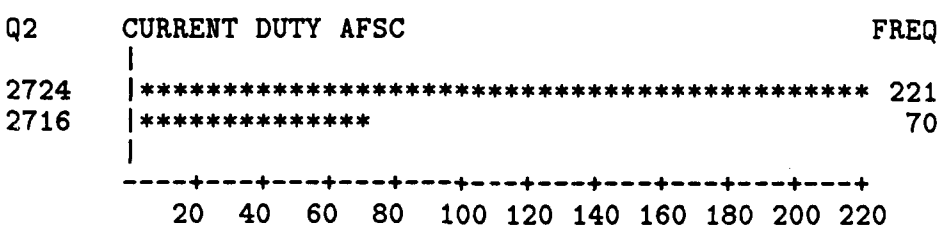


Figure 18: Q2 Current Duty AFSC; All Potential GSM Students from 27xx AFSC

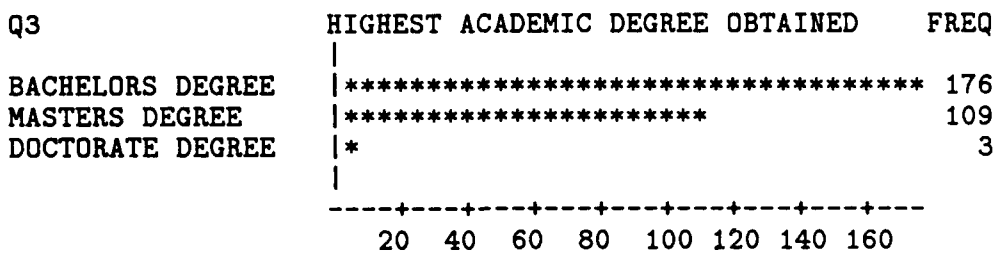


Figure 19: Q3 Highest Academic Degree Obtained; All Potential GSM Students from 27xx AFSC

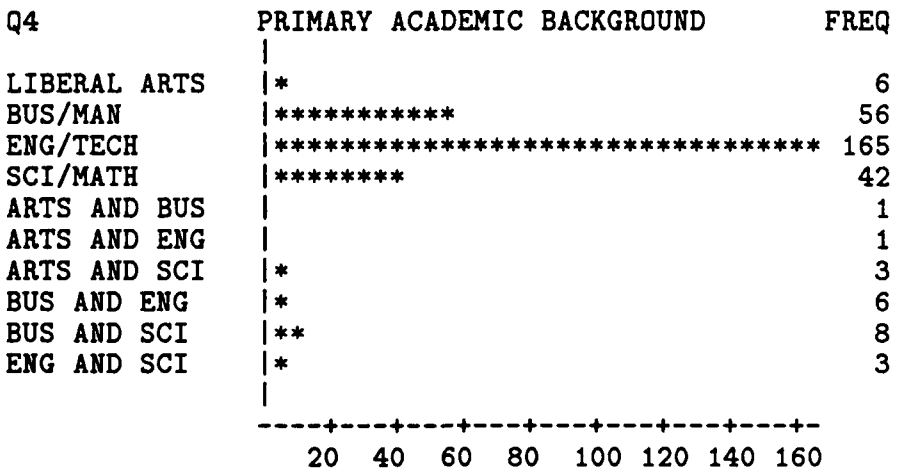


Figure 20: Q4 Primary Academic Background; All Potential GSM Students from 27xx AFSC

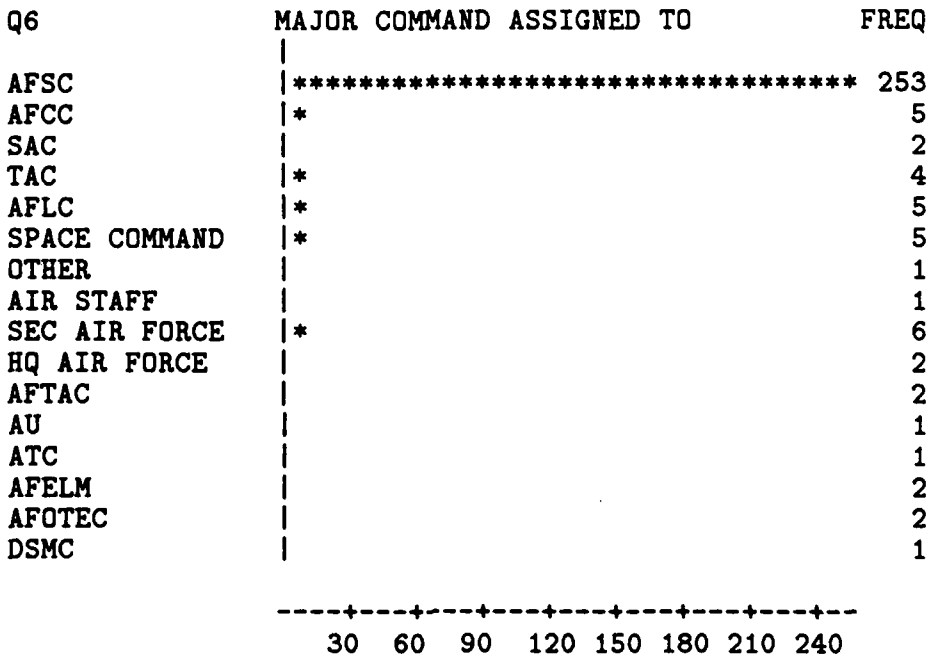


Figure 21: Q6 Major Command Assigned to; All Potential GSM Students from 27xx AFSC

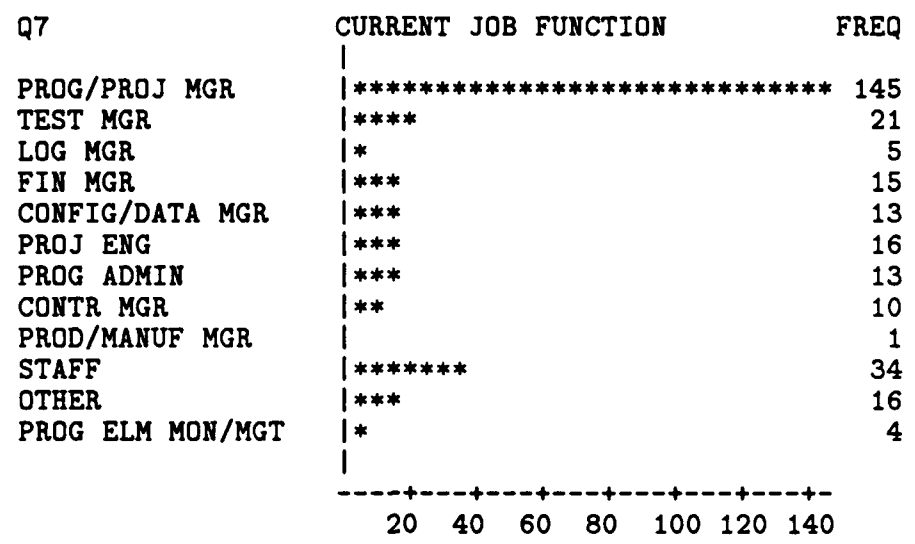


Figure 22: Q7 Current Job Function; All Potential GSM Students from 27xx AFSC

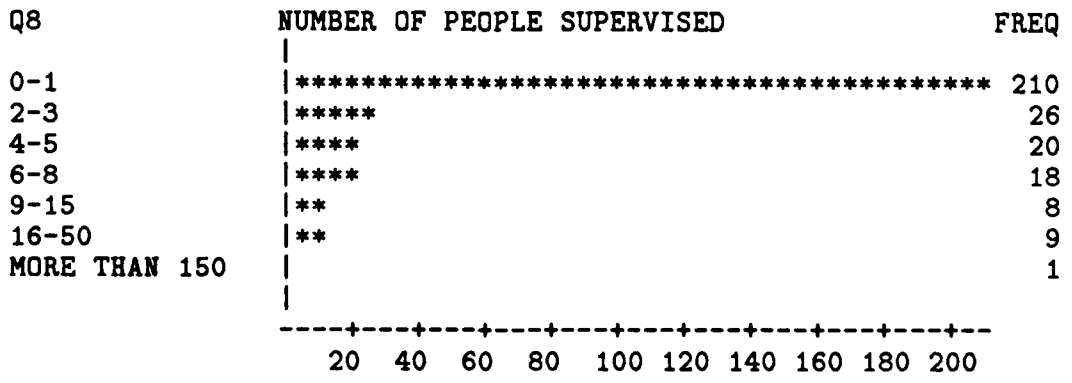


Figure 23: Q8 Number of People Supervised; All Potential GSM Students from 27xx AFSC

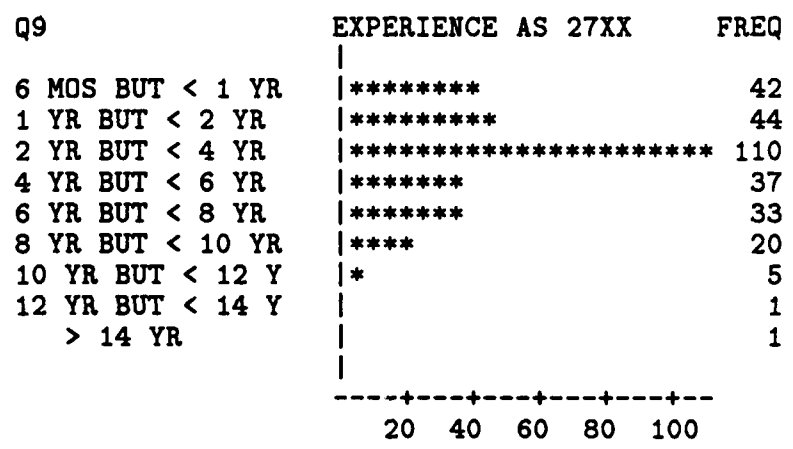


Figure 24: Q9 Experience as 27XX; All Potential GSM Students from 27xx AFSC

PCE Course Contingency Tables Summary

Table 12: Summary of PCE Course Data

Question #	Course Title	χ^2 Value	Reject H_o	Number of YES/ YES	Percent of YES/ YES	Number in Table	Significant YES/ NO
Q71	SAS 001	12.100	YES	128	95.52	134	YES
Q72	SYS 100	30.197	YES	118	90.77	130	YES
Q73	SYS 200	28.766	YES	109	94.78	115	YES
Q74	SYS 123	17.255	YES	16	72.73	22	YES
Q75	SYS 223	21.631	YES	27	79.41	34	YES
Q76	SYS 028	16.582	YES	38	79.17	48	YES
Q77	SYS 128	7.273	YES	8	50.00	16	NO
Q78	SYS 228	14.933	YES	19	67.86	28	NO
Q79	SYS 400	16.776	YES	17	68.00	25	NO
Q80	SYS 229	9.144	YES	22	70.97	31	YES
Q81	QMT 335	9.000	YES	5	55.56	9	NO
Q82	DSMC CPM	14.593	YES	25	78.13	32	YES
Q83	DSMC CFPM	9.450	YES	13	61.90	21	NO
Q84	QMT 355	N/A	NO	0	0.00	6	NO
Q85	QMT 180	5.833	YES	2	20.00	10	NO
Q86	QMT 345	1.935	NO	3	23.08	13	NO
Q87	QMT 353	5.833	YES	2	20.00	10	NO
Q88	SYS 362	5.455	YES	12	54.55	22	NO
Q89	SYS 361	6.198	YES	5	38.46	13	NO
Q90	QMT 551	N/A	NO	0	0.00	7	NO

Academic Course Contingency Tables Summary

Table 13: Summary of Academic Course Data

Question #	Course Title	χ^2 Value	Reject H_o	Number of YES/ YES	Percent of YES/ YES	Number in Table	Significant YES/ NO
Q91	Applied Prob	0.00	NO	39	32.77	119	NO
Q92	Applied Stat (Desc)	0.808	NO	37	28.46	130	NO
Q93	Applied Stat (Reg/ ANOVA)	0.977	NO	34	26.56	128	NO
Q94	Time Series Anal	0.194	NO	4	9.09	44	NO
Q95	Multivar Anal	0.793	NO	7	21.21	33	NO
Q96	Categ Data Anal	0.058	NO	8	20.00	40	NO
Q97	Applied Desc Anal	3.554	NO	19	34.55	55	NO
Q98	Design of Exp	1.853	NO	15	31.25	48	NO
Q99	Non-Parametric Stat	3.500	NO	7	20.00	35	NO

Task Function ANOVA

Table 14: Means of the Six Task Functions; Entire Survey Population

VARIABLE	N	N MISSING	MEAN	STANDARD DEVIATION
		GROUP=1		
FUNC	515	0	1.801	0.794
		GROUP=2		
FUNC	515	0	2.311	0.968
		GROUP=3		
FUNC	515	0	2.574	1.097
		GROUP=4		
FUNC	515	0	2.127	0.903
		GROUP=5		
FUNC	515	0	1.730	0.685
		GROUP=6		
FUNC	515	0	2.321	0.838

Table 15: Analysis of Variance Procedure; Dependent Variable: FUNC

ANALYSIS OF VARIANCE PROCEDURE

DEPENDENT VARIABLE: FUNC

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE
MODEL	5	274.48787899	54.89757580
ERROR	3084	2445.23082545	0.79287640
CORRECTED TOTAL	3089	2719.71870444	
MODEL F =	69.24		PR > F = 0.0

Table 16: Tukey's Studentized Range (HSD) Test for Variable: FUNC

ANALYSIS OF VARIANCE PROCEDURE

TUKEY'S STUDENTIZED RANGE (HSD) TEST FOR VARIABLE: FUNC
NOTE: THIS TEST CONTROLS THE TYPE I EXPERIMENT WISE ERROR RATE

ALPHA=0.05 CONFIDENCE=0.95 DF=3084 MSE=0.792876
CRITICAL VALUE OF STUDENTIZED RANGE=4.033
MINIMUM SIGNIFICANT DIFFERENCE=.15823

COMPARISONS SIGNIFICANT AT THE 0.05 LEVEL ARE INDICATED BY '***'

GROUP COMPARISON		SIMULTANEOUS LOWER CONFIDENCE LIMIT	DIFFERENCE BETWEEN MEANS	SIMULTANEOUS UPPER CONFIDENCE LIMIT	
3	- 6	0.09437	0.25260	0.41083	***
3	- 2	0.10468	0.26291	0.42114	***
3	- 4	0.28866	0.44689	0.60512	***
3	- 1	0.61471	0.77294	0.93118	***
3	- 5	0.68505	0.84328	1.00151	***
6	- 3	-0.41083	-0.25260	-0.09437	***
6	- 2	-0.14792	0.01032	0.16855	
6	- 4	0.03606	0.19430	0.35253	***
6	- 1	0.36212	0.52035	0.67858	***
6	- 5	0.43245	0.59068	0.74891	***
2	- 3	-0.42114	-0.26291	-0.10468	***
2	- 6	-0.16855	-0.01032	0.14792	
2	- 4	0.02575	0.18398	0.34221	***
2	- 1	0.35180	0.51003	0.66826	***
2	- 5	0.42214	0.58037	0.73860	***
4	- 3	-0.60512	-0.44689	-0.28866	***
4	- 6	-0.35253	-0.19430	-0.03606	***
4	- 2	-0.34221	-0.18398	-0.02575	***
4	- 1	0.16782	0.32605	0.48428	***
4	- 5	0.23815	0.39639	0.55462	***
1	- 3	-0.93118	-0.77294	-0.61471	***
1	- 6	-0.67858	-0.52035	-0.36212	***
1	- 2	-0.66826	-0.51003	-0.35180	***
1	- 4	-0.48428	-0.32605	-0.16782	***
1	- 5	-0.08790	0.07033	0.22857	

5	- 3	-1.00151	-0.84328	-0.68505	***
5	- 6	-0.74891	-0.59068	-0.43245	***
5	- 2	-0.73860	-0.58037	-0.42214	***
5	- 4	-0.55462	-0.39639	-0.23815	***
5	- 1	-0.22857	-0.07033	0.08790	

Task Item Reliability

Table 17: Coefficient Alpha and Standardized Item Alpha

COEFFICIENT ALPHA

ALPHA	COL1
ROW1	0.9778

STANDARDIZED ITEM ALPHA

ALPHA	COL1
ROW1	0.9779

Table 18: Scale Statistics with Item Deleted

ID STATS	MEAN	STD DEV	VARIANCE	CORREL	SMC	ALPHA
Q10	127.2136	47.1839	2226.3	0.5538	0.4761	0.9776
Q11	126.8718	47.1099	2219.3	0.5369	0.5397	0.9776
Q12	126.1650	47.0115	2210.1	0.6168	0.5402	0.9775
Q13	127.7495	47.5360	2259.7	0.4168	0.4069	0.9778
Q14	126.8233	47.2704	2234.5	0.4171	0.3156	0.9779
Q15	127.1087	47.1541	2223.5	0.5670	0.5344	0.9776
Q16	127.0039	47.0925	2217.7	0.5843	0.5424	0.9775
Q17	126.7981	46.9261	2202.1	0.7115	0.6562	0.9773
Q18	127.1262	47.0084	2209.8	0.6837	0.6370	0.9773
Q19	125.2330	47.2060	2228.4	0.5275	0.4829	0.9776
Q20	125.9903	46.8758	2197.3	0.7024	0.7825	0.9773
Q21	126.9107	47.0609	2214.7	0.6292	0.5996	0.9774
Q22	126.5573	47.0683	2215.4	0.5278	0.7277	0.9777
Q23	126.1650	46.9359	2203.0	0.6043	0.7036	0.9775

Q24	126.6117	46.9812	2207.2	0.5778	0.6872	0.9776
Q25	126.5592	46.8349	2193.5	0.6897	0.6508	0.9773
Q26	126.2155	46.7987	2190.1	0.7035	0.7604	0.9773
Q27	125.5728	47.0799	2216.5	0.5751	0.5221	0.9776
Q28	126.5961	46.9255	2202.0	0.6612	0.6471	0.9774
Q29	125.8388	46.9074	2200.3	0.6869	0.6642	0.9773
Q30	126.1825	46.8095	2191.1	0.7070	0.7449	0.9773
Q31	127.4214	47.2845	2235.8	0.5408	0.5430	0.9776
Q32	126.4874	46.8321	2193.2	0.7283	0.6891	0.9772
Q33	126.8854	46.8923	2198.9	0.7143	0.6229	0.9773
Q34	127.4272	47.2522	2232.8	0.6057	0.6970	0.9775
Q35	126.4563	47.0192	2210.8	0.5907	0.4737	0.9775
Q36	127.3049	47.1774	2225.7	0.6063	0.6501	0.9775
Q37	126.6155	46.8799	2197.7	0.6723	0.5940	0.9774
Q38	127.3689	47.2422	2231.8	0.5427	0.5601	0.9776
Q39	126.5243	46.9496	2204.3	0.6262	0.6635	0.9775
Q40	127.6272	47.3762	2244.5	0.5551	0.6974	0.9776
Q41	127.3515	47.0785	2216.4	0.6699	0.6488	0.9774
Q42	126.2311	46.8084	2191.0	0.6925	0.7481	0.9773
Q43	127.0738	47.0948	2217.9	0.6079	0.5477	0.9775
Q44	126.7670	46.9602	2205.3	0.6333	0.7222	0.9774
Q45	126.1107	46.8585	2195.7	0.7080	0.6745	0.9773
Q46	126.8233	46.8985	2199.5	0.6988	0.7084	0.9773
Q47	126.7961	46.8104	2191.2	0.7543	0.7279	0.9772
Q48	126.5126	46.8345	2193.5	0.7395	0.7162	0.9772
Q49	126.3922	46.7900	2189.3	0.7248	0.7194	0.9772
Q50	126.5437	46.8709	2196.9	0.6943	0.6328	0.9773
Q51	126.6777	46.9260	2202.1	0.6566	0.6987	0.9774
Q52	126.7786	46.8953	2199.2	0.7110	0.6780	0.9773
Q53	126.2505	47.0557	2214.2	0.5350	0.5467	0.9777
Q54	126.5689	46.8022	2190.4	0.7690	0.6956	0.9772
Q55	127.3825	47.1642	2224.5	0.6407	0.6367	0.9775
Q56	126.9126	47.0175	2210.6	0.6372	0.6945	0.9774
Q57	126.6447	46.7858	2188.9	0.7312	0.6849	0.9772
Q58	126.9087	46.9873	2207.8	0.6871	0.6074	0.9773
Q59	127.3126	47.1483	2223.0	0.6243	0.5911	0.9775
Q60	126.6214	46.8197	2192.1	0.7226	0.7601	0.9773
Q61	127.5010	47.2530	2232.8	0.5986	0.5661	0.9775
Q62	126.3767	46.8084	2191.0	0.6892	0.6301	0.9773
Q63	127.1456	47.1429	2222.5	0.5434	0.5608	0.9776
Q64	127.1087	46.9594	2205.2	0.7106	0.7098	0.9773
Q65	127.1262	46.9484	2204.1	0.7244	0.6843	0.9773
Q66	126.7883	46.7953	2189.8	0.7676	0.8243	0.9772
Q67	127.4854	47.2583	2233.4	0.5570	0.4851	0.9776
Q68	126.9864	46.9706	2206.2	0.6602	0.7021	0.9774
Q69	127.3670	47.1537	2223.5	0.6162	0.6095	0.9775
Q70	126.8194	46.8347	2193.5	0.7377	0.7994	0.9772

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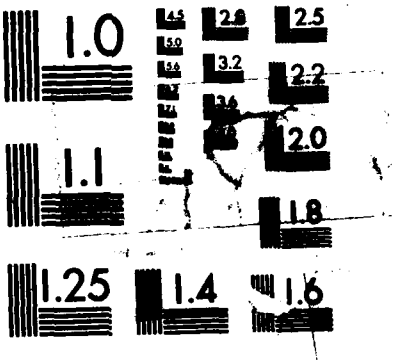

Vita

Captain Michael L. Linnenburger was born 27 March 1951 in Peoria, Illinois. He graduated from high school in Galesburg, Illinois, in 1969. Went to work for the Burlington Northern, Inc. (formerly the CB&Q RR). In 1973 entered the Air Force as an Air Traffic Control Radar Repairman. In 1979 applied for to the Airman Education and Commissioning Program (AECP), and attended Texas A&M University from which he received the degree of Bachelor of Science in Electrical Engineering in May 1983. Upon graduation, he attended Officer Training School (OTS) and received a commission in the USAF. He served as a Digital Systems Design Engineer in the 1000th Satellite Operations Group, Offutt AFB, Nebraska, until entering the School of Systems and Logistics, Air Force Institute of Technology, in June 1986.

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The purpose of this thesis was to collect basic information on the statistical concept base potential GSM students usually bring to AFIT and to determine which statistical concepts are used by acquisition managers. The specific application of Ausubel's Learning Theory and Johnson's Curriculum Model was to statistics, even though both can be applied to other disciplines.

In order to accomplish this purpose the following objectives were developed: (1) to collect data on statistical background and work experience of acquisition managers so an inference could be made concerning the statistical concept base of entering GSM students; (2) to determine the job functions being performed by acquisition managers so that problems and exercises for statistical courses can be developed to represent the types of situations GSM students can be expected to encounter upon graduation from AFIT.

Three conclusions were reached and these were; (1) while there are indications that statistics is needed by acquisition managers, the current survey results show that the acquisition managers are not using any of the identified statistical course/concepts in their work; (2) while the top ranked task functions are primarily quantitative in nature, the courses most used are qualitative with little or no quantitative nature; (3) while the response was good to the survey, the use of this survey to try and infer the concepts entering acquisition management GSM students would bring to AFIT produced unclear results. Any attempt to infer an association among the statistical concepts with the activity job groups will most likely require personal interviews of selected field personnel. (Thesis).

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