DEFINING AND MEASURING ACADEMIC STANDARDS FOR HIGHER EDUCATION: A FORMATIVE STUDY AT THE UNIVERSITY OF SONORA

by

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DEDICATION

This work is dedicated to

My Wife, Addy Fatima,

Our Children, Jorge Manuel and Alejandro,

Our Grandchildren Jorge Manuel and Alexa Maria,

My Parents Manuel† and Lucila, and to my Sisters,

To my Grandparents†, Uncles and Aunts,

To Thayer and Carol† Erringer, and to

All of my Teachers through many years

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ABSTRACT

Institutional efforts to organize the admissions process in several Mexican universities have led to the adoption of standardized instruments to measure applicants' initial academic qualifications for career programs. The University of Sonora, located in four campuses throughout the state, initiated the administration of a college level entrance exam in the fall of 1997. The Examen de Conocimientos y Habilidades Básicas (EXCHOBA), developed in 1991, is the instrument employed for aiding the academic and administrative agencies in making admissions and career placement decisions to date. Drawing on current practice, this project develops a model for investigating the alignment of the high school curriculum with the entrance examination by extracting and clarifying the academic standards that derive from the official curriculum. Through a series of statistical analyses on data from exam administrations, a working model for defining the standards along with the instruments' sub-tests is proposed. The basis for a system are then suggested to assist high school and university agencies and administrators to interpret the results with a clear set of procedures for making curricular and instructional decisions that will help improve the current rates of success in the different career programs at the institution. In particular, the results obtained will lead to a proposal to improve the academic advising and guidance programs that the Universidad de Sonora is currently implementing to improve student retention and graduation rates in its career programs.

CHAPTER 1

INTRODUCTION

Systematic testing and measurement practices in educational contexts in Mexico are rather new and have depended mostly on standardized instruments of recent construction (Backhoff, 1998). As usage of these devices is becoming more prevalent it is now both necessary and justifiable to assess their measurement properties in particular reference to officially published school curricula. In the state of Sonora located in the northern section of the country, the practice of employing standardized tests instruments was legally instated in 1997 through internal legislation passed at the state level (UNISON, 1996). These legal decisions were based on the need for a uniform system for student selection and placement into university career programs. Beyond the original purpose that motivated this legislation, this project is presented as platform for advancing testing and measurement practices to a different level. Namely, this project is based on the fact that testing and measurement results can be profitably used to inform curriculum development, instructional practices, and academic guidance activities at the high school and university levels. The author takes the position that selected curricular content areas should be officially treated as academic standards to be attained by curriculum and instruction. These standards can be only be realistically defined through a technically sound measurement system and the resulting interpretation of scores.

A formative study consists of a series of methodological trials to build a customized system for analysis of a measurement situation where no precedent studies exist. The aim the methodological exercise is to produce a working model that can be in turned applied to systematize investigations in this relatively new educational research area in Mexico. This approach is warranted in the case of the Sonoran High School System and its relation with its corresponding state university for at least two reasons:

a) The practice of using standardized instruments to select students for university programs is relatively recent in the state of Sonora, and b) No preceding studies have taken on the task to compare the existing high school curriculum with the measurement properties and factorial design of the instrument under use.

Consequently, the methods to be employed in the formative study are indicative of two specific purposes:

a) to develop a model for assessing the correspondence of the curricular content with the factorial structure of the instrument, and b) assessing the instrument's sub-scales by obtaining calibrations on item difficulty and ability of the examinees.

The combined application of these methods will in turn enable the researcher to make a determination on the degree of alignment between the curricular content areas and the instrument's sub-scales. Based on the findings recommendations can then be made as to the type of alignment adjustments that are required. However, the most important result is that the curricular content areas can be successfully defined as Academic Standards to be attained by the students showing also that the instrument to determine such attainment is in fact available.

Background of the Study

This project focuses on developing a working model for studying the technical definition and measurement specifications required to set academic standards for admission and completion of university degree programs in a selected setting. The University of Sonora is the largest publicly funded institution in the state and recently declared an enrollment of 22,622 students in 31 career degree programs, (UNISON, PDI 2001, p.25).

Throughout its history the institution - founded in 1942- maintained an open admissions policy based on a standard criteria of high school completion before university enrollment. Beginning in 1997, the first attempts to place order in the admissions process were put into effect by the adoption of a college level entrance examination named "*Examen de Habilidades y Conocimientos Basicos*" – EXHCOBA. The instrument was developed between 1986 and 1991 by a team headed by Eduardo Backhoff Escudero of the University of Baja California (UABC) and Felipe Tirado Segura, of the National Autonomous University (UNAM), (Backhoff & Tirado, 1992).

EXHCOBA's adoption at the University of Sonora resulted from a process of policy changes developed and mandated by the Academic Council between 1994 and 1996. It must be noted that this policy was implemented in order to develop an institutional system to reduce enrollment in careers that were saturated with applicants. While this purpose has been served, the university officially recognized the need for advancing in this direction and determining the complete set of factors that interact to produce the current rates which are 55.50% for completion of overall career programs of study and 31.00 % for completion of all degree requirements leading to the official degree conferral (UNISON, PDI 2001, p.30).

For the administrative period comprised between 2001 and 2005, the University of Sonora produced an Institutional Development Plan (PDI) that addresses the international and national contexts of the university and describes strategic programs for meeting the challenges the institution presently faces. In this document the Universidad de Sonora expressly recognized the need for developing and applying evaluation processes that are valid, reliable, and methodologically sound to technically assess the learning outcomes for students in all career programs, (PDI, p. 62). In the same context, the Universidad de Sonora developed and began to implement in 2002 an Academic Advising and Guidance Program denominated *Tutorias Academicas.* This program is directly aimed at the early detection and remediation of undergraduate students' academic deficits as they progress through the initial semesters of their career programs. However, the relation of the academic difficulties experienced by entering students has not yet been technically linked to the academic standards that the students are required to meet to exit the high school system and to apply to their chosen career programs.

However, the relation of the academic difficulties experienced by entering students has not yet been technically linked to the academic standards that the students are required to meet to exit the high school system and to apply to their chosen career programs. A detailed description of the instrument along with the main aspects of its development is presented in Chapter 2 of this dissertation.

Purpose and Rationale

Continuing with the precedents set by current testing practices and in particular by the use of EXHCOBA the research questions being addressed in this project are:

A) What are the academic standards that underlie the official high school curriculum in the Sonoran Preparatory Sub-systems?

B) What are the technical properties of an instrument that measures these academic standards?

C) How can the definitional and measurement results be applied by the high school system to enhance curriculum and instruction?

D) How can the definitional and measurement results be applied by the university to enhance its academic guidance efforts to improve current retention and graduation rates in its career programs?

If this project is successful, the high school institutions involved as well as the University of Sonora will benefit from a wealth of information derived from the investigation of the actual relations of the current academic content and the initial measurement efforts in place.

Methodological Approach

In order to shed light on the present situation, the project was divided in two phases: a preliminary and a full project phase. During the preliminary phase, the demographic and academic characteristics of university applicants taking the EXHCOBA in the 2003 cohort are described as background context for the application of statistical methods to the data generated by the examination.

During the full project phase the measurement properties of the instrument are examined employing Exploratory Factor Analysis (EFA) and Confirmatory Factor Analysis (CFA) in order to obtain a determination of construct validity. The procedures employed are those available in the TESTFACT 4 program (Wood, Bock, Gibbons, Schilling, & Muraki, 2003). The data to conduct this part of the analysis was obtained from sub samples of the cohort of applicants that have taken the examination during the months of May and June of 2004.

It is likely that the instrument functions as specified in its original structure (see Figures 2, 3, and 4). However, it is precisely this internal structure that must be determined in relation to the curricular content areas being covered in the high school system. The resulting measurement dimensions are to be compared to the existing standards in the high school curriculum. The working models will then produce an initial basis for studying the areas of correspondence as well as discrepancies to compare the actual alignment of the instrument with the curriculum content areas.

To conclude the full project phase, the alignment analysis of the instrument and curriculum are extended to study the measurement properties of the specific EXHCOBA subtests and in the measured dimensions.

In order to accomplish the above, the test result are analyzed by sub-test and items employing one - parameter item response theory techniques (Embretson & Reise, 2000; Wright & Stone, 1979). Namely, the item data are analyzed employing the Rasch Model with the WINSTEPS Program, (Linacre, J. M., 2003). Once the measurement properties of each of the EXHCOBA sub-scales are determined by this type of item analysis, the university and the high school institutions involved will be in a better position to examine and compare the academic standards being pursued at both levels.

As stated above, the exam results will be obtained from the Admissions Record Data Base from the 2003 and 2004 applicant cohorts. Access to these records has been secured by agreement with the Universidad de Sonora Admissions Committee. The information of the data sets will be accessed and handled applying all the necessary rules to insure the anonymity of the applicants. The Official Academic Standards will be obtained from the curriculum of the *Colegio de Bachilleres de Sonora* (COBACH), which is the largest state high school institution in the state with 25 campuses throughout the state. Permission to study the standards alignment will be obtained from the central administration of the state institution. It must be noted that the greater majority of university applicants graduate from high school under the COBACH curriculum which has been recently modified for the academic periods of 2003-04.

Expected Results

The expected results are as follows:

(1) A dialogue centered on Academic Standards will be initiated and carried out between the academic authorities responsible for the curricular content areas and instruction at the high school level and the university agencies responsible for defining the admissions criteria.

(2) By examining the resulting conclusions the related university agencies will have at their disposal a database that will enable them to develop and apply programs to enhance the success rate of the students admitted to the different career programs.

(3) In particular, the University has begun an extensive academic guidance program know as "*Tutorias Academicas*" (Academic Tutoring), which is to be eventually offered to all students in the initial semesters of their career programs. The results by knowledge domains can be applied to enhance the academic guidance efforts currently in place by career programs.

(4) The academic authorities of the high school system will also have at their disposal a database and a model for examining the curricular and instruction decisions made by content area particularly for the junior and senior years. The model, once tested,

can be extended to aid in the decision-making procedures for semesters prior to the Junior and Senior years.

Before proceeding to the next sections, it must be noted again that the original purpose of the study was to define a set of procedures that afford technically sound answers to the questions posed. Namely, once the system is in place for identifying and measuring academic standards, the testing system can be profitably used to inform educational practices in curriculum development and academic guidance programs.

This set of procedures will subsequently be treated as a working model for conducting a full research program centered on the full definition of academic standards in the State of Sonora. It is foreseeable that these research efforts will have to be extended to the Sonoran educational system in grade levels preceding high school. In fact that approach would be the ideal one. Nevertheless, this effort must begin at the high school level because the only existing instrument to date the EXHCOBA was designed and constructed to measure abilities upon completion of this particular level.

Reasons for Studying Factorial Validity and Item Properties

The EXHCOBA examination is a consolidated instrument. Its development and usage have established content validity of the test subsections to a reasonable extent. However, the documentation on file at the test development institute of the Universidad de Baja California (UABC) indicates that while a considerable amount of information has been gathered on the instrument's performance, to this date no studies have been conducted to study the factorial structure of the test (Antillon, 2002; Backhoff, 2001).

It seems logical that the next step in the development was to test the factorial validity of the nine subtests. However, this dissertation project was based on the position that studying the factorial structure of the test does more than gathering evidence for establishing construct validity. A confirmatory analysis of the test structure based on empirical data is a legitimate methodological tool that can be employed to technically locate and define the academic standards that are implicit in a uniform curriculum. Once results are obtained on the factorial structure of the nine subtests, a detailed study of the item properties can be used to obtain calibrations of examinees' actual abilities as well as item difficulty indices. This in turn yields the basis for studying the actual alignment of the instruments' subtests with the curricular content areas that comprise the official curriculum. The approach outlined here combines two solidly established measurement techniques in to a systematic formal definition of academic standards which includes its corresponding measurement apparatus.

CHAPTER 2

LITERATURE REVIEW

The main objective of this section is to review documentation from two stages of development of educational assessment practices that are relevant to the current context of the state of Sonora. It must be noted that this section briefly traces the relevant antecedents of the introduction of standardized testing in the state but it will not render a complete account of the history of educational evaluation in Mexico.

Historical Background

The practice of educational evaluation in Mexico and in the State of Sonora follow parallel development stages because in the country educational policy has bay an large been implemented following centralized directives that originate in the federal agency responsible for designing and implementing educational policy, the Secretaria de Educacion Publica (SEP) which is the national secretariat of public instruction.

For the purposes of assessing the publications that relate to educational evaluation the project divides policy making and practice for evaluation in two stages. The first stage includes the developments prior to 1990 in which educational evaluation was carried out by educational agencies in Mexico largely as a self-contained series of processes. During these stages evaluation criteria, procedures, and instruments were applied in each state by educational institutions following an internal interpretation of federally designed directives. By and large, the evaluation criteria for assessing attainment of educational objectives were teacher assigned grades throughout the different levels of schooling. That is, beginning in the elementary level, passing through middle school, and ending with the preparatory level, students were required to complete twelve years of instruction in which teacher assigned grades were the main indicator of achievement. Beginning in the decade of the 70's the Secretaria de Educacion Publica (SEP) began administering National Evaluations with self-designed and self-appraised evaluation processes with limited external criteria and lacking externally designed measurement instruments and evaluation criteria. Nonetheless, by these practices the states including Sonora amassed a considerable database containing information on student's aptitude and knowledge deriving from a uniform curriculum but with self-generated indicators of student achievement. Nonetheless, as the main indicators were teacher assigned grades within the different levels, grade point averages at the completion of every level were taken to validly represent the required measures of educational attainment. The vast majority of the information on student achievement handled by the federal and state governmental agencies followed the same procedures of maintaining grades by subject matter and grade point averages as the adequate indicator of educational attainment.This manner of defining evaluation criteria for subject matter and schooling subsystems is relevant because in the development of the instrument under study the same conceptual structure was followed to make the examination parallel subject matter division, sequences and general organization by schooling levels from Elementary through High School.

This stage may be called for the practical purposes of this investigation the stage of self-contained evaluation because the evaluation criteria were generated from within the educational processes. This does not necessarily entail that previous practice was undesirable. It merely represents a stage of development in which teacher and school generated indicators of student achievement were the only evaluation tools available. This situation must be understood in the context in which schooling practices are based on a uniform curriculum that is delivered and regulated nationally by the Secretaria de Educacion Publica (SEP). The uniformity in curricular content in the elementary, secondary and preparatory levels affords a particular type of confidence in the teaching practices that are so guided and therefore teacher assigned grades – assuming teachers follow the curriculum − are taken to represent a valid measure of student educational achievement.

During two decades − from 1960 to 1980 − there were important steps in the development of psychometrics at the Universidad Autonoma de Mexico (UNAM) and at the Instituto Politecnico Nacional (IPN) namely in the Schools of Psychology and Medicine. However, the testing systems designed then were not extended to educational levels outside these areas. Also, during the late 60's several Mexican private institutions of higher education began to utilize a Spanish version of the SAT called Prueba de Aptitudes Academicas (PAA), developed at the Puerto Rico office of the College Board.

An important breakthrough in the history of educational evaluation in Mexico came about with the foundation of the Centro para la Evaluacion de la Educacion Superior A.C. known as CENEVAL. This national center began operating in 1994 under the auspices of the largest public universities notably the Universidad National Autonoma de Mexico (UNAM) as well as the Asociacion Nacional de Universidades e Instituciones de Educacion Superior ANUIES. CENEVAL is registered as a national not for profit civil association since April 28, 1994. Its mission is to organize educational testing and evaluation systems for higher education institutions from the public and private sectors.

The institutions that contract the testing and evaluation services of CENEVAL do so on a voluntary basis. The institutional decision to contract and apply the CENEVAL systems conveys the institutional commitment of insuring the quality of their programs by submitting to an independently designed formal evaluation program. The center began to act as the entity officially responsible for organizing standardized testing systems to regulate the admission processes for the most populated universities as Universidad Autonoma de Mexico (UNAM) and also the Universidad Autonoma Metropolitana UAM in central Mexico. The center marks a stage in which the practice of educational evaluation would no longer be self contained as an external and independent entity running standardized testing to diagnose achievement of exiting High School students. For this purpose, CENEVAL produced the Examen Nacional de Ingeso (EXANI) which is to date widely used by universities in central Mexico to organize admissions and placement processes. This entrance and placement exam is available in two versions EXANI-1 and EXANI-2, which have been designed to measure student achievement at the high school level. The use of this instrument and the associated practices are not the focus of the present study. Nonetheless, it is important to mention that these practices set important national precedents for standardized testing in Mexico in the sector of public education.

It must be noted that even before the large scale instruments above were available for use, the EXHCOBA examination was already developed and employed by several institutions. Thus, the EXHCOBA instrument which is the object of study in this dissertation can be viewed as the precursor of large scale standardized testing in Mexico (Martinez R., 2001).

Another turn of events recently modified educational evaluation practice in Mexico. On August 8th 2002, the Mexican Congress passed a law creating the Instituto Nacional de Evaluacion Educativa (INEE). This national institute is by law designed to organize and conduct an educational testing program that will assess learning outcomes at all levels throughout all levels of the country's federal and state sub-systems. As national testing begins to enter as a large scale practice, the national institute began in 2004 to offer select results from national piloting studies at the elementary and secondary levels

Development of the Instrument

It was in this context that the need for an instrument measuring basic abilities and knowledge possessed by students graduating from high school was addressed by the developers of (EXHCOBA). It can be said that the instrument was constructed anticipating the need for organized testing practices that employ independently developed measurement instruments.

The EXHCOBA examination was developed based on initial research conducted between 1986 and 1990 (Backhoff & Tirado, 1992). The test development phase was based on the analysis of examination results from a total of 14,166 students entering the University of Baja California (UABC) seeking to pursue careers in 23 academic departments and 53 career programs. The basic research included the administration of several instruments which include: the Raven Test of Matrices, the Thurstone Test for Primary Mental Abilities, and the Kuder Scale for Vocational Interest among others.

Based on the data analysis the authors decided to develop a college entrance examination, which in turn produced the present EXHCOBA. This stage was accomplished by an extensive item construction process. Item construction was based on the content from the uniform curriculum applied in Mexico at the elementary, secondary, and college preparatory levels.

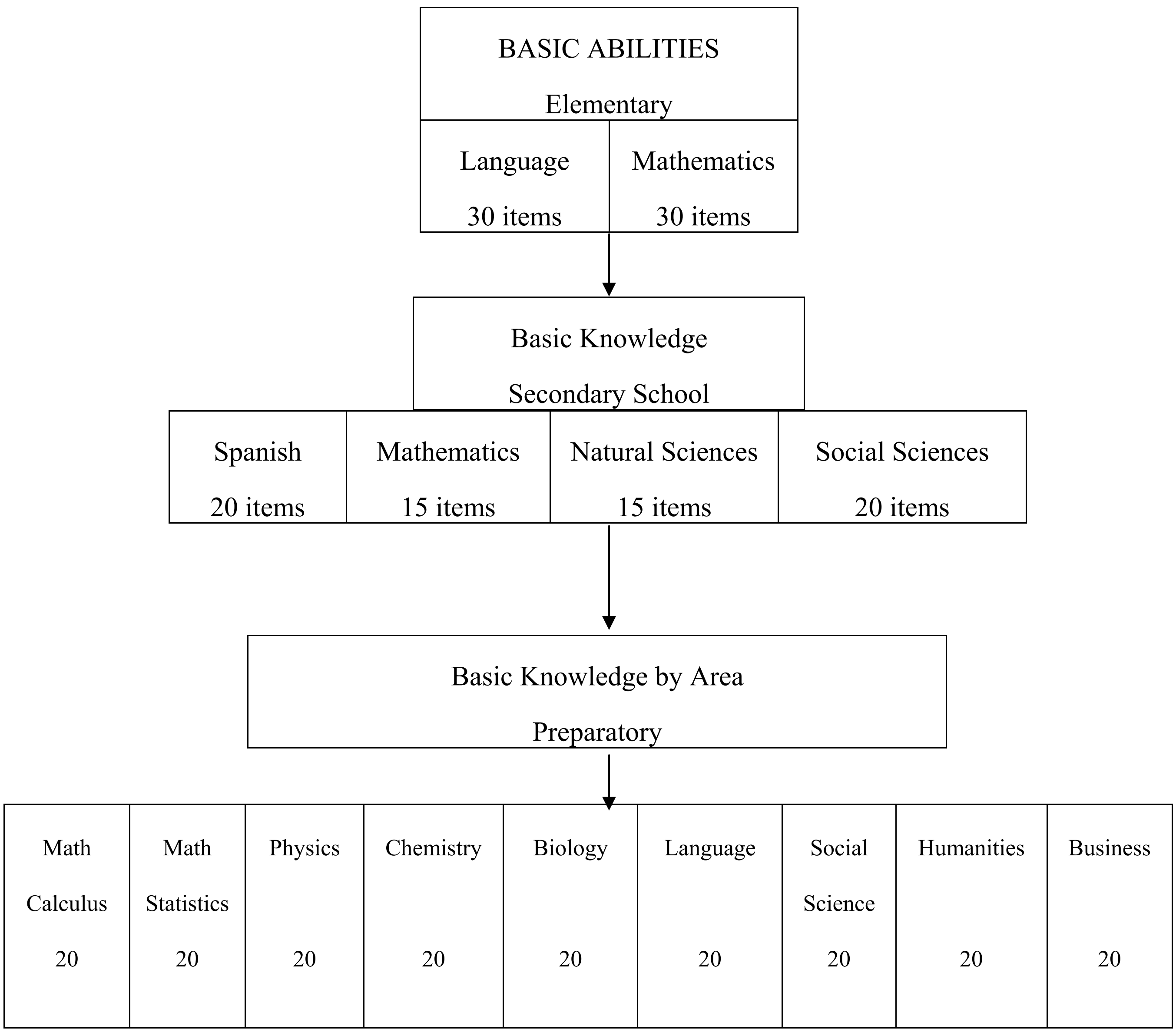
After content and format analysis were completed, the instrument was produced in computer format to enable electronic administration. The current version of the instrument contains 310 multiple-choice items divided in two sections.

The first section has 130 items that must be answered by all students regardless of their career choice and which are distributed as follows: 30 items for quantitative abilities, 30 items for verbal abilities, 15 items for Spanish, 15 items for math, 20 items for social sciences, and 20 items for natural sciences.

The second section comprises 9 content disciplines with 20 items each. The content disciplines are: math for calculus, math for statistics, physics, chemistry, biology, social sciences, humanities, language, and business administration. These disciplines are in turn grouped in blocks of three each according to the area in which the career pursued by the applicant belongs. The areas are denominated: 1) Economics and Business Administration, 2) Biology and Chemistry, 3) Health, 4) Engineering, 5) Physics and Mathematics, 6) Social Sciences and 7) Humanities. In this section students answer only three blocks of 20 questions each according to the knowledge area of the career program to be pursued. Hence, this last part contains 60 items grouped by knowledge area. Adding the 130 items from the first section with the 60 from a selected knowledge area any individual applicant must attempt to answer a total of 190 items (See Figure1 below).

Figure 1

Conceptual Structure of EXHCOBA*



* The downward arrows indicate the sequence in which applicants progress through the examination sections

In sum, EXHCOBA is designed to measure:

1) Basic Abilities from the elementary school level
2) Basic Knowledge from the middle school level
3) Basic knowledge for an area of specialization from the high school level.

According to the developers the focus of the tests require from the examinees:

1) Notions and not specific precision in knowledge
2) Operative abilities such as execution and algorithms
3) Comprehension of written language and mathematics
4) Fundamental notions from selected disciplinary areas and related to professional careers.

However, a formal psychometric approach to the structure of the examination requires that the factorial structure underlying each subsection be examined with an appropriate statistical procedure. For this reason the methods selected in this dissertation attempt to examine the structure of the data as presented in the following figures, 2, 3, and 4.

Figure 2

Theoretical-Factorial Structure of EXCOBHA Part Ia

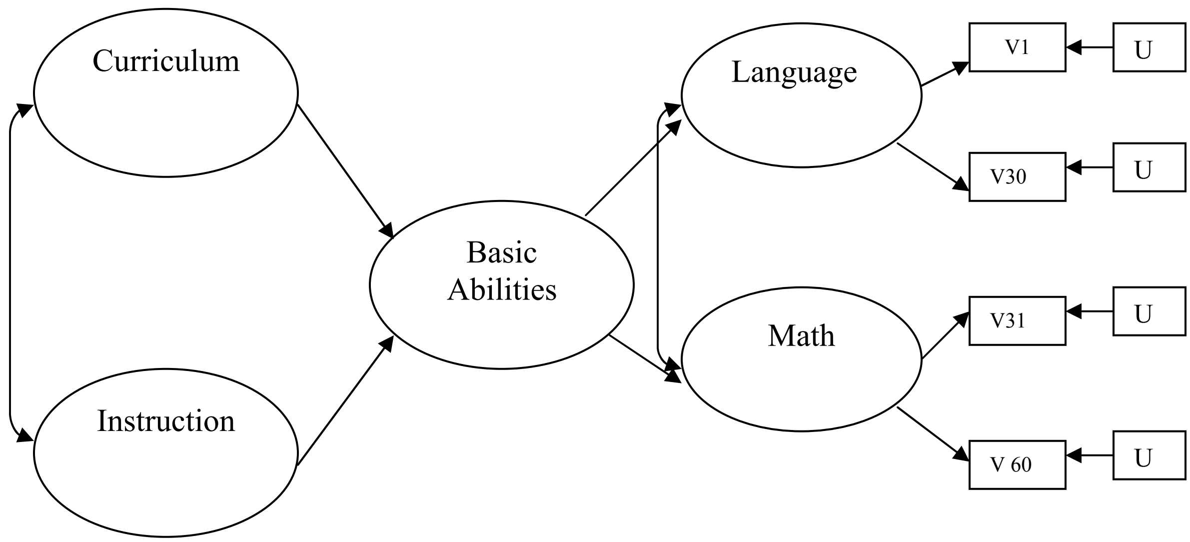


Figure 3

Theoretical- Factorial Structure of EXCOBHA Part Ib

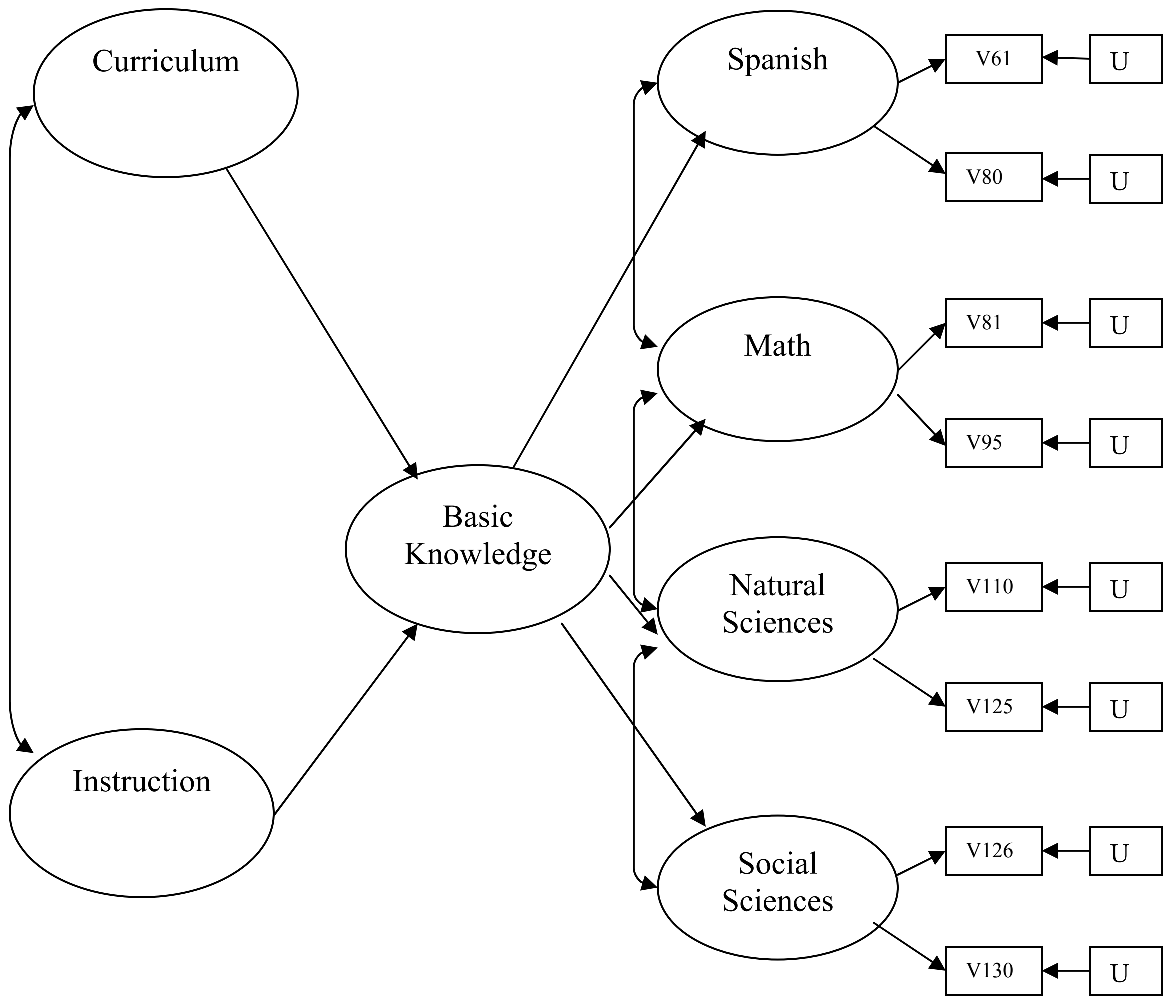
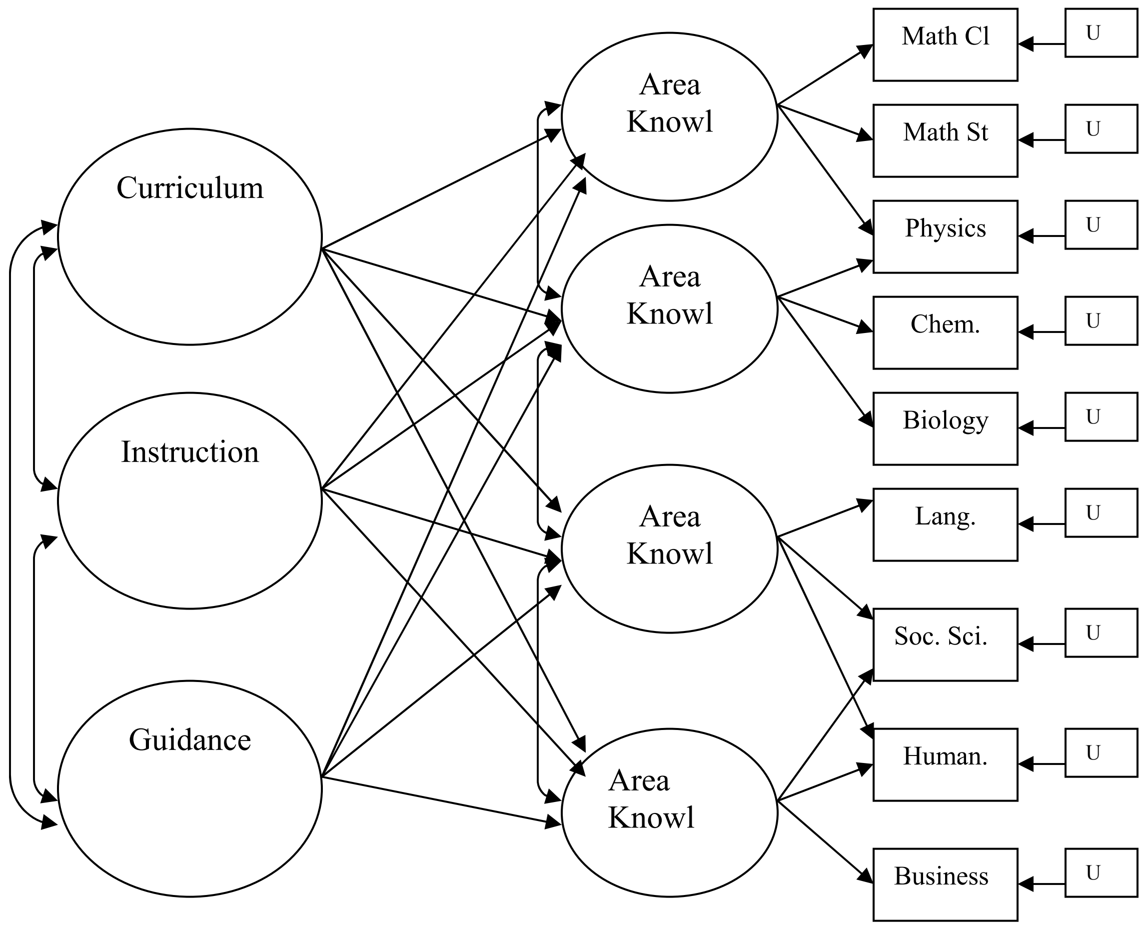


Figure 4

Theoretical-Factorial Structure of EXHCOBA Part II



The Basic Assumptions of EXHCOBA

Returning now to the origin of the EXHCOBA system as portrayed in the literature, the educational assumptions that initially guided the developers' effort were:

(1) Poorly grounded learning has little value for future learning and for this reason it is appropriate and desirable to evaluate the basic learning that the student has acquired through formal schooling from the elementary to high school sequence.

(2) Basic learning is required in order to achieve meaningful learning in post-secondary schooling and to complete successfully a higher education program.

(3) Academic competencies are relatively stable and they develop over a long period of time. Academic competencies do not change abruptly and this fact allows for making predictive judgments based on test scores.

(4) EXHCOBA focuses on evaluating abilities to perform deductions, abstractions, conceptualizations, and inferences of verbal and quantitative content that are indispensable for the study and understanding of any given subject matter in higher education.

The Student Selection Model

In order to develop a viable model for student selection the following criteria were applied:

(1) A composite score based on the EXHCOBA score and High School GPA was applied.

(2) The composite score alternative is based on the fact that admission exams have limited predictive power.

(3) High School GPA is a suitable indicator of success at the university level and can be a better predictor than admissions scores taken alone.

(4) The combination of these indicators improves the correlation with exam scores obtained at the university level.

(5) The weighting scheme that resulted in the best combination for these variables is 65% for EXHCOBA scores and 35% for High School GPA.

(6) The application of the selection model resulted in a predictive validity coefficient of 0.55 (Backhoff, 2002).

A Diagnostic of Academic Performance

An important implication of the selection process is that it provides a diagnostic scheme for assessing the levels of academic performance with which the student attempts a university level program. Since the process evaluates the actual possession of basic knowledge and abilities, where there are measurable deficiencies in these, the acquisition of new knowledge by students will be problematic. This situation if detected calls for corrective action in two levels. Once the discrepancies between what is expected of the student and what he or she can actually perform are identified, an institution can:

(1) Adjust its plans and programs of study to begin the educational process at an adequate level.

(2) Remediate the academic deficiencies with special preparation and devise systematic corrective actions until the deficiencies are solved in a measurable manner.

Development of the Conceptual Framework

Intellectual abilities-broadly defined- results from combinations of knowledge, capacities and effort. To locate a set of particular intellectual abilities at least two questions require full answers:

(1) How many dimensions are required to describe individual differences in cognitive task execution?

(2) What are the interrelations among dimensions of mental ability?

For the purposes of the present project, and following the approach initiated by Backhoff and Tirado (2002), the two principal research questions guiding this dissertation are a direct follow-up on the conceptual framework that underlies the EXHCOBA effort. Namely, the questions concerning the identification of Academic Standards underlying the official high school curriculum in Sonora converge on an attempt to analyze the curricular and instructional results as these appear in the empirical datasets produced by the EXHCOBA administrations to cohorts 2003 and 2004.

Standard Setting through Measurement

It has been noted that the systematic use of standardized instruments is rather recent in the educational context under study. For this reason the literature review presented has focused on the documentation generated mainly in relation to the initial use of the EXHCOBA examination. However, in the United States an abundant body of literature is available providing researchers with detailed technical analyses of the relationship between educational measurement frameworks and the setting of academic standards. Examples of this type research are found in Cizek (2001) among other sources.

CHAPTER 3

METHODS

The major section of this chapter provides a full description of the methodology p along with the main technical requirements being met to conduct EFA, CFA, and IRT analyses on the data obtained from the 2004 cohort of applicants. The general requirements and procedures for each statistical technique are described along with the computer programming appropriate for each type of analysis. Each case includes a complete account of the decision making process to assess fit of the theoretical models of EXHCOBA to the empirical data obtained from the 2004 cohort.

Preparation of the 2004 Cohort Data

The 2004 data set contains a total of 9,196 applicants to the University of Sonora. The applicants are divided by the career program in which they seek admission. Each of the segments contains a total of 190 variables per applicant corresponding to the number of EXHCOBA items administered. As noted before, items 1 through 60 belong to section 1a of the test, items 61 through 130 belong to section 1b of the test, and items 131 through 190 belong to section 2 of the test. It must be noted that the 60 items in section 2 are presented to the applicants in combinations that correspond to the knowledge area of the career program they have selected. The first step in applying the statistical methods selected to obtain a representation of the constructs being measured by each subscale and of the item properties of the instrument's subsections, began by dividing the 2004 cohort into in three randomly selected sub samples.

The random sampling procedure employed is available in the SPSS package and it yielded the following sub samples: Sample 1 with n= 3051 analyzed with exploratory factor analysis (EFA). Sample 2 with n= 3054 analyzed with confirmatory factor analysis (CFA). Sample 3 with n=3091 analyzed with the one parameter item response model (IRT). The purpose of analyzing the data under this sampling scheme is to obtain a cross validation of the results.

Statistical Methods

Since the main objective of this dissertation was to devise and test a particular methodology to identify and define the academic standards implicit in the high school curriculum, a detailed description of the combination of statistical methods for this purpose follows along with a technical justification for their use.

It must be noted that the approach taken focuses on a theoretical construct, which is designated as the High School Curriculum as instantiated in the cohorts of university applicants. For further clarification of the nature of this construct the reader is asked to consider that the basic abilities and knowledge detected by the EXHCOBA instrument as operating in the students' measured academic backgrounds are part of a form of factual curriculum as operationalized by their responses to the test item sets in nine sub-sections.

Given the above, the methodological task becomes the employment of the proper statistical methods that will operationally define the sub-constructs of basic abilities and knowledge factually possessed by the applicants. Once these sub-constructs are identified through the statistical analysis of the measurement instruments' data as observed in the cohorts, it remains to be decided if these entities as identified actually correspond to proper academic standards for higher education. The methods are employed sequentially to attain a pattern of cross validation of the results obtained in each approach. The cross validation is accomplished by applying the statistical procedures to three randomly selected sub samples drawn from the 2004 Cohort. The results of each procedure are then compared across the 3 sub samples to locate the similarities and the differences in the structure of the data set.

The statistical groundwork resulting from the cross validation pattern becomes the basis for a technical definition of academic standards as attained in practice and as attainable in theory. The description of the statistical procedures that follows is based largely on the literature of the computer implementation of the techniques (Bock et al. 1988); (Knoll & Berger, 1991). A similar application of the item factor analysis techniques employed to assess teacher's knowledge of subject matter exemplifies the approach to factor analysis described and applied in this project (Hill, Schilling, & Lowenberg, 2004).

Exploratory Factor Analysis

The first goal in the methodological approach is to identify the structure in the EXHCOBA 2004 data set. The application of EFA procedures here is done in preparation of the latent trait analysis performed with CFA. This aim is accomplished by investigating the factual dimensionality of the data set. Exploratory factor analysis is appropriate to identify the underlying dimension structure of a set of data. This is accomplished by reducing a number of variables, 190 in the present case, to a smaller set of factors that account for the covariation in the data set.

Drawing on the initial specifications, the instrument's items are arranged into nine subscales and these item groups should exhibit underlying dimensions. The idea behind applying exploratory factor analysis is to determine the item sets that belong in each of the dimensions that underlie the structure of the data sets. In the EXHCOBA examination the factor analytic approach initially determines the number and the nature of constructs being measured by the instrument's subscales. In particular, it is of interest to obtain a preliminary mapping of the basic ability and basic knowledge sub-constructs as these emerge from the item response patterns in the 2004 data set. Drawing on the item intercorrelations and following the ordering of the items in each subscale a pattern of item sets emerges representing the factual curricular content being detected by the instrument's sub-sections. These patterns of item sets correspond in turn to the common factors that account for the response patterns and a portion of the variance in the data set.

The common factors influence more than one observed variable, and in the particular case these are expected to influence a number of item responses within a given subscale. In the case of basic abilities and knowledge by content area these common factors are also expected to be correlated among themselves. This calls for a particular type of analysis in which the factors are plotted to be oblique in their geometrical representation. This means that the common factors tend to influence each other as well as the variables observed through the item responses.

Process and Computer Implementation

The package for computing the data analysis makes use of IRT estimation procedures that employ all of the information in each examinee's pattern of correct and incorrect responses to the test items. These estimation procedures are called “full information methods” because they compute the response information in all possible occurrences and joint occurrence frequencies of all orders. That is all possible item combinations, pairs, triplets, quadruples, etc., are considered information for the analysis (Bock & Schilling, 2003).

The full information procedure in TESTFACT 4 (Bock , 2003) maximizes the likelihood of the item factor loadings given the observed pattern of correct and incorrect responses. The procedure solves the corresponding likelihood equations by integrating over the latent distributions of factor scores assumed for the population of examinees, called the θ distribution. The estimation method implemented in TESTFACT 4 is called marginal maximum likelihood (MML) because the integration procedure employed by the program is referred to as “marginalization”. This MML procedure has been shown to produce feasible estimations for fitting item response models in multi-dimensional factor spaces (Bock, Aitkin, & Muraki, 1988).

Since the EXHCOBA is a multi-dimensional test and the data set contains the item responses given by the 2004 applicants coded “1” if the item was correctly answered and “0” otherwise, the EFA procedure employed is the full information item factor analysis based on inter-item tetrachoric correlations. This is a special requirement because as the instrument’s items are dichotomously scored either correct or incorrect, the inter-item correlations must be estimated in a manner that does not produce biased estimates. The tetrachoric correlation meets this requirement and it is therefore used throughout all of the subsequent analyses. Occasionally the tetrachoric correlation matrix must be recalculated during the analysis in order to obtain a matrix with the property of positive definiteness. In a smoothed inter-item correlation matrix the elements of the diagonal are replaced with corrected roots and the non-positive roots are replaced with either zero or a small positive quantity. Once the inter-item matrix is modified the analytical procedure can be applied to obtain an initial representation of the structure of the data derived from dichotomous variables.

The analysis is conducted in a sequence of steps requiring certain decisions to be made at each step. The first step in performing EFA is the initial extraction of the factors from an analysis of the inter-item tetrachoric correlation matrix. A common factor is a hypothetical latent variable that is postulated to explain the covariation between two or more observed variables.

The extracted factors will have two essential properties:

- Each factor will account for a maximal proportion of variance not accounted for by other factors extracted in the process.
- Upon initial extraction each factor will be uncorrelated with all of the previously extracted factors. If any of the extracted factors are in fact correlated their relationships will be analyzed in subsequent steps of the process.
- To obtain an accurate representation of the variables in their relationship with the extracted factors, a rotation procedure is applied. In the present case, VARIMAX rotation is selected to represent the variable factor relationships maximizing the observed variance among the variables.

For present purposes the procedure described is implemented in the TESTFACT program version 4, which uses the minimum squared residuals method (MINRES) to extract the factors from the smoothed correlation matrix. The process and test description that follow are taken from the TESTFACT manual (du Toit, Ed. 2003).

During the first phase of the procedure the item communalities are estimated. These are defined as the squared multiple correlations between the observed variables, in this case item responses and the set of factors that underlie the item sets. The estimated communality is in turn the sum of squares of the loading of the observed variable on the extracted factors. An item's communality ultimately represents the proportion of variance in the observed variable that is accounted for by the extracted factors common to the variable. The item factor loadings represent the correlations between the observed variable and the extracted factors. By general rule variable loadings above .30 are considered meaningful for interpretation of the extracted factors. Loadings of .30 and greater indicate that the item aligns with the factor where the significant loading occurs as well as with other items that load on the same factor. It follows that the greater the loading of an item on a factor there is a greater association between the item and the construct it measures. In this manner by inspecting the pattern of item loadings on the extracted factors, and by attempting to match the loadings with the basic abilities and areas of knowledge that the item subsets were designed to measure, conclusions can be reached about the factual statistical relationships between the item sets and the hypothetical latent variables that the extracted factors represent in the analysis. However, before the conclusions on the item loadings and item sets can be reached, it is necessary to determine if the number of factors extracted adequately represents the structure of the data. This is accomplished by conducting a hypothesis test on the number of factors.

The TESTFACT program provides a means for conducting the test as follows: The initial run of the program is done with a hypothesized number of factors k. The statistical test is then applied in the form:

H_0: A k-factor model provides an adequate description of the data.

H_1: A (k+1)-factor model provides an adequate description of the data.

As the program is run under the H_1 number of factors specified, a χ^2 statistic with the corresponding degrees of freedom is obtained. Then the program is modified to run under the H_0 number of factors specified and the corresponding χ^2 value and the degrees of freedom are obtained.

The χ^2 values with their respective degrees of freedom are then compared by subtracting the value obtained under H_0 from the value obtained under H_1 and the corresponding degrees of freedom are also subtracted. The resulting value is the test statistic for testing a k factor model versus a k+1 factor model. If the resulting value is significant, H_0 is rejected and it is concluded that the number of factors in k+1 provide a more adequate representation of the data.

Once the program is run under the conditions specified by the hypothesized structure of the data in the item sets and the test results are significant it is then possible to reach conclusions about the alignment of items and the number of factors tested. The particular application of the procedures and tests just described to each of the EXHCOBA sections are presented in the TESTFACT programs described in Appendix 1.

As noted before the exploratory phase of this analysis is run on a randomly selected sub-sample of 3054 applicants that took the EXHCOBA in May of 2004 and the hypothesized factor structures follow the conceptual framework of the two sections of the instrument. The results of the statistical tests on the number of factors as well as item loadings on the extracted factors are reported in the second section of Chapter 4.

Confirmatory Factor Analysis

The second step in the methodological approach to be tested involves the use of confirmatory factor analysis (CFA) to approximate a representation of the latent traits involved in the observed item response patterns. This statistical technique is properly employed in a situation where the objective of a study is to test the hypothesis that a particular linkage between a set of observed variables and a set of underlying factors does in fact exist. As noted above, a factual curriculum exists as represented by the observed variables measured by the EXHCOBA subsections, and it is reasonable to examine the relationships between these variables as observed and the theoretical structure of the instruments' subsections. Drawing on theory it is postulated that basic abilities and knowledge should be operationally present in students as result of their exposure to the uniform high school curriculum and consequently a CFA application should identify as factors these constructs or attributes.

Upon application, confirmatory techniques postulate either a full structural model or a measurement model. The full structural model includes theoretical relationships among latent variables as well as among observed variables and their corresponding constructs. The measurement model is limited to depicting the relationships among observed variables and their corresponding latent variables. Also, CFA models are first order when the relationships postulated are hypothesized among latent and observed variables only. Second order models include hypothesized relationships among latent variables themselves as well as among latent and observed variables

In this project the application of CFA models the relationships among basic abilities as latent variables and subtest item responses as observed variables, thus it is a second order full structural model.

The primary task of the model testing procedure is to determine the goodness of fit of the hypothesized models and the sample data. That is the structure of the EXHCOBA subtests is imposed on the sample data as obtained from the cohorts, and the CFA procedure tests how well the observed data fit the specified theoretical structures.

The description the model fitting process is summarized as:

Data= Model + Residual

- **Data** represent score measurements related to the observed variables as derived from persons comprising the sample,
- **Model** represents the hypothesized structure linking the observed variables to the latent variables, and
- **Residual** represents the discrepancy between the hypothesized model and the observed data.

In sum, the CFA application is properly employed to test the factorial structure of the instrument as captured in the cohort’s sample data. The application is considered a first order CFA measurement model as it tests the relationships of the observed data sets to the postulated basic abilities and knowledge exhibited by the applicants upon test administration.

For purposes of this study three second-order structural models are tested as defined by the relationships presented in the following section.

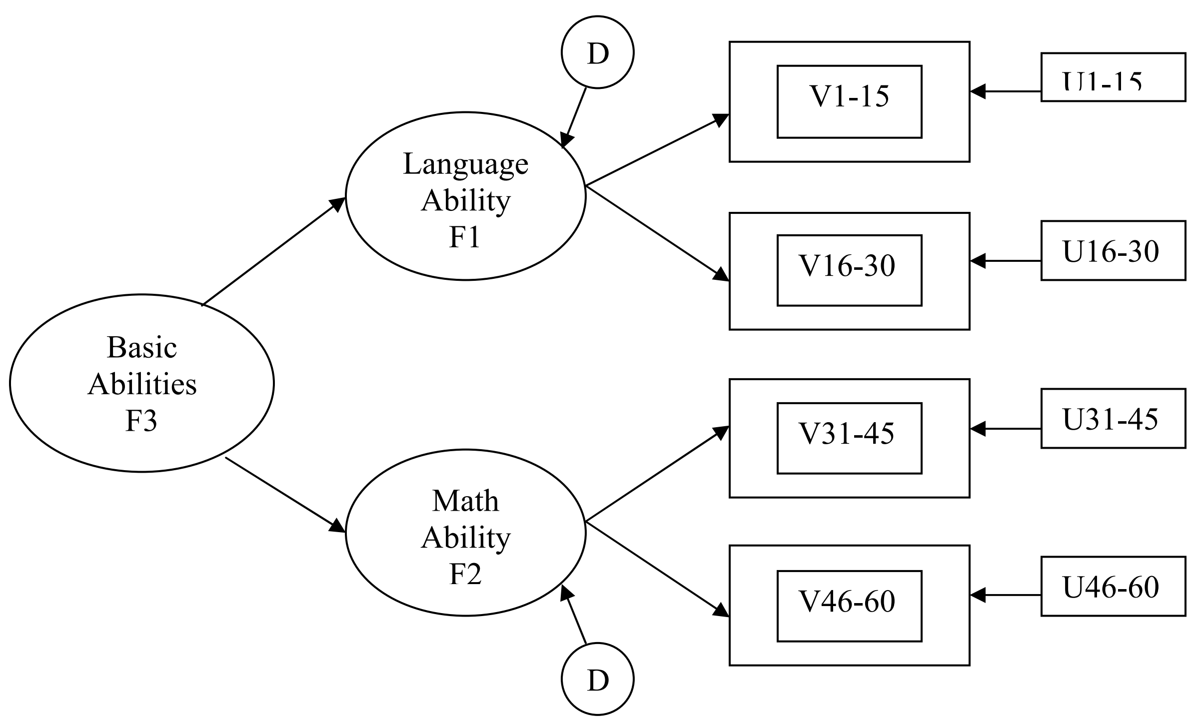
Structural Models under Study

Following standard conventions and notation from structural equations modeling this section describes the three models to be tested with a diagrammatic representation for each along with the TESTFACT programming required for each testing procedure. Model 1 corresponds to the basic abilities that result in students as a result of their exposure to curriculum and instruction at the elementary school level.

Figure 5

CFA Second Order Structural Model with Observed Variables

EXHCOBA Part 1a



It must be noted that this diagram differs from the complete model structure presented before (see Figure 2), in that the relationships under study are restricted only to latent variables hypothesized as attributes that operate at the level of the individual examinees. For economy of space the observed variables are represented as sets of items corresponding to the domain being tested rather than as individual variables. Also, error or unique terms are represented by sets rather than as individual terms.

The model postulates the existence of a general second order factor denominated “Basic Abilities”. This factor in turn influences two first order factors denominated “Language Ability” and “Math Ability”. There are two disturbance terms corresponding to each first order factor.

Before proceeding it must be clarified that the three models under study do not contain factors corresponding to curriculum, instruction, and guidance per-se as the original models do. This restriction on the number of hypothesized factors has been taken in the interest of parsimony and because it can be assumed that basic abilities and knowledge operationalized by the examinees’ observed responses to the item sets could be assumed to stem from formal and systematic exposure to curriculum and instruction.

The TESTFACT programming for the first test run of Model 1 is reproduced in Appendix II. In a general case the analysis proceeds in a series of steps based on the results of the program in the initial run. The item to factor model is postulated following a theory on the arrangement of the latent constructs as in the present case following Figure 5. Model fit is evaluated by an overall procedure in which the focal point is to determine the adequacy of the model in describing the sample data. This determination involves several criteria which are presented below. The confirmatory procedure under

TESTFACT is called BIFACTOR and it specifies a general or domain factor and a *k* number of factors to which the item subsets belong. The BIFACTOR procedure estimates the loadings on a general factor with the presence of item-group factors. The items' ordering as they are hypothesized to belong to each of the uncorrelated factors is specified in the command file and the program is run to obtain the initial estimations.

The resulting output provides the basis for a goodness of fit test in which two competing models are compared as follows:

H_0: The item sets are indicators of a general factor and of *k* uncorrelated group factors.

H_1: The item sets are indicators of a general factor and of *k*+1 uncorrelated group factors.

The competing models are run to obtain the χ^2 statistics and the degrees of freedom that correspond to each model. To test H_0 versus H_1 the difference between the χ^2 values and their respective degrees of freedom is computed. If the result is significant H_0 is rejected and it is concluded that the items belong sets to the group factors postulated by the theory.

Up to this point the CFA procedure under TESTFACT has been described in general terms following the basic statements of the programming presented for Model 1. The technical specifications of usage and the decision making process in this section are taken from the guidelines published in the program's reference manual (SSI, 2003).

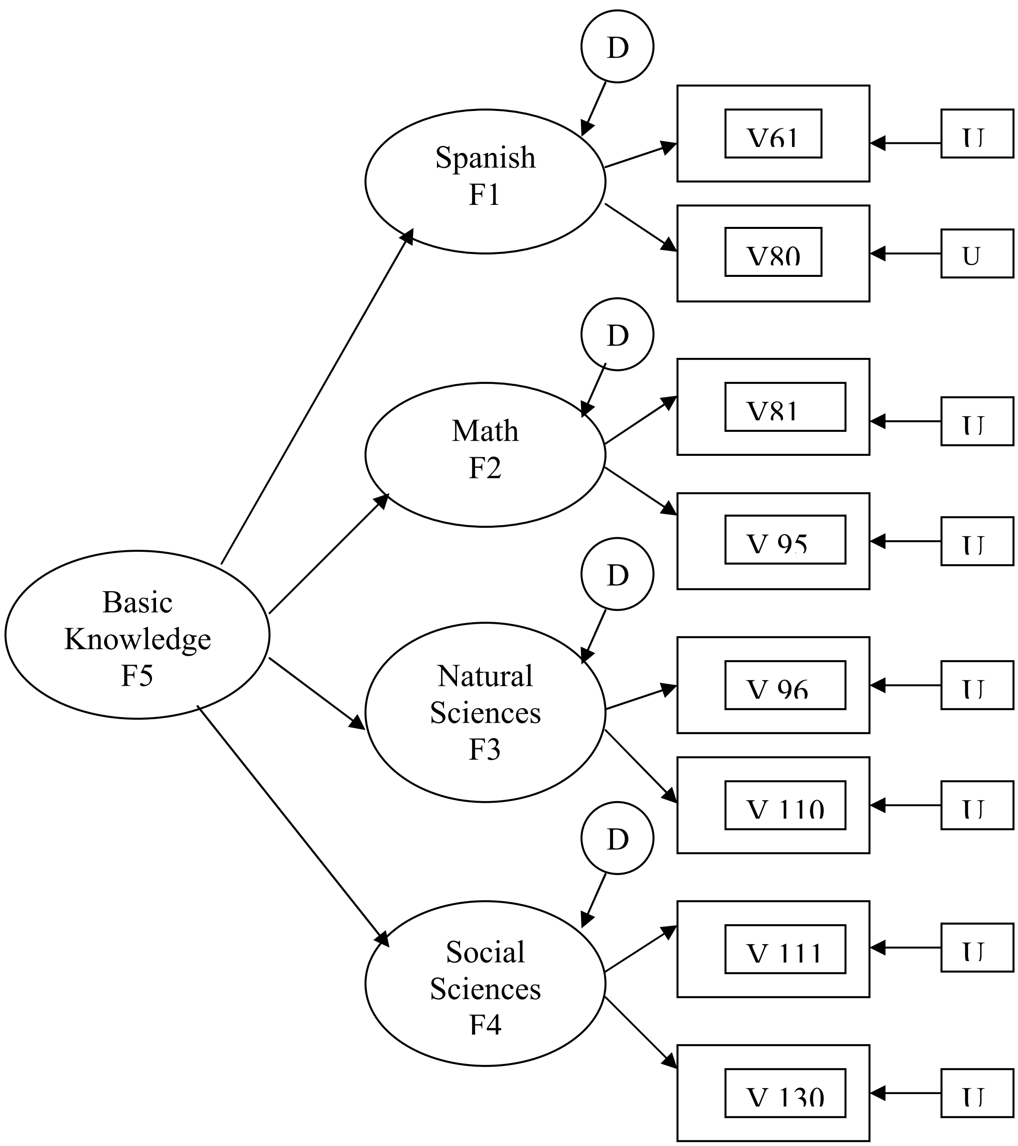
The next task in this section is to complete the CFA – TESTFACT methodology by describing the computer programming for testing Models 2 and 3. These parts complete the confirmatory factor analysis section of this project.

In the present series of analysis Model 2 consists of an attempt to capture the structure of basic knowledge by subject matter domain that corresponds to part 1b of EXHCOBA. These are taken as results of the students' exposure to curriculum and instruction at the secondary school level.

Figure 6

CFA Second Order Structural Model with Observed Variables

EXHCOBA Part 1b



The convention of representing observed variables as sets rather than individual variables is also followed in the diagram above but the complexity of the model increases as it postulates four separate subconstructs of basic knowledge corresponding to distinct subject matter domains. The programming required is consequently modified to model the influence of five factors: a general second order basic knowledge factor and four first order factors for the four subject matter domains in the secondary school curriculum. The corresponding program is presented in Appendix III.

Part 2 of the EXHCOBA consists of blocks of 60 items each. These blocks are formed from combinations three sets of 20 questions taken from sub domains that correspond to knowledge areas of the career program that the applicants choose to pursue. Therefore, any 3 blocks of these 60 item sets is designed to measure specialized area knowledge considered essential for attempting a career program at the university level. In Sonora the high school system divides the student population by career tracks upon students' choice aided by a vocational counselor. Once this choice is made in the junior year the students in each career track receive instruction in the specialized knowledge area of the chosen track. This stage is considered to be the university preparatory level in which students acquire the knowledge base from distinct but related disciplines. The content disciplines are: math for calculus, math for statistics, physics, chemistry, biology, sociology, economics and business, humanities and literature.

Following the classical distinction of exact sciences, natural sciences, social sciences, and humanities, the specialized knowledge areas are distinct domains. It must be noted that each subset in either the natural or the social sciences is considered to be related by a common underlying factor that represents specialized knowledge pertaining to specific area disciplines. The following diagrams represent these discipline areas and their hypothesized relations.

Figure 7

CFA Second Order Structural Model with EXHCOBA Observed Variables

Part 2a

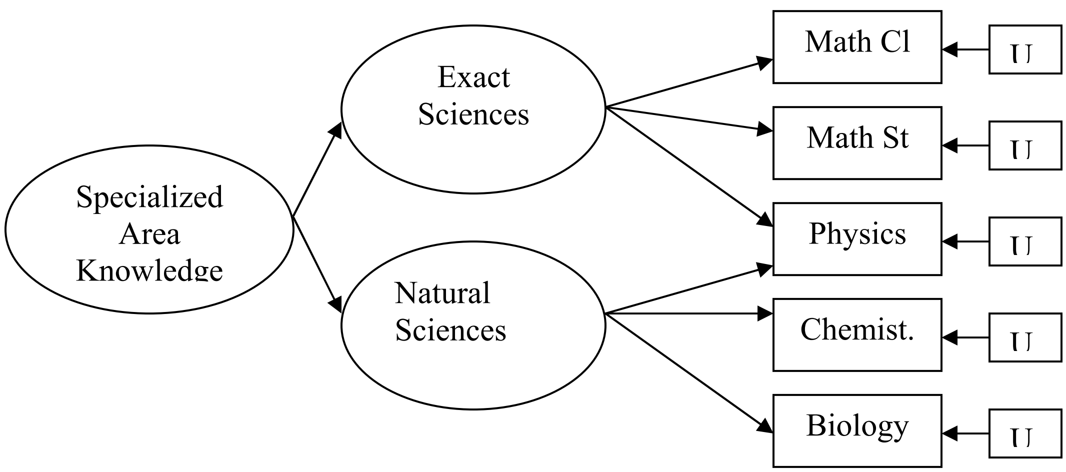
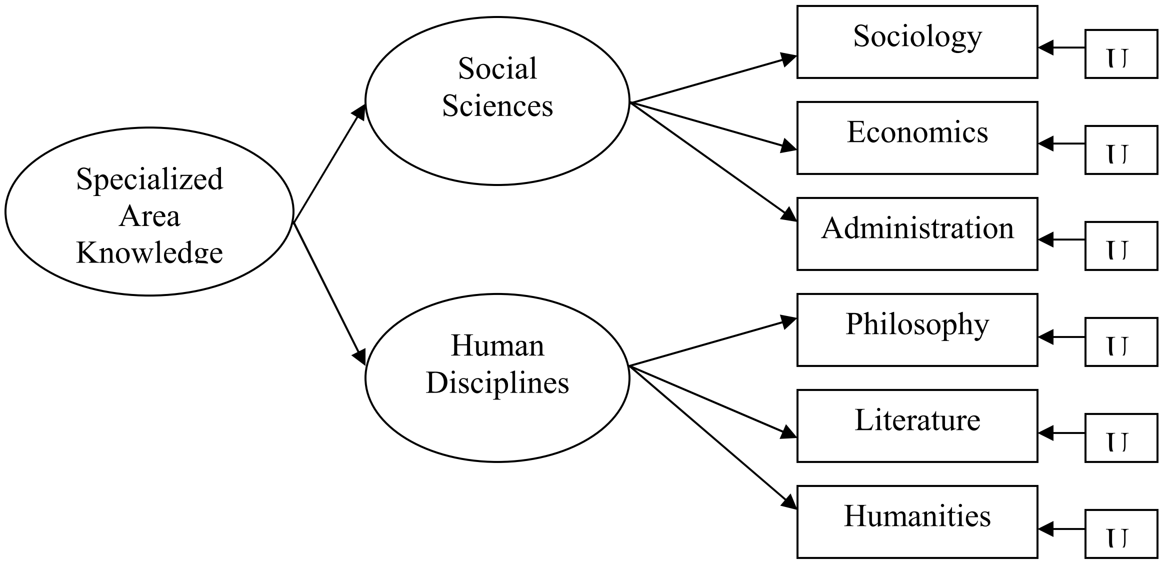


Figure 8

CFA Second Order Structural Model with EXHCOBA Observed Variables

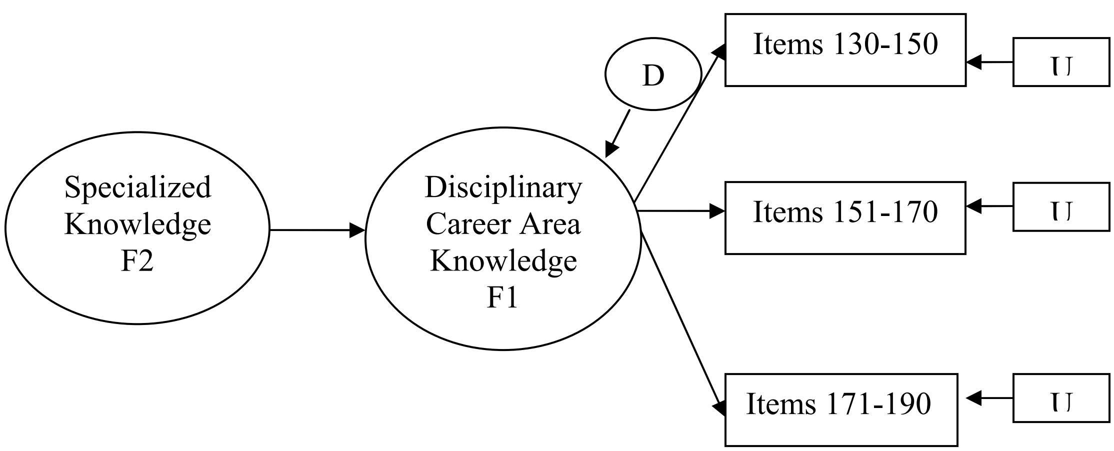
Part 2b



However, the examination in part 2 requires that each individual examinee answer only a subset of 60 items composed from the combined knowledge areas and therefore the actual structure of the data for this part takes on a general form as follows:

<u>Figure 9</u>

<u>CFA Second Order General Structure of EXHCOBA 2</u>



Consequently the programming for testing this factor structure in Model 3 has been modified to reflect the distribution of factors and observed variables in the EXHCOBA part 2. The program is presented in Appendix IV.

With the above the methods section describing the CFA procedures applied in this project is complete. The results of testing the three models as specified are presented in Chapter 4.

Application of Item Response Theory

With the factors that operate in the EXHCOBA measurement system identified, it becomes of interest to investigate the properties of each of the nine sub scales contained in the instrument. The factors operationalize a technical definition of academic standards but the instrument's sub scales and item properties remain to be examined. The approach for this task is the one parameter model known as Rasch Measurement. This exposition of IRT principles and procedures follows the work of Hambelton and colleagues (1991).

Item response theory comprises a group of measurement techniques which originated from the Rasch Model. The basic principles of the model are:

- The performance of examinees on a test can be predicted by a set of factors called latent traits or abilities.
- The relationship between examinees' item performance and the set of traits underlying item performance is described by a monotonically increasing function called the item characteristic curve.

- The item characteristic curve plots the relationship between the examinees' level of ability and the probability of a correct response to an item. This implies that examinees with higher ability levels have higher probabilities of a correct response to a given item.
- Item difficulty symbolized by δ, and the ability of examinees symbolized by β, are sufficient elements to explain and predict performance in an examination because these elements contain all the necessary information.

Since the abilities of individual examinees are taken by the technique as latent traits and item difficulty is the parameter to be estimated, it becomes of interest to compare the results of an application of the Rasch model to the EXHCOBA data with the factors identified to operate in each subscale of the examination. Applying the technique in this way yields calibrations for item difficulty and examinees' abilities that are especially relevant to the definition of the academic standards being identified by the EXHCOBA measurement process.

IRT procedures for analyzing properties of examinations require that certain assumptions be met:

- The unidimensionality assumption specifies that only one ability is measured by a particular set of items. This requirement is adequately met when the presence of a dominant factor is detected influencing test performance in a set of test data.
- The local independence assumption specifies that when the abilities influencing test performance are held constant the responses of examinees to any pair of items are statistically independent.

The unidimensionality assumptions has an important implication for the analysis of EXHCOBA test data because the instrument's sub scales are designed to tap on to specific and discrete sub sets of abilities at the level of the examinees. These sub sets have been previously identified as operating factors by the CFA procedure. Therefore, the results of the IRT analysis confirm from a different methodological stance that these sub sets of abilities are in fact identifiable by more than one statistical procedure.

The local independence assumption when met proves that the items of the EXHCOBA sub scales are in fact congeneric and that as sub sets they tap into the specified sub construct; but it also demonstrates important features of the ability levels detected in the test data. The property of local independence means that for a given group of examinees with a fixed ability level the probability of a response pattern on a set of items is equal to the product of probabilities associated with the examinees' responses to the individual items. This in turn implies that when the ability levels are identified and held constant, individual items as variables become uncorrelated and are likely to be independent as the basic ability underlying test performance has been partialled out.

Basis and Application of the Rasch Model

As noted before under the Rasch model item difficulty and ability level are the only elements that account for test performance and it is the most stringent and parsimonious approach. The model is represented in the formula:

$$P_i(\beta_v) = \frac{e^{(\beta - \delta_i)}}{1+e^{(\beta - \delta_i)}} \qquad i = 1,2,\ldots,n$$

Where:

- $P_i(\beta)$ is the probability that a randomly chosen examinee answers item i correctly.
- δ_i is the item i difficulty parameter
- n is the number of items in a test
- e is a transcendental number constant whose value is 2.71828.

And $P_i(\beta)$ plots an S- shaped logistic curve with values 0 and 1 over the ability scale which is the item characteristic curve (ICC) for a given item.

The item difficulty parameter b_i is the point on the ability scale where the probability of a correct response is 0.5, consequently the greater the value of a difficulty parameter the greater the ability level required for an examinee to have a 50% chance of responding correctly to the item. The full implications of these relationships are described in detail in the next section.

In the estimation of item and ability parameters the major feature of the IRT model is the property of invariance. This property implies that the parameters that characterize an item do not depend on the ability distribution of the examinees and the parameter that characterizes an examinee does not depend on the set of test items (Hambleton, Swaminathan, & Rogers, 1991). This condition holds when the IRT predicted model fits the observed data since the same item characteristic curves are obtained for test items regardless of the ability distribution in the group of examinees used to estimate the item parameters.

The property of invariance as described derives from linear regression. In the context of linear regression, the line plotted by the joint values of variables X and Y predicts values of Y for any possible values of X. When a regression model holds the same regression line will be obtained within any restricted range of the values of the variable X in the regression equation. That is, in any sub-population of values of X the slope and intercept values will be the same as long as the model fits the data. In the case of item response models the same condition holds since these can be regarded as non-linear regression models (Hambleton, Swaminathan, & Rogers, 1991, p. 19). However, the property of invariance cannot be observed directly in the strict sense of the word. To determine when invariance occurs in samples of test data the degree to which it holds in observed test data can be assessed by determining the congruence of two or more sets of estimates. If two samples of examinees of different ability are drawn from a population, the comparison of item ability parameters can be taken as indication of the degree to which invariance is holding in the particular case. The degree of congruence can be approximated by obtaining the correlation between the two sets of estimates and by examining the corresponding scatterplot.

Estimation of Person Ability and Item Difficulty Parameters

As stated previously in a one parameter model, the probability of an examinee's response to an item depends on the examinee's ability β, and the item's difficulty δ. Given that both of these parameters are unknown the responses to the item are the elements from which the estimation of the parameters is made. Since these elements are observed, a probabilistic approach does not apply and the appropriate method for estimation is the maximum likelihood approach.

Parameter estimation is also known as item properties and person abilities calibration. The one parameter or Rasch model procedures for obtaining these calibrations are described in detail by Benjamin Wright and Mark Stone. The exposition below follows this source (Wright & Stone, 1979). The calibration procedure is described in detail since it is a major aim of this project to obtain item and examinee calibrations from the EXHCOBA examination data.

As described previously any ICC plots the probability of a correct response to a test item combining the parameters β_ν for person ability and δ_ι for item difficulty. To construct the mathematical form for this plot these parameters are combined through their difference $(\beta_\nu - \delta_\iota)$. This difference in theory determines the outcome of the encounter of an examinee ν with ability β_ν with an item ι of difficulty δ_ι. However, a constraint is required since the difference $(\beta_\nu - \delta_\iota)$ can vary from $-\infty$ to $+\infty$ and the probability of a successful response must be kept between 0 and 1. This constraint is placed by specifying the difference $(\beta_\nu - \delta_\iota)$ as an exponent of the natural constant e = 2.71828. The resulting expression is written as $e^{(\beta\nu - \delta\iota)} = \exp^{(\beta\nu - \delta\iota)}$ which varies between 0 and $+\infty$ and it is converted to the interval between 0 and 1 by forming the ratio:

$$\exp(\beta_\nu - \delta_\iota)/ [1 + \exp(\beta_\nu - \delta_\iota)]$$

This ratio is then used to specify the probability of a successful response to an item by the equation:

$$P\{x_{\nu\iota} = 1 \mid \beta_\nu , \delta_\iota\} = \exp(\beta_\nu - \delta_\iota)/ [1 + \exp(\beta_\nu - \delta_\iota)]$$

This equation is the Rasch model which specifies the logistic function that plots an ICC. The model allows the estimation of β_v and δ_ι independently of one another in a way such that the obtained estimates of β_v are freed from the effects of δ_ι and the estimates of δ_ι are freed from the effects of $\beta_{v.}$ This property was designated as "specific objectivity by George Rasch who showed when developing the model that the measurements obtained are in a linear scale with generality of measure (Rasch, 1960). Following the equation it can be seen that when a person ν is of higher ability than the item's difficulty δ_ι the difference (β_v - δ_ι) is positive and the person's probability of success in the item is greater than .50. As the person's ability surpasses the item's difficulty the positive difference grows greater. Conversely, when the item's difficulty is greater than the person's ability their difference is negative and the person's probability of success is less than .50. With a greater item difficulty the negative difference grows greater and the probability of success approaches zero.

The units for representing estimates of β_v and δ_ι are called "logits" because a person's ability is calibrated as the natural log odds for succeeding on items that are chosen to define the zero point in the scale. An item's difficulty in "logits" is its natural log odds for eliciting failure from persons with zero ability. The item difficulty and person ability calibrations are performed under the Rasch model by a procedure called PROX which exemplifies the transformations done to obtain the calibrations by hand computation. The PROX procedure is described in detail here because it exemplifies Rasch model and the results approximate calibrations under most computer programs that follow the one parameter model (Wright & Stone, 1979, p. 28).

The PROX procedure assumes that person abilities (β_ν) are approximately normally distributed with a mean M and standard deviation σ and that item difficulties (δ_ι are also more or less normally distributed with average difficulty H and difficulty standard deviation ω. Thus when $\beta_\nu \sim N(M, \sigma^2)$ and $\delta_\iota \sim N(H,\omega^2)$,for any person ν with person score r_ν on a test of L items the ability estimation is given by the equation: $b_\nu = H + X \ln [r_\nu/(L-r\nu)]$. For any item ι with item score s_ι in a sample of N persons the difficulty estimation is given by the equation: $d_\iota = M + Y \ln [(N- s_\iota)/ s_\iota]$.

The coefficients X and Y are expansion factors which are required to follow the difficulty dispersion of items in the case of X, and the ability dispersion of persons in the case of Y. Specifically $X= (1+ \omega^2/ 2.89)^{1/2}$ and $Y = (1+ \sigma^2/ 2.89)^{1/2}$ and the value $2.89 = (1.7)^2$ comes from the scaling factor 1.7 which brings the logistic ogive into approximate coincidence with the normal curve. This occurs because the logistic ogive values 1.7z are never more than one percent different form the normal curve values of z.

The estimates b_ν and d_ι have standard errors which are :

$SE(b_\nu) = X [L/r_\nu(L- r_\nu)]^{1/2}$, and $SE(d_\iota) = Y [N/ s_\iota(N- s_\iota)]^{1/2}$.

The estimation method can be applied directly to observed item scores (s_ι) by calculating the item score logit of item ι with the equation:

$x_\iota = \ln [(N- s_\iota)/ s_\iota]$.

The item score logit of person ν is calculated with the equation:

$y_\nu = \ln [r_\nu / (L- r_\nu)]$.

The expansion factors X and Y are then estimated by applying the equations

$X = [(1+U/2.89)/(1-UV/8.35]^{1/2}$ for the person logit expansion factor, and

$Y= [(1+V/2.89)/(1-UV/8.35)]^{1/2}$ for the item logit expansion factor.

In these equations $2.89 = (1.7)^2$ and $8.35 = (2.89)^2 = (1.7)^4$, U is the item logit variance, and V is the person logit variance. These variances are given by the formulas:

$U = (\Sigma x_\iota^2 - Lx.^2)/(L-1)$ and $V = (\Sigma y_v^2 - Ny.^2)(N-1)$.

The parameter estimation is completed by setting the test center at zero so that H=0.

Then the parameters are obtained by: $d_\iota = M + Yx_\iota = Y(x_\iota - x.)$ for each item difficulty and $b_v = H + Xy_v = Xy_v$ for each person's ability.

The corresponding standard errors are given by the equations:

$SE(d_\iota) = Y[N/s_\iota(N - s_\iota)]^{1/2} \simeq 2.5/N^{1/2}$

$SE(b_v) = X[L/r_v(L - r_v)]^{1/2} \simeq 2.5/N^{1/2}$.

Finally the estimated person sample mean and standard deviation are given by $M \approx -Yx$ and $\sigma \approx 1.7(Y^2 - 1)^{1/2}$.

Once the person and item parameters are estimated with the procedure above, the next step is to assess the fit of the data to the model. With the actual estimations of b_v and d_ι taken from sample data, the difference between what the model predicts and the data actually observed can be is obtained. These residuals from the model are calculated by estimating the model expectation at each $x_{v\iota}$ from b_v and d_ι and subtracting this expectation from the $x_{v\iota}$ which is observed.

The model expectation for $x_{v\iota}$ is $E\{x_{v\iota}\} = \pi_{v\iota}$ and the model variance is $V\{x_{v\iota}\} = \pi_{v\iota}(1 - \pi_{v\iota})$, where $\pi_{v\iota}$ is obtained from : $\pi_{v\iota} = \exp(\beta_v - \delta_\iota) / [1 + \exp(\beta_v - \delta_\iota)]$. The standardized residual is obtained from: $z_{v\iota} = (X_{v\iota} - \pi_{v\iota}) / [\pi_{v\iota}(1 - \pi_{v\iota})]^{1/2}$.

If the observed data fit the model the standardized residuals must be more or less normally distributed with mean zero and variance one.

Computer Implementation

It must be noted that the PROX procedure just presented is appropriate for hand calculation of a person and item parameters and has been described as an approximation of the actual process used when the procedure is run in a computer. The equivalent procedure is called UCON and it is implemented in the WINSTEPS program developed by John M. Linacre (Linacre, J.M., 2003). The program is designed to construct Rasch measurement from the responses of a set of persons to a set of items. WINSTEPS begins with a central estimate for each person measure and item calibration. These initial estimates are obtained by an iterative version of the PROX procedure which is used to reach a rough convergence to the observed data pattern. Then the UCON method is iterated to obtain more exact estimates, standard errors, and fit statistics. The implementation of the UCON procedure instantiates an unconditional maximum likelihood and joint maximum likelihood methods for arriving at the final estimates of the person and item parameters. The measures are reported in logits (log odd units) and the fit statistics are reported as mean square residuals and also as standardized residuals with N(0,1).

The estimation of fit starts by the program's calculation of a response residual for each person *n* when responding to each item *i*. This calculation produces an estimate of how far the observed response departs from the model's expected response given the calibration of the person's ability and the item's difficulty. The response residual is calculated with the formula:

$$y_{ni} = x_{ni} - E_{ni.}$$

The residuals across persons and items are summarized in a fit statistic expressed as a mean square fit statistic and as a standardized fit statistic with a z or a t distribution.

In the program's output the fit statistics are reported as INFIT and OUTFIT values for persons and items. The INFIT value is interpreted as weighted mean square residuals which are sensitive to irregular patterns of response. This fit statistic is sensitive to unexpected behavior affecting responses to items near the person's measured ability level. The INFIT statistic is calculated with the formula: INFIT = $\Sigma Z^2_{ni} W_{ni} / N$.

The residuals are weighted by their individual variance to reduce the influence of unexpected responses far from the person's measured ability level or an item's measured difficulty level.

The OUTFIT statistic is the average of the standardized residuals across both persons and items. This average is not weighted to produce estimates more sensitive to unexpected responses far from the person's measured ability level or an item's measured difficulty level. It is calculated with the formula: OUTFIT = $\Sigma Z^2_{ni} / N$. The OUTFIT value is therefore interpreted as an unweighted mean square residual which is sensitive to unexpected extremes in the observed response patterns. This fit statistic is sensitive to outliers and more sensitive to unexpected behavior affecting responses to items far from a person's measure level.

For their interpretation the fit statistics are then compared to the following criteria:

For INFIT: The mean square infit statistic (MNSQ) has an expectation of 1. Values substantially below 1 indicate dependency in the observed data; while values substantially above 1 indicate noise. A MNSQ of 1.0 indicates perfect fit. A value of 1.3

indicates the measure is suspect of misfit. Values above the 1.3 threshold are definite misfits indicating noise or error in the data. Values less than 1.0 are also suspect of misfit because they appear to fit too well.

In INFIT the standardized values appear as INFIT ZSTD. This is the infit mean square statistic reported in natural logarithms. When this statistic ranges between -2 and +2, the values are within an acceptable logit range for both persons and items. Values greater than +2 are suspect of misfit and values less than -2 are also misfits.

For OUTFIT: The mean square outfit statistic (MNSQ) has also an expectation of 1.0. Values substantially less than 1 indicate dependency in the observed data; while values substantially greater than 1 indicate the presence of outliers. A MNSQ of 1.0 indicates perfect fit. A value of 1.3 indicates the measure is suspect of misfit. Values above the 1.3 threshold are definite misfits indicating noise or error in the data. Values less than 1.0 are also suspect of misfit because they appear to fit too well.

In OUTFIT the standardized values also appear as OUFIT ZSTD. For this statistic values between -2 and +2 are within an acceptable logit range for both persons and items. Values greater than +2 are suspect of misfit and values less than -2 are also misfits.

For further interpretation of the values of INFIT and OUTFIT a measure is considered to be *Muted* when it has unmodelled dependence, redundancy, or significant error trends. This occurs when the values of the fit statistic are MSNQ < .08 or ZSTD < -2. Conversely a measure is considered to be *Noisy* when it has unexpected unrelated irregularities and extremes with values of MNSQ > 1.3 or ZSTD >+2.

The results of the person measures and item calibrations in from the EXHCOBA 2004 data for each of the nine subscales of the instrument are reported in Chapter 4.

CHAPTER 4

RESULTS AND DISCUSSION OF THE STATISTICAL ANALYSES

This chapter is divided in two major sections. The first contains preliminary information describing the population of student applicants on academic background aspects. An initial analysis of the performance on the EXHCOBA as observed in the 2003 cohort of applicants is included. This first part is presented merely as descriptive background portraying the academic and social contexts in which the methodological system is applied. The second major section of this chapter describes the results of the data analysis based on the 2004 cohort's performance in the EXHCOBA administration

Academic Background Information

This initial section describes the main characteristics of the student population with a focus on key indicators of educational background and trajectory. The content of this section is taken from two main sources: (1) a database that contains the entrance exam scores and grade point averages of the applicants in the incoming cohort, and (2) a Student Entrance Survey administered to students that complete the admissions process. Access to these databases has been provided by the Admissions Committee and the Direction of Planning of the Universidad de Sonora. This section reviews these databases with the aid of a publication that analyzes the data bases with interpretive comments of the demographic data as well as the academic history of the applicants that completed the registration process in full. (Gonzalez & Lopez, 2004)

During the 2003 admissions cycle 8814 high school graduates in Sonora applied for admission to the Universidad de Sonora. A total of 5046 students were admitted and registered for career programs distributed among the three Regional Units Campuses of the university (Dirección de Planeación UNISON, 2003a).

The following information is gathered from the results of an Entrance Survey (Encuesta de Ingreso) which is completed online by applicants at the time of registration. This information has recently been compiled and published for educational research purpose by the UNISON (Direccion de Planeacion, 2004)

Gender and Age

In the 2003 cohort the gender of 5046 admitted applicants is 52% female and 48% male. As for age the largest percentage occurs in the 17 -18 and19 -20 ranges with 44% and 36% respectively. The remainder of the cohort corresponds to 10% in the range of 21-22, 3% in the range 23-24, and 7% in the range of 25 years and above. With regard to marital status, 95% of the students are single which indicates that the majority can devote a substantial amount of time to their studies. The remaining 4% indicated being married and 1% live under common law marriage. It was also found that 96% of the students report not having children, while 4% report they do. Again, this reinforces the notion that the cohort's situation is quite favorable for following a full course of studies in the career university program for which they gained admission.

Academic Trajectory

With respect to scholastic trajectory the survey data indicate that most of the cohort's students completed their high school program in public institutions in each educational level from pre-school up to high school and some completed their university preparatory in a technical school. The following table lists the percentage of students that completed their studies in either sector.

Table 1

Cohort 2003 School System of Origin by Educational Level

Educational Program	Sector	%
Pre-school	Public	86
	Private	14
Elementary	Public	86
	Private	14
Secondary	Public	88
	Private	12
Preparatory	Public	79
	Private	21
Technical	Public	95
	Private	5

It is important to note that the great majority of career program completed their university preparatory or high school programs in institutions of the public sector. For this reason the focus of the present study is the high school programs of that sector of the Sonoran Educational system.

Regarding the scholastic trajectory of students a prime concern of this investigation is the academic progress status upon entrance to the university system as reflected by the high school grade point average (HSGPA) with which applicants exited their respective preparatory programs. It must be noted that in the State of Sonora and throughout Mexico, a students GPA is measured in a scale from 0 to 100 points with 60 points being the minimum score for exiting any given level of the system and progressing to the next one. That is, a grade of 60 points represents the minimum passing score.

In the 2003 cohort the average HSGPA is taken as a rough indicator of the scholastic trajectory of the typical student as it represents the collective assessment of all teachers intervening in the instructional process of the student. It is granted that the GPA by itself is not a pure measure of academic achievement or students scholastic aptitudes. However, it is common practice to use it as a gross indicator of academic success. Precisely for this reason it is of prime interest and concern to study the relationship of GPA scores to other indicators of academic ability and achievement such as the EXHCOBA scores.

For present purposes the Universidad de Sonora takes GPA scores as a general indicator which reflects progress of students in the different levels of the educational system as well as an overall indicator of students' adjustment to academic life. (Gonzalez L., 2004). In the 2003 cohort the highest HSGPA averaged over career programs was observed in Medicine with 92 points and the lowest in Public Administration and Agronomy with 77 points.

It must be noted that the 2003 cohort is the first one in which a systematic analysis of scores obtained in the entrance examination EXHCOBA is performed. It must be remembered that these scores are obtained with the first standardized instrument ever selected for use at the Universidad de Sonora. For the purposes of this study, the analysis must proceed under the working assumption that these scores are a stable indicator of scholastic trajectory and adjustment to high school academic demands. In the cohort under analysis the observed EXHCOBA scores are considered to be low with an overall average of 50.06 points out of a possible 190 total points. The highest average score over career programs was observed in students registering for the Physics Sciences career program with an average of 71.54 points. The lowest average was observed in students registering for the Mining Engineering program with 43.72 points on average obtained by this subset of applicants. These performance scores are similar to those observed in previous cohorts and therefore are taken to be stable indicators of the overall academic trajectory with which the applicants seek admission and attempt to complete a professional career program, (Gonzalez, L., 1999, 2000, 2004).

The Table 2 below presents in ascending order the average HSGPA and EXHCOBA scores observed in applicants to professional career program in the cohort under study.

Table 2

2003 EXHCOBA Scores and HSGPA

Average over existing Career Programs

Career Program	EXHCOBA Average	HGSPA
Mining Engineering	43.72	79.00
Law	45.19	78.66
Business Administration	46.56	79.75
Fine Arts	47.70	81.00
Chemistry-Biology	47.70	86.00
Agronomical Engineering	48.18	77.00
Media Communication	48.27	80.00
Biological Sciences	48.53	83.00
Information Systems	48.74	79.00
Geology	49.18	80.00
Mathematics	49.17	81.50
Public Accounting	50.53	83.00
Industrial and Systems Engineering	50.58	82.00
Psychology	50.94	83.00
Hispanic Literature	51.90	83.00
Finances	52.16	85.00
Computer Sciences	52.74	85.00
General Medicine	53.21	92.00
Economics	53.54	78.00
History	53.71	81.00
Social Work	54.30	82.00
Sociology	55.00	77.33
Public Administration	55.50	77.00
Civil Engineering	56.15	78.50
English Teaching	56.49	82.00
Electronics Technology	57.63	82.00
Nursing	58.46	84.00
Architecture	58.65	86.00
Linguistics	63.15	80.00
Physics Science	71.54	89.00

Average Results by EXHCOBA Structure

Disaggregating the proportion of items correct by each section of the entrance examination shows that the knowledge area that has the highest observed proportion of items correct is Basic Abilities corresponding to Elementary School instruction. The next highest proportion of items correct was observed in Basic Knowledge corresponding to secondary chool instruction. Finally, the lowest proportions of items correct were observed in the areas of Knowledge by Career Specialty. These areas are taken as the basic prerequisites for students attempting a professional career program. In these areas the students are required to answer only 3 specialty subsections according to the knowledge domain of the career program that they choose to attempt.

Table 3

2003 Average Proportion of Items Correct by EXHCOBA Sections

EXHCOBA Section	Items Correct	No. of Items in Section
Basic Abilities		
Verbal Abilities	60%	30
Quantitative Abilities	53%	30
Basic Knowledge		
Spanish	53%	15
Mathematics	40%	15
Natural Sciences	55%	20
Social Sciences	50%	20
Knowledge by Career Area		
Mathematics-Statistics	35%	20
Social Sciences	45%	20
Economics-Administration	45%	20
Mathematics-Calculus	40%	20
Biology	50%	20
Chemistry	35%	20
Physics	50%	20
Language	55%	20

Humanities	60%	20
English	82%	60

Overall, the scores observed in the 2003 cohort are low, especially if compared with the mean performance at the Universidad Autonoma de Baja California (UABC), where the EXHCOBA Examination was developed. The observed averages of performance in UABC applicant cohorts have been consistently above 120 total items correct since over the last ten years (Larrazolo, 2004).

Reflecting on the average scores observed at UNISON, it stands to reason that the High School institutions should be able to profitably use these observed results. In particular, the different high school institutions and sub-systems in the state must become aware of the fact that their graduating students are now examined with a standardized instrument. This in turn requires that the high schools prepare their students for the standardized testing system now in place. It may also require that parts of the curriculum be aligned with the examination in use. This point will be elaborated on when the initial alignment indicators surface during phase 2 of the data analysis with the 2004 applicant cohort.

In Mexico, university students have been viewed as elite since they have succeeded in staying within the educational system. It is estimated that only two out of every ten persons actually enter an institution of higher learning as Universidad de Sonora (Gonzalez & Lopez, 2004). The systemic causes that underlie these phenomena are beyond the scope of the present study. From a review of the testing practices in place it can be estimated that approximately 40% of applicants to the university do not obtain the scores required to register in the career program of their choice and may attempt other programs elsewhere, but this cannot be determined with certainty.

The students that did obtain the required scores in the 2003 administration of the EXHCOBA have a mean high school GPA that approximates 77 points on a 60 to 100 points scale. However, the average observed raw scores on the EXHCOBA are around 50 points (items correct) on a 190 scale and are therefore considered low as on the average the incoming students are answering 26.32% of the items correctly. The observed low percentage of items correct absolutely compels the analysis by the statistical methods advocated in this dissertation. With the observed performance scores the situation remains uncertain and it cannot be determined if the standards that are implicit in the high school curriculum are those that the Universidad de Sonora requires of its incoming students. It appears from the demographic and socio-economic information available that if their economic situation is not optimal it is at least adequate and that the students can devote a greater percentage of their available time to academics and study related tasks. Yet, from reviewing the academic trajectory of the students and their perception of their needs concerning improvement of basic study skills and strategies it can be concluded that even if students know individually their obtained EXHCOBA score on the whole they are not cognizant of the apparent academic deficits with which they attempt the first semesters in the professional career programs that they have entered.

Descriptive Statistics on EXHCOBA Performance

Before presentation of the results on the instrument's dimensionality and item properties, it is necessary to have an overall picture of the applicants' average performance on the instrument on the nine subscales as well as on the total final score. The descriptive statistics that follow are computed on the 2003 and 2004 cohorts of students actually admitted and registered at the University of Sonora.

For the 2003 cohort N=5046 and for the 2004 cohort N= 5888, and the comparative descriptive statistics are presented in Table 4. An inspection of the scores reveals that except for minor variations the values in the nine EXCHOBA subscales as well as over all performance on the instrument remain relatively stable for year to year. This relative stability in admitted applicants' performance has been observed in previous cohorts (Gonzalez, L.,1999, 2000, 2004).

Table 4

Average EXHCOBA Raw Score Performance and GPA

Section	Possible Points	Cohort 2003 Mean	Cohort 2003 SD	Cohort 2004 Mean	Cohort 2004 SD
Basic Language Abilities	30	17.63	4.50	18.30	4.52
Basic Math Abilities	30	16.10	6.55	17.34	6.50
Basic Knowledge Spanish	20	8.07	2.55	8.30	2.52
Basic Knowledge Math	15	6.04	3.31	6.50	3.40
Basic Knowledge Natural Sc.	15	11.50	3.21	12.00	3.24
Basic Knowledge Social Sc.	20	9.92	3.60	10.16	3.45
Career Area Knowledge 1	20	7.87	4.15	8.67	4.05
Career Area Knowledge 2	20	9.40	3.25	9.43	3.30
Career Area Knowledge 3	20	9.60	3.75	9.43	3.90
Total Items Correct	190	96.11	25.90	100	25.50
Final Score	190	77.14	31.13	82.04	30.88
High School GPA	100	80.52	7.94	82.00	8.12

Results of the Exploratory Factor Analysis

As indicated in the methods section the dimensionality of the instrument was analyzed using item factor analysis by subscale and the results are presented in this section. For section 1-A of the instrument which attempts to measure basic language and math abilities developed by students during elementary school, the results indicate that a general problem solving ability factor as well as two domain factors are present.

In the TESTFACT 4 program the test for the appropriate number of factors in the analysis is done in the following sequence:

H_0: A *k*-factor model provides adequate description of the data.

Because the instrument's design postulates two separate subscales for this section the testing of the factor structure began hypothesizing two factors. The resulting values under the 2-factor model are: χ^2= 161096.72, DF = 2871.

The next step tests an alternative hypothesis:

H_1: A *k*+1 model provides adequate description of the data.

The next run of the program was done hypothesizing three factors. The 3- factor model resulted in a decrease of the test value to: χ^2 = 160661.25, DF = 2813.
The statistical test is then applied by subtracting the obtained values and in this case the result is:

161096.72 – 160661.25 = 435.47 with 2871−2813= 58 DF.

Since the critical value for $\chi^2_{(50)}$ = 76.154, at the α= .01 level and the obtained χ^2 = 435.47 with 58 degrees of freedom , the result indicates that the three factor solution represents the structure of this data set more adequately. The result may be explained by the fact that language and math abilities acquired through the exposure to a uniform elementary school curriculum are difficult to differentiate through answers to the test items and therefore it appears that the response patterns are subsumed under one general ability factor. With these initial results it is appropriate to explore the instrument's dimensionality to determine the correspondence of the test items with the actual factors present in the data structure. VARIMAX rotation resulted in a distinct pattern of loadings which is presented and discussed next. Inspection of the items loadings on the extracted factors indicate a general ability factor as well as factors of language and math ability being detected by the items as shown in Table 6 below.

Table 5

Pattern of Item Loadings for EXHCOBA Section 1-A: Basic Abilities

Item	Factor 1	Factor2	Factor 3
ITEM1	.14	**.32**	.13
ITEM4	**.33**	.17	.11
ITEM5	.11	**.33**	.10
ITEM6	.30	**.33**	.13
ITEM8	.14	**.30**	.13
ITEM12	.14	**.41**	.10
ITEM14	**.43**	.17	.13
ITEM21	.13	**.30**	.24
ITEM22	**.32**	.11	.13
ITEM24	**.38**	.24	.19
ITEM31	.17	.16	**.36**
ITEM32	**.32**	.17	.27
ITEM33	.08	.21	**.33**
ITEM34	**.39**	.14	.24
ITEM35	.14	.19	**.32**
ITEM36	**.33**	.22	.28
ITEM37	.14	.17	**.32**
ITEM38	.30	.19	**.32**
ITEM39	.11	.16	**.44**
ITEM40	.29	.16	**.35**
ITEM41	.21	.30	**.33**
ITEM42	**.35**	.09	.34
ITEM43	.20	.10	**.43**
ITEM44	**.37**	.07	**.32**
ITEM45	.24	.11	**.41**
ITEM46	.17	.08	**.40**
ITEM47	**.35**	.04	.34
ITEM48	.18	.08	**.41**
ITEM49	**.36**	.21	.23
ITEM50	.15	.13	**.35**
ITEM51	**.36**	.15	.28
ITEM53	.28	.13	**.35**
ITEM54	.15	.27	**.35**
ITEM55	.17	.17	**.41**
ITEM56	.14	.14	**.36**
ITEM57	**.36**	.15	.26
ITEM58	.08	.16	**.36**
ITEM59	.25	.24	**.31**
ITEM60	.06	.16	**.42**

For economy of space only the items with at least one significant loading are reported. Values in bold are added to emphasize the highest loading of each item. Inspection of the loading pattern reveals the presence of a primary general factor with items from the language ability and math ability subscales loading on this factor. The fact that six language ability items and ten math ability items load under this general factor strongly suggests that this factor represents a general problem solving ability. This interpretation is supported by the contention that in general math ability items tend to associate more with problem solving than language ability items. In this case the pattern is clear as ten math items appear to be associated with the problem solving ability while only four of the language items are associated with this general factor.

A noticeable language pattern is clear as items 1, 5, 6, 8, 12, and 21, which belong to the language ability subscale, appear with bold loadings under factor 2. This suggests the presence of a distinct language ability factor that is being detected by the language subscale which is composed of items 1 through 30.

The definitive indication of a clear pattern becomes evident by considering the loadings beginning with item 31. According to the instrument's conceptual structure, item 31 is the first item of the math ability sub scale. From this point on it can be clearly seen that all the remaining items load under factor 3. This warrants the conclusion that this factor represents math ability. It must be noticed that 13 of the 30 items on the subscale load under the math ability factor.

The pattern of loadings under discussion is at least initially consistent with the instrument's theoretical structure. The loading pattern exemplifies item properties as attempting to measure a common construct named general problem solving ability with two distinct sub constructs named language and math ability.

Section 1-B of the instrument which comprises 70 items related to basic knowledge acquired through exposure to secondary school curriculum contains an assortment of items related Spanish, Math, Natural Sciences, and Social Sciences.

The arrangement of the items in that order required that the EFA program be modified to explore the dimensionality of the Spanish and math items ina subscale including of items 61 through 80 for basic knowledge of Spanish, and another subscale including items 81 to 95 for basic knowledge of math. In the same manner the analysis program was modified to run on items 96 through 110 representing a subscale of basic knowledge of natural science and items 111 through 130 as a separate subscale attempting to measure basic knowledge of social sciences.

The first run of the program on the items sets of Spanish and Math basic knowledge was done hypothesizing the presence of one factor to account for the structure of the data. This program run resulted in the following test values $\chi 2 = 77543.87$, DF= 2980.

The next run hypothesizing two factors resulted in $\chi^2 = 72113.25$, DF= 2946. The test for the number of factors is then $77543.87 - 72113.25 = 5430.56$, with $2980 - 2946 = 34$ degrees of freedom. By this result the one factor hypothesis is rejected since the critical value is $\chi^2_{(34)} = 56.061$ at $\alpha = .01$, concluding that two factors are more appropriate to account for the structure of the data.

With the above conclusion the next logical step is to explore the correspondence of the item sets with the extracted factors. After applying VARIMAX rotation, the item loadings show the patterns found in the data as presented in Table 6 below.

Table 6

EXHCOBA Section 1-B: Basic Knowledge of Spanish and Math

Pattern of Item Loadings

Item	Factor 1	Factor2
ITEM61	**.42**	.27
ITEM62	.09	.01
ITEM63	.02	.01
ITEM64	**.32**	.26
ITEM65	.28	.24
ITEM66	.28	**.34**
ITEM67	**.38**	.22
ITEM68	**.36**	.29
ITEM69	**.31**	.29
ITEM70	**.36**	.24
ITEM71	.21	.12
ITEM72	.14	.15
ITEM73	.22	.12
ITEM74	.17	.15
ITEM75	.22	.14
ITEM76	.23	.18
ITEM77	.17	.10
ITEM78	.22	.23
ITEM79	.24	.21
ITEM80	.24	.17
ITEM81	.10	.10
ITEM82	.18	.13
ITEM83	.26	.23
ITEM84	.21	.07
ITEM85	.17	.12
ITEM86	**.30**	.22
ITEM87	**.33**	.25
ITEM88	**.35**	.29
ITEM89	.27	.23
ITEM90	.25	.27
ITEM91	**.42**	.27
ITEM92	.09	.01
ITEM93	.02	.01
ITEM94	**.32**	.26
ITEM95	.28	.24

Most of the items bold loadings appear under factor 1 and only item 66 loads on factor 2. In this result no discernible pattern of loadings can be detected in Table 6. However, modifying the original expectation to two general knowledge factors allows a better interpretation. Notice that items 61, 64, 67, 68, 69, and 70 belong originally to basic knowledge of Spanish while items 86, 87, 88, 91, and 94 belong originally to basic knowledge of math. This is an indication that in this data set the two knowledge domains are not so distinct. This might well be because the items are worded in such a way that general problem solving ability factor is applied by the respondents. This possibility can be tested after the item sets are examined in their final groupings after the rest of the item diagnostics.

The plausible explanation for this second result is that basic Spanish knowledge and basic math knowledge align under a general knowledge factor rather than under the two distinct cognitive domains originally expected.

The analysis for the next two item sets also required a separate program run to explore the dimensionality of the knowledge of natural science subscale (items 96 through 110), and the knowledge of social science sub scale (items 111 through 130).

The program run was performed hypothesizing a two factor structure and the result gives a χ^2 = 73412.24, DF=2946, P=0.00. Although an attempt was made to test the hypothesis of a one factor structure, the result was not obtainable as the program output indicated a singular matrix under the one factor hypothesis. With this limitation imposed by particularities of this section of the data set, the two factor structure is retained although in a speculative way.

Under this circumstance the item to factor correspondence is presented in the following table of loadings:

Table 7

EXHCOBA Section 1-B: Basic Knowledge of Natural Sc. and Social Sc.

Pattern of Item Loadings

Item	Factor 1	Factor2
ITEM96	**.41**	.17
ITEM97 .	02	.01
ITEM98	.01	-.02
ITEM99	**.41**	.23
ITEM100	**.33**	.08
ITEM101	.25	.14
ITEM102	**.39**	.20
ITEM103	**.36**	.19
ITEM104	**.31**	.19
ITEM105	.28	.21
ITEM106	.14	.11
ITEM107	.23	.13
ITEM108	.25	.15
ITEM109	.18	.02
ITEM110	.27	.18
ITEM111	.14	.12
ITEM112	.19	.18
ITEM113	.29	.19
ITEM114	**.33**	.19
ITEM115	.20	.17
ITEM116	.29	.21
ITEM117	.26	.20
ITEM118	.12	.03
ITEM119	.28	.21
ITEM120	.28	.06
ITEM121	**.32**	.25
ITEM122	.26	.08
ITEM123	**.31**	.18
ITEM124	**.35**	.14
ITEM125	.29	.12
ITEM126	**.41**	.17
ITEM127	.02	.01
ITEM128	.01	-.02
ITEM129	**.41**	.23
ITEM130	**.33**	.08

As in the case of the two previous subscales of basic knowledge the items from basic knowledge of natural and social science load under one factor. This results reiterates the finding that a single general knowledge factor appears to be present in the data set from section 1-C of the instrument.

The analysis for section 2 of the instrument has substantial changes. It focuses on the last 60 items that each applicant responds in combinations that are arranged to the career program each applicant pursues.

For the analysis the section 2 data sets were divided in the following order**:**

Table 8

Career Program and Item Set Combinations on EXHCOBA Section 2

Career Area	Item Sets	No. of Applicants
Economics and Administration	131-190 [1]	562
Chemistry and Biology	191-250 [2]	233
Health Sciences	211-270 [3]	372
Engineering and Science	191-210, 231-270 [4]	552
Architecture	191-210, 251-290 [5]	119
Law and Literature	151-170, 271-310 [6]	576
Sociology and Psychology	131-170, 271-290 [7]	625

[1] Items sets: Math-Statistics, Social Science, Economics and Administration.

[2] Item sets: Math-Calculus, Biology, and Chemistry.

[3] Item sets: Biology, Chemistry, and Physics.

[4] Item sets: Math-Calculus, Chemistry, and Physics.

[5] Item sets: Math- Calculus, Physics, and Language.

[6] Item sets: Social Sciences, Language, and Humanities.

[7] Item sets: Math-Statistics, Social Sciences, and Language.

Consequently separate exploratory factor analyses were run for these cases. The program file was adapted in each run to read the corresponding item data set and the applicants' responses in each of the seven series. The table above shows that the sample sizes in each program run varied according to the number of applicants in each category. It must be noted that in these program runs the sample size decreased to a point in which the procedure cannot be properly applied in the cases of the areas of chemistry, biology, medicine and architecture. For all other cases the EFA procedure was applied hypothesizing two and three factors models. The comparative results appear below.

Table 9

EFA Results for Career Area Sub samples

	χ^2 Under H_0		χ^2 Under H_1		
Career Area	**Two Factors**	**DF**	**Three Factors**	**DF**	**χ^2 Difference**
Area [1]	34214.00	387	34055.50	329	$158.50_{(58)}$
Area [2]	32832.36	372	32619.00	314	$213.36_{(58)}$
Area [3]	35389.70	396	35242.00	388	$147.70_{(8)}$
Area [4]	36716.44	445	36525.94	387	$190.50_{(58)}$

[1] Economics-Administration, [2] Engineering –Science, [3] Law-Literature, [4] Sociology and Psychology.

Inspection of Table 9 shows that in all cases the χ^2 difference is in favor of the 3 factor model. The cases of Chemistry- Biology, Health Sciences, and Architecture sub samples the procedure could not applied as it does not yield appropriate results due to inadequate sample size for factor analysis (See Table 9).

Nonetheless, as in all of the previous cases it is of interest to explore the dimensionality of the data under the hypothesis that the last 60 items of the instrument comprise three separate sub scales. It must be noted that the exploratory results are not complete for most of these cases as the sample size was reduced and only 4 areas approached the samples size to meet the criterion of at least 10 observations per variable. The item to factor loadings is presented for the career knowledge areas where the sample size was reasonably adequate:

Table 10

Pattern of Item Loadings for EXHCOBA Section 2

Area of Economics and Business Administration (N=562)

Item	Factor 1	Factor2	Factor 3
ITEM1	.10	**.36**	.18
ITEM2	.12	**.43**	.16
ITEM3	.01	**.48**	.09
ITEM4	.01	.28	.06
ITEM5	.14	**.42**	.14
ITEM6	-.04	**.24**	.26
ITEM7	.12	**.41**	.21
ITEM8	.12	**.45**	.14
ITEM9	.11	**.46**	-.01
ITEM11	.24	.25	**.31**
ITEM12	.11	**.42**	.12
ITEM13	.02	**.34**	.17
ITEM14	.29	.24	.19
ITEM15	.20	**.41**	.15
ITEM16	.16	**.39**	-.03
ITEM17	.24	.24	.28
ITEM18	.09	**.36**	.27
ITEM20	.06	.23	-.10
ITEM21	.21	.24	.16
ITEM22	**.34**	.16	-.04
ITEM23	**.33**	.16	.08
ITEM24	**.42**	.13	-.11
ITEM25	**.33**	.05	.19
ITEM26	.28	.03	.13
ITEM27	.19	.01	.03

ITEM28	.29	.02	-.02
ITEM29	.16	.05	.07
ITEM30	.17	.03	.01
ITEM31	.01	.18	.11
ITEM32	**.41**	.11	.13
ITEM33	.28	.14	.13
ITEM33	.30	.16	.15
ITEM34	.20	-.07	.27
ITEM35	.29	.10	.12
ITEM36	.27	-.03	.02
ITEM37	-.01	-.16	.06
ITEM38	.20	.09	.29
ITEM39	.15	.02	.01
ITEM40	.24	.08	.16
ITEM41	.21	.10	.21
ITEM42	.17	.11	**.40**
ITEM43	.27	-.05	.26
ITEM44	-.02	.13	**.43**
ITEM45	-.04	-.03	**.39**
ITEM46	.23	.10	**.40**
ITEM47	.28	.01	.07
ITEM48	.09	.17	**.42**
ITEM49	-.03	.12	.27
ITEM50	.05	.18	**.37**
ITEM51	.25	.13	.17
ITEM52	**.32**	.17	.23
ITEM53	37	.02	.19
ITEM54	.26	.10	.21
ITEM55	.15	.01	.29
ITEM56	.21	.20	**.35**
ITEM57	.19	.09	.27
ITEM58	.24	.07	.28
ITEM59	.07	.14	**.30**
ITEM60	.23	.24	.27

The pattern of loadings gives a clear indication that there are three sub scales being measured by the 60 items administered to the applicants of the career area of Economics and Business Administration. As can be seen the majority of the first 20 items which by content belong to math-statistics, load under factor 2. The majority of the next 20 items belong to the social science domain are loading under factor 1. Finally, the next 20 items which belong to the domain of economics and business administration load under factor 3. Although there is not a perfect correspondence of the item sets and the area of knowledge they attempt to measure the pattern of loadings above supports -at least in part- the theoretical structure of this part of the instrument.

This result is by itself a fair indication that the subscales in this part of the instrument are in fact measuring constructs intended in the original design of the instrument. In regard to the items that do not load strongly on any of the extracted factors it must be noted that their properties must still be examined in the next stages of the present study.

The next run of the program is applied to the responses of applicants in the knowledge area of Science and Engineering as the size of the sample is minimally adequate for the procedure. The pattern of item to factor loadings for this subset of the data follows:

Table 11

Pattern of Item Loadings for EXHCOBA Section 2

Area of Science and Engineering (N=552)

Item	Factor 1	Factor2	Factor 3
ITEM1	.15	.24	.12
ITEM2	**.40**	.02	-.11
ITEM3	**.39**	.06	-.12
ITEM4	**.32**	.23	-.13
ITEM5	**.48**	.05	-.04
ITEM6	**.33**	.06	-.09
ITEM7	**.45**	-.01	-.09
ITEM8	**.44**	.06	-.06
ITEM9	**.47**	.06	-.05
ITEM10	**.49**	.05	-.02
ITEM11	**.43**	-.05	-.18
ITEM12	**.37**	.16	-.25
ITEM13	**.47**	.06	-.12
ITEM14	.15	.22	-.13
ITEM15	**.40**	.09	-.13
ITEM16	.27	.22	-.04
ITEM17	**.39**	.17	-.09
ITEM18	**.31**	.20	-.25
ITEM20	.21	.27	-.04
ITEM21	**.45**	.07	-.04

ITEM22	.07	-.03	-.06
ITEM23	.15	.15	**-.35**
ITEM24	.05	.17	-.17
ITEM25	.25	.12	**-.33**
ITEM26	.14	.15	-.27
ITEM27	-.01	**.46**	-.01
ITEM28	.10	.08	**-.42**
ITEM29	.08	.27	-.25
ITEM30	.09	.01	**-.30**
ITEM31	.09	.03	**-.40**
ITEM32	.11	-.10	**-.30**
ITEM33	12	.24	-.16
ITEM33	05	**.35**	-.18
ITEM34	.10	.05	**-.30**
ITEM35	.13	.08	**-.30**
ITEM36	-.05	.17	-.19
ITEM37	.05	.12	-.28
ITEM3	.16	.17	-.23
ITEM39	.04	**.37**	.24
ITEM40	.07	.10	**-.35**
ITEM41	.25	.17	-.10
ITEM42	.18	.15	-.13
ITEM43	.16	.06	-.07
ITEM44	.30	-.07	-.14
ITEM45	.07	.04	-.07
ITEM46	-.07	.25	-.28
ITEM47	-.02	**.30**	.08
ITEM48	.15	.37	-.10
ITEM49	.40	.19	-.22
ITEM50	.25	.19	-.17
ITEM55	.25	-.03	**-.31**
ITEM52	.24	.24	.18
ITEM53	.27	.16	-.08
ITEM54	.08	.08	**-0.30**
ITEM55	.27	**.36**	-.08
ITEM56	.13	**.45**	.03
ITEM57	.11	.12	-.24
ITEM58	.29	.24	-.18
ITEM59	**.38**	.10	-.22
ITEM60	.07	-.07	-.20

In this section of the data set there is less evidence that the items comprise three distinct subscales. However the pattern of loadings detects a subscale in the first 20 items which by content domain belong to math-calculus. The pattern is less clear with the next 20 items which belong to the chemistry domain. The last 20 items belonging to the domain of physics give a slight indication of a separate subscale. It is interesting to note that in this subset there are negative loadings which indicate that these items are measuring a construct opposite the one measured by items that load with positive values on the other factors. In any case, for this particular subset is appropriate to assume that a math knowledge factor is predominant as the greater number of the items with significant loadings are related to the math domain.

The next subset of data pertains to career programs in the knowledge area of law and humanities. Consequently the program was modified to run on the responses to the 60 items administered in to applicants in this area. The item to factor loadings are presented in Table 12 below:

Table 12

Pattern of Item Loadings for EXHCOBA Section 2

Area of Law and Humanities (N=576)

Item	Factor 1	Factor2	Factor 3
ITEM1	.11	.29	.09
ITEM2	.10	.26	.10
ITEM3	.04	**.36**	.12
ITEM4	.21	.12	.23
ITEM5	-.01	.18	.17
ITEM6	.14	.25	-.06
ITEM7	.01	.23	.05
ITEM8	-.03	.09	.15
ITEM9	.02	**.38**	-.06
ITEM10	.07	.06	.23
ITEM11	.24	.17	.28
ITEM12	.08	.22	.15
ITEM13	-.02	.45	.14
ITEM14	.15	.13	.08
ITEM15	.09	**.34**	.14
ITEM16	.14	.29	.07
ITEM17	-.10	.03	.08
ITEM18	.29	.01	.12
ITEM20	-.11	.27	.09
ITEM21	.14	.19	.12
ITEM22	**.40**	-.11	.14
ITEM23	**.30**	.15	.12
ITEM24	**.42**	.19	.15
ITEM25	**.40**	.04	.06
ITEM26	**.32**	.16	.09

ITEM27	**.35**	.03	.18
ITEM28	**.40**	.10	.06
ITEM29	.23	**.36**	.17
ITEM30	.05	.32	.04
ITEM31	**.44**	.16	-.05
ITEM32	.13	**.30**	.04
ITEM33	**.35**	.08	.16
ITEM33	.14	.39	-.03
ITEM34	**.43**	.22	-.03
ITEM35	.29	.03	.09
ITEM36	**.44**	.11	.16
ITEM37	.13	.03	.23
ITEM38	**.41**	.06	.09
ITEM39	**.36**	.19	.08
ITEM40	.07	.15	.10
ITEM41	.07	**.30**	.11
ITEM42	.14	.07	.27
ITEM43	.22	**.33**	.10
ITEM44	.09	**.34**	.12
ITEM45	.16	.16	.27
ITEM46	.19	.24	.16
ITEM47	.28	.01	.11
ITEM48	-.04	.15	.40
ITEM49	.12	.09	.35
ITEM50	.12	.05	.47
ITEM51	.20	.05	.02
ITEM52	.09	**.32**	.12
ITEM53	.22	.10	.09
ITEM54	.22	.24	.08
ITEM55	.27	**.32**	.04
ITEM56	-.01	.26	.19
ITEM57	.14	.27	.22
ITEM58	.24	.16	.11
ITEM59	.19	.13	.25
ITEM60	.15	.06	**.46**

The pattern of loadings above does not give a clear indication of three subscales being measured by the 60 items. The only consistency in these item sets appears in item s 22 through 49 which are originally designed to measure knowledge of the social science domain in the applicants to the Law and Humanities career programs. The rest of the item loadings do not conform to the expected sub scale arrangement in the original design of the instrument.

The next and final program run of the EFA procedure is done on the test data from applicants to career programs on the Social Science area. The results are shown in Table 13 below:

Table 13

Pattern of Item Loadings for EXHCOBA Section 2

Area of Sociology and Psychology (N=625)

Item	Factor 1	Factor2	Factor 3
ITEM1	.24	**.38**	-.02
ITEM2	.09	**.45**	.09
ITEM3	-.01	**.46**	.12
ITEM4	.07	.28	-.08
ITEM5	.11	**.42**	.14
ITEM6	.12	**.31**	.01
ITEM7	.08	**.46**	.11
ITEM8 .	17	**.43**	-.04
ITEM9	.01	**.45**	.06
ITEM10	.04	**.40**	.04
ITEM11	.27	.24	.03
ITEM12	.11	**.44**	-.08
ITEM13	.06	**.34**	.20
ITEM14	.12	**.39**	.19
ITEM15	.09	**.46**	.10
ITEM16	.04	**.41**	.05
ITEM17	.15	**.33**	.07
ITEM18	.26	**.39**	.11
ITEM20	-.05	.17	.17
ITEM21	**.31**	.27	.07
ITEM22	.07	.09	**.34**
ITEM23	.21	.08	**.32**
ITEM24	.08	.08	**.34**
ITEM25	**.36**	.10	.05
ITEM26	.13	.13	.08
ITEM27	.11	-.01	.19
ITEM28	-.06	.09	**.36**
ITEM29	.17	.06	.08
ITEM30	.06	.04	**.35**
ITEM31	.21	.12	.17
ITEM32	**.31**	.14	.25
ITEM33	.11	.09	.22
ITEM34	.02	.03	**.46**
ITEM35	.21	.06	**.34**
ITEM36	.24	.04	.13
ITEM37	-.11	-.04	.19
ITEM38	.28	.13	-.02
ITEM39	.07	.01	.16
ITEM40	.20	.06	.26

ITEM41	**.43**	.11	.09
ITEM42	**.32**	.08	.16
ITEM43	**.37**	.12	.25
ITEM44	**.33**	.23	.09
ITEM45	.26	.22	.27
ITEM46	**.42**	.19	.03
ITEM47	**.31**	.08	.27
ITEM48	**.39**	.11	.21
ITEM49	.05	.05	**.32**
ITEM50	**.35**	.02	.31
ITEM51	.17	.10	**.30**
ITEM52	**.41**	.07	-.04
ITEM53	.16	.13	**.34**
ITEM54	**.36**	-.02	.31
ITEM55	.28	-.05	-.03
ITEM56	**.40**	.10	.14
ITEM57	.12	.07	.13
ITEM58	.29	.04	.20
ITEM59	**.35**	.05	.18
ITEM60	.13	-.07	.18

The pattern of loadings presented gives and indication that the items sets comprise three separate subscales. As can be seen, the majority of the first 20 items load under factor 2. These items belong to the math-statistics domain. It is interesting to note that in the sub sample of Economics and Administration this set of items displayed the same loadings. (See Table 10). This result confirms at least in part the contention that the items designed for the math-statistics domain do in fact comprise a sub scale

In the next 20 items there is a clear break in the pattern as items 22 through 35 which belong to the social science domain load together under factor 3. Although the not all items in this sub set are consistent, the majority of them load under the same factor. This lends partial support to the notion that the specialized knowledge of social sciences is comprised under this limited sub scale.

The next and final set of 20 items begins with item 41. The pattern of loadings for items 41 through 60 also exhibits a limited consistency as the majority of these items load together under factor 1. This is again an indication that at least in part; this item set which originally belongs to the Humanities domain does comprise a separate sub scale in this sub sample of applicants.

The overall results of the EFA program applications uncover consistencies as well as discrepancies of the original design of the EXHCOBA sub-scales and the obtained patterns of loadings. Although the originally intended factor structure appears to hold, there are number items that do not load on any of the extracted factors. For this reason, the non-loading items are suspect of misfit. The item properties of both fitting and non-fitting items are examined under the IRT application results.

Results of the Confirmatory Factor Analysis

As noted in the Method Section (Ch. 3), the TESTFACT 4 program includes a special procedure for applying a distinct form of confirmatory item factor analysis under the BIFACTOR command. The technique under this computing implementation is a type of confirmatory factor analysis because it tests a factor pattern in which there is a general factor on which all items have some loading, plus a number of item group factors to which non-overlapping subsets of items are assumed to belong (SSI, 2003, p. 410).This procedure is employed for hypothesis testing following the general form described below:

H_0 : The *n* items in the test section are indicators of a general factor, and the subsets of items *i* to *n* are indicators of *k* uncorrelated item group factors.

H_1:The *n* items in the test section are indicators of a general factor, and the subsets of items *i* to *n* are indicators of *k*+1 uncorrelated item group factors.

As these hypotheses test for different item groupings, the program is run to attempt to confirm the item groupings postulated by the theoretical structure of the instrument with data from the randomly selected cross validation sample (N= 3054).

Therefore the first program run is applied to the first 60 EXHCOBA items hypothesizing one general factor and two uncorrelated group factors against the alternative that the item sets are indicators on one general factor and of three uncorrelated item group factors.

Under the hypothesis of one general factor an item group factor the obtained χ^2 = 162, 955.93, DF= 2933. The alternative hypothesis of one general factor and two uncorrelated group factors yielded a χ^2 = 162,421.00, DF= 2895.

Given the above:

162,955.93 − 162,421.00 = 534.93 with 2933-2895 = 38 DF,

the result allows for the rejection of the hypothesis of one general factor and two uncorrelated group factors. Therefore, the hypothesis of one general factor and three uncorrelated item group factors holds. Since the critical value for $\chi^2_{(38)}$ = 61.162 at α = .01 level; the value obtained in this result is 534.93 which effectively confirms the theoretical model.

The program's output indicates that the general factor accounts for 23.66% of the variance while the three item group factors account respectively for 2.56, .76% and, .58 % of the variance. The remaining 72.42% of the variance is labeled as uniqueness. This final result applies to the 2 subscales contained in the first 60 EXHCOBA items.

The confirmed model matches at least in part the expected model as intended in the instrument's original design (See Figure 6). As noted before the programming specifications for the CFA procedures are presented in Appendix II.

The CFA procedure with the BIFACTOR command is applied to the remaining EXHCOBA subscales following the logic outlined above.

For the next subscale comprised of 35 items measuring basic knowledge of Spanish and math, the EFA finding indicated the presence of a general basic knowledge factor with two item group factors. Therefore this hypothesis is tested against the null hypothesis that p that there are one general factor and one item group factor

Under the null hypothesis the obtained test value is χ^2 = 79,081.17, DF= 2983. The alternative hypothesis of one general factor and two item group factors resulted in χ^2 = 79,030.30, DF= 2971. The difference is then: 79,081.17 − 79,030.30 = 50.87 with 2983-2971 = 12 DF. Since the critical value for $\chi^2_{(12)}$ = 26.217 at the α = .01 level, the difference of 50.87 allows the rejection of the null hypothesis. This in turn supports the conclusion that a model with one general factor and two item group factors accounts for the structure of this part of the instrument. The program's output shows that in this model the general factor accounts for 23.81% of the variance while the two item group factors account for 1.38% and .48% respectively. The uniqueness component is 74.32% of the variance.

The next application of the procedure runs of data from the 35 items corresponding to basic knowledge of natural sciences and social sciences. In this case, the null hypothesis postulates one general factor and one item group factor. The alternative hypothesis postulates one general factor and two item group factors. Under the null hypothesis the obtained test value is χ^2 = 77, 299.83, DF = 2983. The alternative hypothesis resulted in χ^2 = 79, 017.59, DF = 2971. In this case the χ^2 difference is in favor of retaining the null concluding that one general factor and one item group factor account for the structure of the test in this part of the instrument. This result is not surprising since the exploratory analysis results gave a strong indication that the item responses appear to be subsumed under one general factor of basic knowledge of science. As noted before, it is likely that the item responses are not actually distinguishing knowledge of two separate science fields and therefore the items only load on a general knowledge factor. The output indicates that the general factor accounts for 20.10 % of the variance while 79.90% is uniqueness in the data structure. It must be noted that this section of the instrument yields the weakest results both in the exploratory and in the confirmatory analyses. For this reason, the item construction and arrangement of this section requires further examination and possibly a re-formulation of item content. This aspect can be diagnosed better under the item fit analysis of the IRT model yet to be reported later.

The results of the confirmatory procedures applied to section 2 of the examination are presented next. As in the case of the exploratory part, the results that follow are taken from the data on the specialized knowledge areas of: Business-Administration, Science-Engineering, Law-Humanities, and Psychology-Sociology. It must be recalled that these data sub sets met the minimum sample size requirements to be analyzed both in the exploratory and confirmatory phases.

The CFA analysis applied to the Business- Administration sub sample (N=562) gives the following results. Under the null hypothesis of one general factor and two uncorrelated item group factors, the obtained test value is χ^2 = 34,545.32, DF= 441. The value obtained under the alternative hypothesis of one general factor and three uncorrelated item group factors is χ^2 = 34,318.69, DF= 411.

The difference of χ^2 values is 226.72 with 30 degrees of freedom. The critical value of $\chi^2_{(30)}$ =50.892 at the α =.01 level; therefore this result warrants the rejection of the null and the conclusion that the data fit a model of one general factor and three uncorrelated item group factors. This conclusion confirms again the factor structure postulated in the theoretical model.

The proportion of variance accounted for by the factors is: 15.33% for the general factor, 1.44% for factor 1, 5.51% for factor 2, and 1.29% for factor 3. The uniqueness for this sub set of the data is 76.41%.

The CFA analysis applied to the Science Engineering sub sample (N=552) gives the following results. Under the null hypothesis of one general factor and two uncorrelated item group factors, the obtained test value is χ^2 = 35,510.98, DF= 424. The value obtained under the alternative hypothesis of one general factor and three uncorrelated item group factors is χ^2 = 35,371.96 DF= 393.

The difference of χ^2 values is 139.02 with 31 degrees of freedom. The critical value of $\chi^2_{(31)}$ =52.191 at the α = .01 level, therefore this result warrants the rejection of the null and the conclusion that the data fit a model of one general factor and three uncorrelated item group factors. This conclusion confirms again the factor structure expected under the theoretical model.

The proportion of variance accounted for by the factors is: 21.57% for the general factor, 4.15% for factor 1, 1.00% for factor 2, and .72% for factor 3. The uniqueness for this sub set of the data is 72.54%.

The CFA analysis applied to the Law and Humanities sub sample (N=567) gives the following results. Under the null hypothesis of one general factor and two uncorrelated item group factors, the obtained test value is χ^2 = 35,812.72, DF= 456. The value obtained under the alternative hypothesis of one general factor and three uncorrelated item group factors is χ^2 = 35,612.44, DF= 427.

The difference of $\chi 2$ values is 200.28 with 29 degrees of freedom. The critical value of $\chi^2_{(29)}$ =49.588 at the α = .01 level, therefore this result warrants the rejection of the null and the conclusion that the data fit a model of one general factor and three uncorrelated item group factors. This conclusion confirms again the factor structure expected.

The proportion of variance accounted for by the factors is: 14.32% for the general factor, 2.66% for factor 1, 2.35% for factor 2, and .22% for factor 3. The uniqueness for this sub set of the data is 80.43%.

Finally for this phase, the CFA analysis applied to the Psychology and Sociology sub sample (N=625), gives the following results. Under the null hypothesis of one general factor and two uncorrelated item group factors, the obtained test value is χ^2 = 36, 583.00, DF= 498. The value obtained under the alternative hypothesis of one general factor and three uncorrelated item group factors is χ^2 = 36, 177.31, DF= 466.

The difference of $\chi 2$ values is 405.69 with 32 degrees of freedom. The critical value of $\chi^2_{(32)}$ =53.486 at the α = .01 level, therefore this result warrants the rejection of the null and the conclusion that the data fit a model of one general factor and three uncorrelated item group factors. This conclusion confirms again the factor structure expected.

The proportion of variance accounted for by the factors is: 17.07% for the general factor, 2.68% for factor 1, 7.62% for factor 2, and .62% for factor 3. The uniqueness for this sub set of the data is 72.00%.

Given the results above this section concludes with the assertion that the results of the CFA analysis on the cross validation sample support the results obtained under the EFA procedures. However, it must be noted that the proportions of variance accounted for by the factors identified are for the most part small with the uniqueness component attached to the largest proportion of variance in the data sub sets. These results although troubling are not surprising. It must be recalled that the overall applicants' performance on the sub-tests tends to be low in the percentage of items with correct responses. (see Table 4). The low average performance by sub test observed in the 2003 and 2004 cohorts forecasts the general result of the factors identified by EFA and confirmed by CFA accounting for smaller proportions of systematic variance in the 2004 EXHCOBA data sets.

Results of the Rasch Model Application

The final task in this project was to investigate the item properties of each of the EXHCOBA subscales by applying the Rasch Model to the data from the third randomly drawn sub sample of the 2004 cohort (N= 3091).

As explained in the methods section the purpose of this part of the methodology is to obtain item calibrations and an overall picture of how the items map in the applicants' cognitive set of abilities as observed in the cohort.

Since the Rasch Model assumes that a set must be of one-dimension each EXHCOBA section is examined separately to determine the properties of the corresponding subsubscale and in particular to check for unidimensionality of the item subset. The first set of 30 items belongs to Basic Language Ability and the results of applying the model to them are displayed in Table 14.

Table 14

Item Calibrations for EXHCOBA Items 1 – 30: Basic Language Ability

ITEM	LOGIT	ERROR	INFIT MSQ	INFIT ZSTD	OUTFIT MSQ	OUTFIT ZSTD	CORR	DISCR
1	0.75	0.04	0.99	-0.58	1.01	0.80	0.35	1.03
2	1.56	0.04	1.06	3.16	1.07	2.65	0.25	0.88
3	0.40	0.04	1.01	0.88	1.01	0.57	0.33	0.96
4	0.97	0.04	1.01	0.73	1.01	0.33	0.33	0.97
5	-1.19	0.05	0.95	**-1.70**	0.84	**-3.67**	0.35	1.07
6	-0.84	0.05	0.92	**-3.59**	0.84	**-4.62**	0.40	1.14
7	0.01	0.04	1.09	**6.24**	1.12	**5.69**	0.22	0.69
8	-0.77	0.04	1.00	0.00	0.99	-0.36	0.30	1.00
9	0.32	0.04	1.01	0.90	1.01	0.32	0.33	0.96
10	0.42	0.04	1.04	**2.96**	1.05	**2.75**	0.30	0.83
11	0.22	0.04	1.05	**3.99**	1.07	**3.72**	0.28	0.79
12	0.47	0.04	0.93	**-5.99**	0.92	**-5.16**	0.43	1.31
13	-0.48	0.04	1.02	0.99	1.04	1.34	0.29	0.95
14	0.20	0.04	0.91	**-6.90**	0.89	**-6.55**	0.44	1.35
15	0.92	0.04	1.09	**6.62**	1.12	**6.52**	0.23	0.64
16	-1.33	0.05	0.94	**-1.83**	0.87	**-2.77**	0.34	1.07
17	0.65	0.04	1.04	**3.35**	1.05	**2.83**	0.30	0.82
18	-0.18	0.04	1.00	0.25	1.00	0.22	0.32	0.99
19	-1.49	0.05	0.99	-0.24	0.96	-0.80	0.26	1.01
20	-0.84	0.05	0.96	-1.61	0.93	-2.08	0.34	1.06
21	-0.75	0.04	0.97	-1.44	0.92	-2.57	0.34	1.06
22	-0.06	0.04	1.01	0.52	1.00	0.11	0.32	0.98
23	0.56	0.04	1.03	**2.12**	1.02	**1.35**	0.32	0.89
24	-0.28	0.04	0.87	**-8.37**	0.81	**-8.47**	0.49	1.35
25	-0.41	0.04	1.02	1.08	1.01	0.22	0.30	0.96
26	-0.08	0.04	0.99	-0.55	0.98	-0.84	0.34	1.03
27	0.73	0.04	1.02	1.56	1.02	1.31	0.32	0.92

28	0.46	0.04	0.99	-0.98	0.98	-1.22	0.36	1.06
29	-0.61	0.04	1.01	0.32	1.00	0.13	0.30	0.99
30	0.65	0.04	1.08	**6.55**	1.11	**6.52**	0.24	0.63

As can be noted all 30 items in the basic language ability scale have values within the logit range of -2 to +2, with the majority centering around the mean of 0 logit difficulty. The highest logit value is 1.75 for item 2 and the lowest logit is -.06 for item 22. Also it can be noted that the error values for this estimate are relatively small between 0.04 and 0.05.

Inspection of Table 15 with values in bold shows items: 2, 5, 6, 7, 10, 11, 12, 14, 15, 17, 23, 24, and 30, as definite misfits both in INFIT and OUTFIT. It is also interesting to note that these items showed no significant loading on any of the factors extracted in the EFA analysis (see Table 6). All of their values are outside the acceptable ranges of 1 to 1.3 (unstandardized) or -2 to +2 (standardized). The interpretation for the values is based on the standard Rasch modeling criteria presented in Chapter 3. For reference, the values for assessing model fit are reproduced next.

For INFIT - which is a measure sensitive to responses near the person's ability level - the mean square infit statistic (MSQ) has an expectation of 1. Values substantially below 1 indicate dependency in the observed data, while values substantially above 1 indicate noise. A MNSQ of 1.0 indicates perfect fit. A value of 1.3 indicates the measure is suspect of misfit. Values above the 1.3 threshold are definite misfits indicating noise or error in the data. Values less than 1.0 also are suspect of misfit because they appear to fit to well. The rationale behind these limits in the statistic values is that an INFIT mean square value of 1 + x indicates 100x% more variation between the observed and the model-predicted response patterns that would be if the data and the model were fully compatible. Therefore an INFIT value of more than 1.30 indicates 30% more variation in the observed data than the model predicts. In the same manner, values less than 1 indicate a given percentage of less variation in the observed data than expected by the model,(Bond & Fox, 2001, p.177).

In INFIT the standardized values appear as INFIT ZSTD. This statistic is reported in natural logarithms and ideally should take on values between -2 and +2. Values greater than +2 are suspect of misfit and values less than -2 also are misfits.

The unstandardized values for INFIT and OUTFIT are reported as mean squares and these are the mean square residual values for each item. These residual values represent the differences between the Rasch Model's theoretical expectation and the performance observed for each item. It is useful to recall that infit is a weighted statistic more sensitive to person responses that are closer to their ability level as expected by the model. By contrast the outfit statistic is unweighted and it is more sensitive to outliers, that is, persons responding to items that are outside their ability level by the model's expectation.

For OUTFIT - which is a measure sensitive to outliers - the mean square outfit statistic (MSQ) also has an expectation of 1.0. Values substantially less than 1 indicate dependency in the observed data; while values substantially greater than 1 indicate the presence of outliers. A MNSQ of 1.0 indicates perfect fit. A value of 1.3 indicates the measure is suspect of misfit. Values above the 1.3 threshold are definite misfits indicating noise or error in the data. Values less than 1.0 also are suspect of misfit because they appear to fit too well. The rationale behind these values is that an OUTFIT mean square value of 1 + x indicates 100x% more variation between the observed and the model-predicted response patterns that would be if the data and the model were fully compatible. Therefore an OUTFIT value of more than 1.30 indicates 30% more variation in the observed data than the model predicts. In the same manner, values less than 1 indicate a given percentage of less variation in the observed data than expected by the model.

In OUTFIT the standardized values also appear as OUFIT ZSTD. For this statistic values between -2 and +2 are within an acceptable logit range for both persons and items. Values greater than +2 are suspect of misfit and values less than -2 also are misfits.

In the basic language ability subscale the items with definite misfit (2, 5, 6,7, 10, 11, 12, 14, 15,17,23, 24, and 30 are exceeding the limits of the criteria outlined above and should be examined in content and construction to identify possible item design flaws.

The second to last column of Table 15 indicate the correlation of each item with the total score for that item (CORR). When the items are measuring the same construct these values typically range from .25 to .75. Most of the items in this subset meet this general rule. This is an overall indication of unidimensionality. The lower correlations do correspond to those items that show a greater tendency towards misfit.

The last column of the table shows the item discrimination index for each item (DISCR). This index is an estimation of how well the item distinguishes the response patterns of persons of lower and higher ability. The standard interpretation is that the higher discrimination values represent a better ability discrimination power for the item in question relative to the other items in the subset.

It is also useful to examine the map of items and persons which shows the relative location of each of the items to examinees. The items and persons are placed along the scale in an order corresponding to measured item difficulty and person ability. This map is reproduced from the program's output in the next page. Inspection of the alignment of persons and items shows that item 2 was the most difficult (within acceptable range) but that a fair number of persons abilities exceeded this level of difficulty. Conversely item 19 is the easiest and very few persons are mapped below this level. Also the spread of items from 2 to 19 shows evidence of their placement along the unidimensional scale with some items aligned along the same difficulty score.

Figure 10
Map of Persons to Items from EXCHOBA Items: 1-30 Language

```
INPUT: 3091 PERSONS, 30 ITEMS  MEASURED: 3091 PERSONS, 30 ITEMS, 2 CATS     3.37
--------------------------------------------------------------------------------

       PERSONS MAP OF ITEMS
               <more>|<rare>
    4             .  +
                  .  |
                     |
                     |
                     |
    3                +
                  .  |
                     |
                     |
                .##  |
                     |
                    T|
    2          .###  +
                     |
              #####  |
           .#######  |  V2
                     |T
          .######## S|
         .#########  |
    1  .###########  +  V4
                     |  V15
       .###########  |S V1     V17    V27    V30
       .########### M|  V23
      .############  |  V10    V12    V28    V3
       .###########  |  V11    V9
        .##########  |  V14
    0     .########  +M V22    V7
           ########  |  V18    V26
           .####### S|  V24
              .####  |  V13    V25
               ####  |  V29
                .##  |S V21    V8
                     |  V20    V6
   -1           .## T+
                  .  |  V5
                  .  |  V16
                     |T V19
                  .  |
                  .  |
                     |
   -2             .  +
                     |
                     |
                  .  |
                     |
                     |
                     |
   -3                +
                     |
                     |
                     |
                  .  |
                     |
   -4                +
               <less>|<frequ>

 EACH '#' IS 21, '.' Is less than 21.
```

The most interesting feature of this item to person map is that a substantial number of examinees exceed in ability level compared to the items' difficulty level. This is understandable if one takes into account the fact that this part of the instrument measures language ability acquired during elementary school. Therefore, the general ability of the examinees would be expected to match or exceed the subscale's difficulty level.

The next subscale is composed of 30 items designed to measure Basic Math ability corresponding also to the elementary school curriculum. Item calibration results are shown in Table 15.

Table 15

Item Calibrations for EXHCOBA Items 31-60: Basic Math Ability

ITEM	LOGIT	ERROR	INFIT MSQ	INFIT ZSTD	OUTFIT MSQ	OUTFIT ZSTD	CORR	DISCR
31	-0.02	0.04	1.05	**2.81**	1.05	1.48	0.43	0.89
32	-1	0.05	0.97	-1.35	0.94	-1.12	0.43	1.04
33	1.44	0.04	1.15	**6.72**	1.29	**7.15**	0.36	0.72
34	-0.5	0.04	0.95	**-2.39**	0.92	**-2.14**	0.47	1.09
35	0.93	0.04	1.12	**6.46**	1.23	**7.29**	0.39	0.72
36	-0.53	0.04	0.92	**-4.22**	0.94	-1.53	0.49	1.14
37	0.69	0.04	1.14	**7.79**	1.23	**7.78**	0.38	0.65
38	-2.14	0.06	0.92	-2	0.68	**-3.73**	0.37	1.09
39	0.38	0.04	0.93	**-4.07**	0.92	**-3.14**	0.53	1.17
40	-0.09	0.04	0.95	**-2.78**	0.96	-1.2	0.49	1.1
41	-0.9	0.05	0.93	**-3.06**	0.9	**-2.13**	0.46	1.1
42	-0.36	0.04	0.89	**-6.09**	0.84	**-4.59**	0.53	1.23
43	0.53	0.04	0.94	**-3.87**	0.92	**-3.15**	0.53	1.16
44	-0.04	0.04	0.85	**-9.07**	0.79	**-7.35**	0.57	1.35
45	-0.74	0.04	0.9	**-5.08**	0.83	**-4.22**	0.5	1.18
46	-0.52	0.04	1.03	1.74	1	0.1	0.42	0.94
47	0.75	0.04	0.9	**-5.96**	0.85	**-5.64**	0.56	1.24
48	0.71	0.04	1.04	**2.14**	1.06	**2.23**	0.46	0.91
49	1.95	0.05	1	0.04	1	0	0.45	1
50	-0.15	0.04	1.08	**4.34**	1.1	**3.15**	0.41	0.82
51	0.63	0.04	0.96	**-2.41**	0.95	-1.86	0.51	1.1
52	0.36	0.04	1.27	9.9	1.41	9.9	0.29	0.33
53	-0.25	0.04	0.98	-1.06	0.94	-1.68	0.47	1.05
54	-1.07	0.05	0.98	-1.02	0.96	-0.67	0.42	1.03
55	0.16	0.04	0.98	-0.96	0.96	-1.42	0.49	1.05

56	0.2	0.04	1.11	**6.47**	1.16	**5.46**	0.39	0.72
57	-0.12	0.04	0.78	**-9.9**	0.69	**-9.9**	0.62	1.51
58	1.13	0.04	1.14	**7.08**	1.28	**8.15**	0.37	0.68
59	-1.57	0.05	0.94	**-2.07**	1.03	0.43	0.39	1.06
60	0.12	0.04	1.07	**4.05**	1.08	**2.67**	0.43	0.84

The 30 math ability items show logit values within the range of -2 to +2 which indicates that the difficulty range is not extremely high or extremely low. Again the majority of the items center around the 0 logit mean difficulty. As before, the values in bold indicate misfitting items. It must be noted that the sources of misfit need to be investigated in follow up studies. Figure 11 below shows the item to person map.

Figure 11

Map of Persons to Items from EXCHOBA Items: 31-60 Mathematics

```
INPUT: 3091 PERSONS, 30 ITEMS  MEASURED: 3091 PERSONS, 30 ITEMS, 2 CATS
--------------------------------------------------------------------------------

       PERSONS MAP OF ITEMS
               <more>|<rare>
    4            .#  +
                     |
              .####  |
                     |
                     |
                     |
                     |
    3        ######  +
                    T|
                     |
                     |
           .#######  |
                     |
         .#########  |
    2                +  V49
        .##########  |
                    S|T
       .###########  |
        .##########  |  V33
                     |
      .############  |  V58
    1 .############  +  V35
        .##########  |S
                     |  V37    V47    V48
       .###########  |  V43    V51
      .############ M|  V39    V52
        .##########  |
       .###########  |  V55    V56    V60
    0   ###########  +M V31    V44
        .##########  |  V40    V50    V57
       .###########  |  V53
        .##########  |  V42
          .########  |  V34    V36    V46
                     |  V45
         .######### S|S V41
   -1      .#######  +  V32    V54
          .########  |
                     |
           .#######  |
              .####  |  V59
                     |T
                .##  |
   -2               T+
                .##  |  V38
                     |
                  .  |
                     |
                     |
                     |
   -3             .  +
                     |
                     |
                     |
                     |
                  .  |
                     |
   -4                +
               <less>|<frequ>
 EACH '#' IS 13.
```

The item map for subscale 2 shows that most items spread across the basic math ability scale. This is clear by the position of the line of items from 49 to 38. Another segment of items are placed along an equal logit difficulty measure as seen in positions 37, 47 and 48. This might be an indication of redundancy but the number of items in these cases is not extreme compared to the spread of the rest of the items. The overall result gives a fair indication of unidimensionality in this subscale.

It must be noted that as in the previous case the ability level of the examinees surpassed the items' difficulty level. This is an expected result given the basic nature of the math ability being assessed by this section of the EXHCOBA examination.

The next section of the examination is composed of 4 separate subscales originally designed to measure basic knowledge acquired through the exposure of students to the secondary level curriculum (equivalent to grades 7^{th} through 9^{th}). These exams' subsection is labeled 1-B and the subscales are: (1) Basic knowledge of Spanish (20 items), (2) Basic knowledge of math (15 items), (3) Basic knowledge of Natural Sciences (15 items), and (4) Basic knowledge of Social Sciences (20 items).

The data from this section of the test posed the most difficult problems of analysis and interpretation in the EFA and CFA phases, therefore the examination of item fit and scale unidimensionality are expected to yield less interpretable results. On an added consideration, the section on average student performance shows a sharp decrease on the average percentage of items correct observed in the 2004 cohort (see Table 3).

The results from analyzing the 20 items from the basic knowledge of Spanish sub-scale are presented in Table 16.

Table 16

Item Calibrations for EXHCOBA Items 61-80: Basic Knowledge of Spanish

ITEM	LOGIT	ERROR	INFIT MSQ	INFIT ZSTD	OUTFIT MSQ	OUTFIT ZSTD	CORR	DISCR
61	-0.06	0.04	1.02	1.72	1.03	1.44	0.34	0.91
62	-1.39	0.05	1.02	0.64	1.05	1.16	0.28	0.97
63	0.4	0.04	1.01	0.4	1.01	0.27	0.37	0.98
64	-0.03	0.04	1.03	2.1	1.04	1.92	0.34	0.89
65	-0.64	0.04	0.98	-1.44	0.98	-0.74	0.37	1.06
66	-2.71	0.07	0.96	-0.78	0.79	**-2.49**	0.27	1.04
67	0.49	0.04	1.04	**3.17**	1.07	**3.49**	0.33	0.83
68	-0.13	0.04	0.94	**-4.32**	0.91	**-4.56**	0.43	1.22
69	1.17	0.04	0.97	-1.37	1.01	0.26	0.38	1.04
70	-0.45	0.04	0.98	-1.06	0.95	**-2.11**	0.38	1.06
71	-0.04	0.04	1.08	5.7	1.1	**5.02**	0.29	0.7
72	1.63	0.05	1.05	1.96	1.23	**5.67**	0.27	0.9
73	-1.21	0.05	0.96	-1.75	0.92	**-2.17**	0.36	1.07
74	0.49	0.04	1.04	**2.92**	1.05	**2.42**	0.33	0.86
75	0.68	0.04	1.08	**5.15**	1.11	**5.06**	0.29	0.75
76	-0.04	0.04	0.96	**-3.24**	0.94	**-3.02**	0.41	1.16
77	0.15	0.04	0.93	**-5.75**	0.9	**-5.43**	0.45	1.29
78	0.8	0.04	0.93	**-4.65**	0.93	**-3.41**	0.44	1.19
79	1.05	0.04	1.01	0.47	1.05	1.76	0.35	0.97
80	-0.14	0.04	0.98	-1.53	0.97	-1.56	0.39	1.08

It is clear that items 66-69 and 70-78 have standardized OUTFIT values well beyond the -2 to +2 range. One of the apparent reasons for misfit in this case is that these items were answered correctly by persons who were outliers in their ability calibrations. That is, the items were being either responded to correctly by examinees with low calibrations in ability, or the items were being responded to incorrectly by examinees with high calibrations in ability. These irregular or unexpected patterns of response give a warning signal indicating that the items in question might be problematic. The sources of difficulty can only be speculated here due to scope and space considerations. However, all of these cases will be flagged and further examination of this and other subscales will be recommended for follow up studies.

Figure 12 shows the arrangement of examinees and respondents. It is interesting to note below that in this subscale fewer respondents score in ability logits above the highest difficulty score in item (Item 72). Note also that item 66 is definitely below the ability level of respondents. However, for the most part the item distribute vertically in the difficulty scale which is a good indication of unidimensionality along the intended construct.

Figure 12
Map of Persons to Items from EXCHOBA Items: 61-80 Basic Spanish

```
INPUT: 3091 PERSONS, 20 ITEMS  MEASURED: 3091 PERSONS, 20 ITEMS, 2 CATS
--------------------------------------------------------------------------------

       PERSONS MAP OF ITEMS
               <more>|<rare>
    4            .  +
                    |
                    |
                    |
                    |
                 .  |
                    |
    3               +
                    |
                    |
                    |
                .#  |
                    |
                    |
    2          .## T+
                    |T
                    |
              .###  |  V72
                    |
           .######  |
                   S|  V69
    1     .#######  +S V79
                    |  V78
        .#########  |  V75
       .##########  |
                    |  V63    V67    V74
     .############  |
                   M|  V77
    0 .############  +M V61    V64    V71    V76
     .############  |  V68    V80
                    |
        .#########  |  V70
                    |  V65
          .####### S|
                    |
   -1      .######  +S
                    |  V73
              .###  |
                    |  V62
                .# T|
                    |
                    |T
   -2            .  +
                    |
                    |
                    |
                 .  |
                    |  V66
                    |
   -3               +
                    |
                    |
                 .  |
                    |
                    |
                    |
   -4            .  +
               <less>|<frequ>
 EACH '#' IS 28.
```

The next sub scale of 15 items from math gave the following results:

Table 17

Item Calibrations for EXHCOBA Items 81-95: Basic Knowledge of Math

ITEM	LOGIT	ERROR	INFIT MSQ	INFIT ZSTD	OUTFIT MSQ	OUTFIT ZSTD	CORR	DISCR
81	0.28	0.04	0.92	**-5.06**	0.92	**-3.67**	0.5	1.21
82	0.68	0.04	0.97	-1.65	0.98	-0.58	0.46	1.06
83	-0.52	0.04	0.95	**-3.24**	0.98	-0.91	0.45	1.13
84	0.96	0.04	1.04	2.11	1.09	**2.52**	0.4	0.92
85	0.68	0.04	1.09	**4.57**	1.12	4.18	0.37	0.82
86	0.65	0.04	0.89	**-6.12**	0.86	**-5.12**	0.52	1.23
87	-0.24	0.04	0.91	**-6.58**	0.91	**-4.01**	0.5	1.27
88	1.47	0.05	0.93	**-2.82**	0.96	-0.94	0.47	1.08
89	0.8	0.04	0.96	**-2.23**	0.99	-0.2	0.46	1.07
90	-0.99	0.04	0.96	**-2.31**	0.94	-1.74	0.42	1.09
91	-1.34	0.04	1	-0.04	1	-0.12	0.37	1
92	-1.52	0.05	0.95	-1.95	0.93	-1.54	0.39	1.06
93	-0.82	0.04	1.11	**6.44**	1.27	**7.94**	0.29	0.68
94	-0.45	0.04	1.03	**2.09**	1.09	**3.31**	0.39	0.89
95	0.38	0.04	1.18	**9.9**	1.26	**9.9**	0.29	0.52

The results for items 81, 83, 85 through 90, and 93 through 95 show very high misfit values. In general the subscales from the section 1-B of the exam tended to show the worst results in fit in the EFA and CFA phases of the study. The result above corroborates the claim that the four subscales in section 1-B appear to be the most problematic part of the EXHCOBA. These subscales showed the least regular loadings on the extracted factors (see Tables 7 and 8). Since these subscales showed the least consistency in the patterns of loadings, their unidimensionality is questionable and thus the performance of the items under Rasch modeling is also suspect. The item map in Figure 12 shows that these items have larger gaps along the difficulty scale than most other item subsets. However, the item map shows that a small group of respondents surpassed the most difficult items.

Figure 13

Map of Persons to Items from EXCHOBA Items: 81-95 Basic Math

```
INPUT: 3091 PERSONS, 15 ITEMS  MEASURED: 3091 PERSONS, 15 ITEMS, 2 CATS
-----------------------------------------------------------------------

       PERSONS MAP OF ITEMS
               <more>|<rare>
    3             .  +
                .##  |

                     |
                     |
                     |
                     |
                .## T|
    2                +
                     |
                     |T
                     |
              .####  |
                     |  V88
                     |
                     |
             .#####  |
                     |
    1               S+  V84
                     |S
           .#######  |  V89
                     |  V82    V85    V86
                     |
         .#########  |
                     |  V95
                     |  V81
        .##########  |
                     |
    0               M+M
      #############  |
                     |  V87
                     |
                     |
       .###########  |  V83    V94
                     |
                     |
       .###########  |  V93
                     |S
   -1                +  V90
                    S|
          .########  |
                     |  V91
                     |
                     |  V92
             .#####  |
                     |
                     |T
                     |
   -2                +
                .##  |
                    T|
                     |
                     |
                     |
                     |

   -3             .  +
               <less>|<frequ>
 EACH '#' IS 32.
```

The 15 items from basic knowledge of Natural Science give the following results:

Table 18

Item Calibrations for EXHCOBA Items 96-110: Knowledge of Natural Sc.

ITEM	LOGIT	ERROR	INNFIT MSQ	INFIT ZSTD	OUTFIT MSQ	OUTFIT ZSTD	CORR	DISCR
96	-1.11	0.05	1	0.05	1.02	0.39	0.31	1
97	0.1	0.04	1	-0.25	0.99	-0.29	0.39	1.02
98	0.1	0.04	1.04	**2.68**	1.05	**2.3**	0.35	0.87
99	0.61	0.04	0.98	-1.62	0.98	-1.17	0.42	1.08
100	0.93	0.04	1.13	**8.02**	1.18	**7.84**	0.28	0.63
102	-0.56	0.04	1.03	1.81	1.07	2.13	0.32	0.92
103	0.63	0.04	0.94	**-4.54**	0.92	**-4.06**	0.46	1.21
104	-1.36	0.05	0.93	**-2.35**	0.82	**-3.65**	0.37	1.09
105	0.04	0.04	0.98	**-1.35**	0.99	-0.52	0.4	1.06
106	2.31	0.05	0.96	**-1.39**	0.95	-1.05	0.41	1.05
107	-0.69	0.04	0.97	-1.5	0.95	-1.61	0.37	1.06
108	-0.75	0.04	1.09	**4.42**	1.21	**5.52**	0.24	0.81
109	0.59	0.04	1	-0.07	0.98	-0.89	0.4	1.02
110	0.32	0.04	1	-0.21	0.99	-0.68	0.4	1.02

Consistent with previous results in Section 1-B the Natural Science item subset shows a large number of items with higher misfit values. These items are 98, 100, 103-106, and 108. Again, as these item subsets are showing the most fit problems, it is reasonable to conclude that all four subscales in section 1-B are in need of revision and possible reformulation of item content and structure. The domain sampling capabilities of this subsets also needs to be examined before further conclusions are drawn on their overall fit with the rest of the instrument.

Figure 14

Map of Persons to Items from EXCHOBA Items: 96-110 Knowledge of Natural Sc.

```
INPUT: 3091 PERSONS, 15 ITEMS  MEASURED: 3091 PERSONS, 15 ITEMS, 2 CATS
------------------------------------------------------------------------

       PERSONS MAP OF ITEMS
               <more>|<rare>
    4             .  +
                     |
                     |
                     |
                     |
                     |
                     |
                     |
    3           .##  +
                     |
                     |
                     |
                     |
                    T|
                     |  V105
              .####  |
    2                +
                     |T
                     |
            #######  |
                     |
                    S|
                     |
         .#########  |
    1                +S
                     |  V100
      .############  |
                     |  V102   V108   V99
      .############ M|
                     |  V109
                     |
       .###########  |  V97    V98
    0                +M V104
        .##########  |
                     |
                     |
           .####### S|  V101
                     |
                     |  V106   V107
              .####  |
   -1                +S
                     |  V110   V96
                .##  |
                     |  V103
                    T|
                 .#  |
                     |
                     |T
   -2                +
                  .  |
                     |
                     |
                     |
                     |
                     |
   -3             .  +
               <less>|<frequ>
 EACH '#' IS 35.
```

The final subscale in section 1-B of the examination contains 20 items measuring basic knowledge of Social Sciences. The item calibration results appear below:

Table 19

Item Calibrations for EXHCOBA Items 111-130: Knowledge of Social Sc.

ITEM	LOGIT	ERROR	INFIT MSQ	INFIT ZSTD	OUTFIT MSQ	OUTFIT ZSTD	CORR	DISCR
111	1.15	0.04	1.09	**4.25**	1.17	**5.01**	0.28	0.82
112	0.26	0.04	0.99	-0.83	0.98	-0.85	0.4	1.04
113	0.85	0.04	0.95	**-2.97**	0.98	-0.62	0.43	1.1
114	0.59	0.04	1.02	1.28	1.08	**3.49**	0.36	0.92
115	0.78	0.04	1.01	0.42	1.02	0.77	0.38	0.98
116	-0.23	0.04	1.09	**6.8**	1.16	**7.26**	0.28	0.64
117	-0.05	0.04	0.97	**-2.55**	0.95	-2.61	0.42	1.14
118	0.85	0.04	0.99	-0.35	1.01	0.44	0.39	1.01
119	0.6	0.04	1.08	5.3	1.12	**4.93**	0.31	0.76
120	1.85	0.05	1.04	1.19	1.11	**2.26**	0.31	0.95
121	-0.14	0.04	0.89	**-8.5**	0.85	**-7.61**	0.49	1.41
122	0.77	0.04	0.89	**-6.61**	0.86	**-6.06**	0.49	1.27
123	-0.79	0.04	0.94	**-3.78**	0.93	**-2.64**	0.42	1.15
124	-0.77	0.04	0.92	**-5.09**	0.87	**-4.7**	0.44	1.21
125	0.31	0.04	0.96	**-2.7**	0.93	**-3.38**	0.43	1.14
126	0.4	0.04	1.11	**7.53**	1.13	**6.15**	0.28	0.64
127	-1.31	0.05	1.07	**2.75**	1.17	**3.95**	0.25	0.88
128	-2.04	0.05	0.95	-1.43	0.88	-2.1	0.33	1.05
129	-1.73	0.05	0.97	-0.96	0.97	-0.66	0.32	1.03
130	-1.34	0.05	1.01	0.55	1.1	**2.35**	0.31	0.97

It can be easily seen that this subscale shows the same tendency toward misfit as the other three subscales in Section 1-B. It is not possible at this point to examine all sources of misfit. Yet, it is reasonable to suspect that this subscale may have domain sampling problems as the Social Sciences curriculum may well be one of the most scattered areas in content and item construction. For this reason the recommendation of further examination of item content, structure, and domain sampling characteristics applies here as well as in the case of the Natural Science subscale. One interesting aspect is that in Figure 14, items and persons matched in difficulty and ability more than any other subscales have up to this point.

Figure 15

Map of Persons to Items from EXCHOBA Items: 111-130 Knowledge of Social Sc.

```
INPUT: 3091 PERSONS, 20 ITEMS  MEASURED: 3091 PERSONS, 20 ITEMS, 2 CATS     3.37
--------------------------------------------------------------------------------

       PERSONS MAP OF ITEMS
               <more>|<rare>
    4             .  +
                     |
                     |
                     |
                     |
                  .  |
                     |
    3                +
                     |
                     |
                 .#  |
                     |
                     |
                     |
    2           .## T+T
                     |  V120
               .###  |
                     |
                     |
              .####  |
                     |  V111
    1         .##### S+S
                     |  V113   V118
          .########  |  V115   V122
         .#########  |  V114   V119
                     |  V126
        .##########  |  V112   V125
                     |
    0 .############ M+M V117
                     |  V121
       ############  |  V116
        .##########  |
                     |
         .#########  |  V124
                    S|  V123
   -1       .######  +S
                     |
              .####  |  V127   V130
                     |
                     |
                .##  |  V129
                    T|
   -2                +T V128
                 .#  |
                     |
                     |
                  .  |
                     |
                     |
   -3                +
                     |
                     |
                  .  |
                     |
                     |
                     |
   -4             .  +
               <less>|<frequ>
 EACH '#' IS 29.
```

IRT Results by Specialized Career Area Knowledge

The EXHCOBA sub sections designed to measure specialized area knowledge are composed of 3 subscales of 60 items each with 20 items per subscale. Recalling previous descriptions these item subsets are administered to groups of applicants according to the career program to which admission is attempted. For present purposes the behavior of the items in these subsections are analyzed for the career areas of Business Administration (N = 545) Engineering Sciences, Law - Humanities, and Sociology and Psychology, since the data set from these areas were analyzed in the previous phases of this study.

The results of the item subscales administered to the area of Economics and Administration are presented and discussed below. The results of the rest of the career areas are presented in Appendix V due to space considerations.

Table 20

Item Calibrations for EXHCOBA Items 131-150 Math-Statistics

ITEM	LOGIT	ERROR	INFIT MSQ	INFIT ZSTD	OUTFIT MSQ	OUFIT ZSTD	CORR	DISCR
131	-0.46	0.1	0.95	-1.51	0.91	-1.55	0.48	1.17
132	-0.52	0.1	0.94	-1.82	0.9	-1.86	0.49	1.21
133	0.89	0.11	0.92	-1.45	0.92	-0.81	0.47	1.11
134	0.36	0.1	1.16	**3.25**	1.29	**3.67**	0.3	0.67
135	-0.73	0.1	0.96	-1.06	0.96	-0.73	0.46	1.11
136	1.5	0.13	1.05	0.57	1.25	1.64	0.33	0.93
137	-0.68	0.1	0.95	-1.32	0.96	-0.72	0.46	1.13
138	-0.48	0.1	1	0	1	0.02	0.44	1.01
139	-0.55	0.1	0.97	-1.01	0.93	-1.32	0.47	1.13
140	1.33	0.12	1.01	0.13	0.96	-0.29	0.39	0.99
141	-0.98	0.1	0.99	-0.21	1.03	0.45	0.43	1
142	-0.12	0.1	0.95	-1.29	0.97	-0.57	0.47	1.12
143	1.48	0.13	1.03	0.43	1.12	0.82	0.35	0.95
144	-0.58	0.1	1	0.02	0.98	-0.38	0.44	1.02
145	-0.79	0.1	0.94	-1.85	0.91	-1.57	0.48	1.2
146	0.5	0.1	1	-0.09	0.99	-0.07	0.43	1
147	-0.82	0.1	1	-0.04	1.01	0.19	0.43	1
148	0	0.1	0.99	-0.2	1.02	0.39	0.44	1.01
149	1.42	0.13	1.22	**2.74**	1.39	**2.56**	0.22	0.77
150	-0.77	0.1	0.98	-0.47	0.98	-0.29	0.45	1.06

Table 20 shows only two items with INFIT and OUTFIT values higher that the acceptable range of -2 to +2. As only items 134 and 149 have fit problems it must be considered that in the EFA and CFA parts of the analysis this subscale was found to be also one of the better fitting according to the originally design structure, (See Table 11). The IRT result lends partial support to the claim that in general the subscales from the specialized area knowledge show the strongest indications of unidimensionality. The item map in figure 15 shows that most items are in the -1 to +1 range of difficulty with the majority of the examinees aligning in this range. However, it is to be noted that even though this is one of the subscales that performed best in previous analyses, there is a number of respondents with ability levels well below the -1 logit range. This result in particular can be taken as an indication that the content and performance tasks of the items in this subscale are in fact beyond the ability level of those respondents with lower scores. Given the statistical characteristics shown by this subscale, it is paramount to note that the curriculum and instruction, to which the low scoring respondents were exposed, must be traced in the different EXHCOBA versions and come under scrutiny in follow up studies.

Figure 16

Map of Persons to Items from EXCHOBA Items: 131-150 Math-Statistics.

```
INPUT: 545 PERSONS, 20 ITEMS MEASURED: 545 PERSONS, 20 ITEMS, 2 CATS
----------------------------------------------------------------------

       PERSONS MAP OF ITEMS
               <more>|<rare>
    4             .  +
                     |
                     |
                     |
                     |
                  .  |
                     |
    3                +
                     |
                     |
                 .#  |
                     |
                     |
                     |
    2            .#  +
                     |
                    T|T
               .###  |
                     |  V136   V143   V149
                .##  |  V140
                     |
    1          .###  +
                     |S V133
             .#####  |
                    S|  V146
             .#####  |  V134
                     |
             .#####  |
    0      .#######  +M V148
                     |  V142
          .########  |
                    M|  V131   V138
       ############  |  V132   V139   V144
        .##########  |  V135   V137   V150
                     |S V145   V147
   -1  .###########  +  V141
                     |
         .#########  |
                     |
         .######### S|
                     |T
                     |
   -2         .####  +
                     |
                     |
              .####  |
                     |
                    T|
                     |
   -3                +
                 .#  |
                     |
                     |
                     |
                     |
                     |
   -4            .#  +
               <less>|<frequ>
 EACH '#' IS 5.
```

Table 21

Item Calibrations for EXHCOBA Items 151-170 Social Sciences

ITEM	LOGIT	ERROR	INFIT MSQ	INFIT ZSTD	OUTFIT MS	OUTFIT ZSTD	CORR	DISCR
151	-0.23	0.09	0.98	-0.62	1	0.06	0.34	1.07
152	-0.18	0.09	0.98	-0.89	0.98	-0.64	0.35	1.12
153	-0.54	0.09	0.93	**-2.18**	0.91	**-2.14**	0.4	1.27
154	-1.77	0.12	0.95	-0.64	0.99	-0.13	0.38	1.05
155	-0.37	0.09	0.96	-1.45	0.96	-1.11	0.37	1.18
156	-1.01	0.1	1.06	1.25	1.1	1.62	0.27	0.88
157	0.31	0.09	0.98	-0.71	0.97	-0.83	0.33	1.1
158	0.84	0.1	1.05	1.28	1.06	1.09	0.22	0.87
159	0.72	0.1	1.03	0.66	1.03	0.58	0.27	0.94
160	1.73	0.12	1.03	0.43	1.01	0.06	0.21	0.97
161	-0.13	0.09	0.99	-0.38	0.98	-0.6	0.33	1.07
162	-0.53	0.09	1	-0.11	1.01	0.26	0.33	1.01
163	-0.65	0.09	0.92	**-2.36**	0.9	**-2.31**	0.41	1.27
164	-0.2	0.09	1.01	0.24	1	-0.1	0.32	0.99
165	0.37	0.09	0.93	**-2.52**	0.92	**-2.07**	0.38	1.3
166	0.56	0.09	1	-0.1	1	-0.08	0.3	1.01
167	0.97	0.1	1.09	**1.89**	1.16	**2.35**	0.17	0.8
168	-0.74	0.09	1.08	**2.24**	1.1	2	0.24	0.75
169	0.67	0.1	1	0.11	1.01	0.22	0.29	0.98
170	0.18	0.09	1.02	0.76	1.04	0.96	0.29	0.89

The social science subscale has five items with infit values greater than expected. This is an indication of unexpected patterns of response observed near the respondents ability levels. Figure 16 shows a no overall noticeable disparities between the item set difficulty estimates and the ability levels observed in this subsample. It is fair to speculate that these unexpected responses might represent incorrect responses to items near or at the ability levels in respondents who might have been working in haste as this subscale is located near the end of the examination.

Figure 17

Map of Persons to Items from EXCHOBA Items: 151-170 Social Sciences

```
INPUT: 545 PERSONS, 20 ITEMS  MEASURED: 545 PERSONS, 20 ITEMS, 2 CATS
-----------------------------------------------------------------------
       PERSONS MAP OF ITEMS
               <more>|<rare>
    4                +
                     |
                     |
                     |
                     |
                     |
                  .  |
                     |
    3                +
                     |
                     |
                     |
                     |
                  .  |
                     |
                     |
    2                +
                  .  |
                     |  V160
                     |
                  .  |T
                    T|
                .##  |
                     |
    1         .####  +  V167
                     |  V158
             .#####  |S V159
                    S|  V169
            .######  |  V166
                     |  V165
          .########  |  V157
                     |  V170
    0  ############ M+M
                     |  V152   V161
         .#########  |  V151   V164
                     |  V155
         ##########  |  V153   V162
                     |  V163
           .####### S|S V168
                     |
   -1          .###  +  V156
                     |
                .##  |
                     |
                  . T|T
                     |
                     |  V154
                  .  |
   -2                +
                     |
                     |
                  .  |
                     |
                     |
                     |
                     |
   -3             #  +
               <less>|<frequ>
 EACH '#' IS 7.
```

Table 22

Item Calibrations for EXHCOBA Items 171-190 Economics-Administration

ITEM	LOGIT	ERROR	INFIT MSQ	INFIT ZSTD	OUTFIT MS	OUTFIT ZSTD	CORR	DISCR
171	-0.02	0.09	1.01	0.24	1.01	0.29	0.36	0.98
172	0.55	0.1	0.97	-0.79	0.93	-1.25	0.37	1.11
173	-0.59	0.1	1.08	**2.16**	1.09	1.78	0.32	0.78
174	0.76	0.1	0.99	-0.28	0.97	-0.46	0.34	1.04
175	1.07	0.1	1.1	**2.01**	1.24	**2.87**	0.21	0.8
176	-0.62	0.1	0.96	-1.19	0.97	-0.62	0.42	1.12
177	-0.24	0.09	1.1	**3.26**	1.13	**2.91**	0.28	0.61
178	-1.21	0.1	0.99	-0.17	0.99	-0.19	0.4	1.02
179	1.21	0.11	1.04	0.66	1.18	1.96	0.25	0.91
180	0.98	0.1	0.92	-1.71	0.88	-1.73	0.39	1.16
181	-0.02	0.09	0.96	-1.35	0.95	-1.23	0.4	1.18
182	0.07	0.09	0.94	-2.2	0.91	**-2.18**	0.42	1.28
183	0.37	0.09	0.94	-1.81	0.91	-1.9	0.41	1.22
184	0.16	0.09	0.99	-0.47	1	-0.07	0.37	1.05
185	-0.37	0.09	1.07	2.08	1.09	2.01	0.31	0.75
186	-0.52	0.09	0.92	**-2.34**	0.89	**-2.4**	0.45	1.27
187	0.02	0.09	0.95	-1.56	0.94	-1.5	0.41	1.2
188	-0.63	0.1	1.02	0.44	1.07	1.36	0.36	0.93
189	-0.63	0.1	1.03	0.82	1.01	0.28	0.36	0.94
190	-0.32	0.09	1.01	0.4	1.01	0.21	0.37	0.96

Again the higher infit values here might be an indication of the haste effect given the mapping of item difficulties and respondents' abilities shown in Figure 17. As can easily bee seen all items and respondents are within acceptable ranges, although a small number of respondents scored below in ability.

Figure 18

Map of Persons to Items from EXCHOBA Items: 171-190 Economics

```
INPUT: 545 PERSONS, 20 ITEMS  MEASURED: 545 PERSONS, 20 ITEMS, 2 CATS
----------------------------------------------------------------------

       PERSONS MAP OF ITEMS
               <more>|<rare>
    4                +
                     |
                     |
                     |
                     |
                     |
                  .  |
    3                +
                     |
                     |
                     |
                  .  |
                     |
                     |
    2                +
                 .#  |
                    T|
                .##  |
                     |
                     |T
               .###  |  V179
    1                +  V175   V180
            .###### S|
          #########  |  V174
                     |S V172
       .###########  |  V183
                     |
        .##########  |  V184
    0   .########## M+M V171   V181   V182   V187
                     |
      .############  |  V177   V190
       .###########  |  V185
                     |S V173   V176   V186   V188   V189
         .#########  |
           .####### S|
   -1                +
               .###  |
                     |T V178
                     |
               .###  |
                    T|
                 .#  |
   -2                +
                     |
                  #  |
                     |
                     |
                     |
                     |
   -3                +
                  #  |
                     |
                     |
                     |
                     |
                     |
   -4            ##  +
               <less>|<frequ>
 EACH '#' IS 5.
```

The remaining scales in the specialized career knowledge areas were analyzed and the results for the most part are similar to the description of item and subscale performance presented above. The subscales on the specialized career area knowledge of the instrument showed for the most part equivalent results as the item maps indicate that these subscales are targeted to the observed ability levels of the applicants in the 2004 cohort. This result is encouraging because it is also an indication that factual curriculum as measured by the applicant's responses is aligned with the subscales administered according to career program choice. The item fit indices and item maps for these subscales are presented by career knowledge area in Appendix III.

The overall results of the Rasch analysis reveal that while most subscales perform as expected the item sets belonging to Section 1-B are the most doubtful in performance. This finding is consistent with the EFA and CFA results. It will be recalled that items targeted at basic knowledge of Spanish, Math, Natural Science, and Social Science showed the least strength in factor loadings and the two common factors model was not confirmed with respect to the 35 items targeted at basic knowledge of Natural and Social Sciences. This particular situation is a cause of concern about the fit of the items in this subscale with the rest of the instrument. The next and final section of this manuscript addresses this concern and advances recommendations for further analysis of the problematic aspects of this subscale.

Most importantly, the EXHCOBA subscales - with the exceptions noted above - demonstrate reasonable unidimensionality under the IRT application. This finding is also encouraging as it corroborates the structural properties found in previous analyses and gives fair support to the instrument's originally intended design vis a vis the Sonoran high school curriculum. The investigation of unidimensionality indicates that in most cases the subscales are constructed in a manner which affords the instrument's expected performance and intended use. As in all cases the item difficulty calibrations exhibit values within acceptable ranges, it can be concluded that the irregular patterns of response found to produce item misfit may be indications of problems during the exam administration or of factors related to special circumstances in examinees that need to be uncovered by studies that focalize on the actual dynamics to the test administration.

CHAPTER 5

REVIEW OF IMPLICATIONS AND CONCLUSIONS

This chapter reviews the results and implications for the EXHCOBA testing practices at the Universidad de Sonora. The findings after applying the three methodological phases of this study show reasonable consistency. While the instrument's subscales performed according to original design expectations, the four subscales in Section 1-B, showed the least consistency overall. However, the concern with the performance of the EXHCOBA subscales needs to be reviewed in the context of the overall characteristics of the testing program as applied at the University of Sonora. The main implications of the findings presented in Chapter 4 are discussed below. The order of the discussion addresses first general concerns that emerge form current use of the EXHCOBA in Sonora. The psychometric implications of the findings are then discussed in the content of academic standards definitions. The section closes with general conclusions and recommendations.

Discussion of General Implications

The testing system is presently serving the purpose for which it was adopted in 1997 which is to aid in the selection and placement of applicants in professional career programs. Beyond this fact, the methodology applied to the test data has revealed important differences in the performance of applicants. This concern has been recognized by the academic authorities at the University of Sonora (Gonzalez & Lopez, 2004). With the findings contained in the present study it is possible to point to specific issues that need to be addressed.

First and foremost the issue of test preparation for the EXHCOBA examination needs to be given serious consideration by academic authorities in the high school system as a whole. The overall low performance in the subsections of the test that is consistently observed in the 2003 and 2004 cohorts is a strong indication that the first obstacle may be the lack of a student support system for the standardized testing requirements.

The overall average performance of applicants in all sections of the examination barely rises above 18 correct out of 30 items in the basic language ability subscale. The lowest performance is observed in the basic knowledge of math subscale with 6 items out of 15 items correct. (see Table 4). In percentage terms the average for these cohorts is 60% items correct in basic language and 40% correct in basic math. The overall picture is that in these basic areas the applicants are scoring well below a minimum proficiency level. The traditional standard of proficiency is defined as 60 % minimum performance for a passing grade throughout the Mexican educational system. None of the other observed performance levels in the other subscales show substantial improvement over these basic area skills. These performance trends have been recognized and documented by researchers at the EXHCOBA development facility (Larrazolo, 2004) and also by researchers at the Universidad de Sonora (Gonzalez & Lopez, 2004).

Given that the low performance is observed in areas and skills that are so basic it is reasonable to suppose that adequate attention is not being given in current practice to resources for basic skills review and adequate test preparation practices. The most obvious place to begin is by enacting institutional strategies that ensure that all applicants receive adequate preparation on the EXHCOBA format and general requirements before graduation from their highs schools of origin. Recommendations for a strategy that ensures systematic exam preparation and fair practice are presented in the conclusions section of this manuscript.

Implications for Current Testing Practice

The statistical properties of the instrument have shown an acceptable degree of subscale performance under a three-stage methodological framework. The exploratory and confirmatory methods employed at the item level have produced sufficient evidence to support limited claims of construct validity for Sections 1-A and 2 of the EXHCOBA. Limited evidence was also found to question further the properties of the item sets that attempt to measure basic knowledge constructs of knowledge of natural and social sciences in Section 1-B.

The factor solutions explored and confirmed indicate that basic abilities and basic knowledge are measured by the item subsets following distinct unidimensional structures. However, there are also item sets that did not perform under the framework expected by subscale design. The item sets that did not load on any of the extracted factors are listed by subscale below:

Basic Language Ability (Subscale 1) Items: 2, 3, 7, 9, 10, 11, 13, 15, 16, 17, 18, 19, 20, 23, 25, 25, 27, 28, 29, and 30.

Basic Math Ability (Subscale 2) Item: 52.

Basic Knowledge of Spanish (Subscale 3) Items: 62, 63, 65, and 71 through 80.

Basic Knowledge of Math (Subscale 4) Items: 81 through 85, 89, 90, and 93.

Basic Knowledge of Natural Sciences (Subscale 5) Items: 97, 98, and 101 through 110.

Basic Knowledge of Social Sciences (Subscale 6) Items: 111 through 113, 115 through 120, 125, 127, and 128.

For those item sets that do load on the extracted factors it must be taken into consideration that the confirmed factors accounted for very modest proportions of variance in the data sets. This is a clear indication that the variability in the data sets that represent applicants' academic performance is stemming from sources not being directly detected by the examination. These sources need to be hypothesized, tested, and explained in follow up studies. Further application of the methods employed in this dissertation can be profitably used to examine differences between selected sections of the high school system. Particularly, a study employing the three-stage methodology can be conducted with a focus on the test performance of students that are about to exit the state high school system. The item subsets listed above need to be reviewed to locate at least initially if the source of the problems lies in the content or construction characteristics of the items or on the particularities of curriculum and implementation in high schools.

The item review can be accomplished by comparing the item tasks to selected parts of the curriculum to find at least fair indications of conceptual correspondence. The same implication holds for selected items in the specialized knowledge subscales by career area. This aspect of the technical properties of the items can profitably be investigated by adapting a method of alignment studies as the one proposed by Webb (1999), as a follow up to the present study. Follow up studies on alignment need to be implemented as a concerted effort between the test developer and curricular design offices of the high school system. The study of alignment of curricular content with the subsections of the exam that have shown areas of concern is presented as a general recommendation in the concluding section of this manuscript.

However, the study of the alignment of EXHCOBA and the Sonoran High School official curriculum must follow a concerted effort to apply the fair and professionally testing preparation practices at the high school level. The reason that such strategy must be implemented first is that the curricular content and the examination in place may have a high degree of conceptual correspondence, but this possibility is likely to be obscured by the lack of an adequate system of academic review and test preparation for students at the high school level.

Implications for Academic Standard Setting

The original intent of this study is addressed in light of the main findings as with the following lines of argument:

(a) EXHCOBA, as a large-scale comprehensive examination for selection and placement of applicants to university career programs, embodies a set of content standards defined by the technical properties of the nine subscales.

(b) The University of Sonora has adopted these content standards in a general form at least implicitly by the continued use of the EXHCOBA testing system. Based on the analysis of current practice, the academic authorities of the institution are in the position to define specific performance standards for the academic process of each professional career program on the basis of the EXHCOBA system implementation.

(c) The statistical methodology employed in this dissertation offers a preliminary but adequate picture of the type of results that can be expected by continuing current trends. While future results cannot be judged as adequate or inadequate a priori, the trends observed and reported in this study merit the design and implementation of strategies of academic standards setting for professional studies at the University of Sonora.

(d) An explicit definition of basic academic standards for each of the existing career programs begins with a large-scale statistical analysis or data derived from current educational practice. The results obtained serve as a definite baseline against which future results can be compared. A comparative process allows defining, on the basis of sound measurement instruments, the academic standards that are being met *de facto* by applicants. The processes will likewise reveal grey areas where the data analysis suggests that the academic standards are not being adequately met. Consequently, these areas are to be targeted for improvement at the levels of curricular design and instructional implementation.

(e) Given the fact that at present no minimum performance standard has been defined either for the total score or for the separate subscales of the instrument, the applicants have continued to score in the lower end of the EXHCOBA scale. The descriptive statistics and the statistical analysis presented in this study have given an adequate representation of the lower limits on EXHCOBA performances and the overall inconsistencies on performance by subscale.

Following the argumentation above leads to the proposal or three lines of action:

(1) The design and implementation of a test preparation program at the high school level,

(2) The definition of expected performance standards by career program at the university level, and

(3) The design and implementation of alignment studies to match the Academic Standards defined with the assessment instrument in place.

The lines of action above are proposed and justified as a result of the appraisal of current practice and based on the statistical analysis results produced in this study. The general content of each proposal is presented below.

Design and Implementation of a Test Preparation Program

The EXHCOBA examination system has a student preparation system available for applicants in Sonora. This system consists of an electronic guide to the examination which is available in floppy disk format and also online at the test developer's website. In the past, the University of Sonora has recommended that applicants review the EXHCOBA guide and take the practice exam. Yet, this has been left up to the individual applicant's discretion and has not been set forth as an official requirement.

The situation described can change and progress toward substantial improvement in applicants' performance if a simple and systematic process is enacted at the high school level.

Namely, the academic orientation or school counseling programs in place at the High School level can be modified to include a test preparation program based on the EXHCOBA format and general requirements. It is perfectly feasible that at the beginning of the senior year (5th high school semester in Sonora), all students be inducted into a two phase test preparation program as outlined below:

> A) Phase I would consist of an individual self-assessment of academic performance. This would be a systematic exercise where each senior examines her or his own academic strengths and areas in need of improvement with the aid of a academic assessment survey to be developed ex-profeso.
>
> B) Phase II would consist of the actual EXHCOBA Practice Exam adapted to give students individual results by each of the nine subscales. The student individual results can then be compared with the data obtained from the Individual Self-assessment of Academic Performance. This comparative exercise in turn would enable the student and the academic counselor to target areas of concern to be worked on before the actual EXHCOBA examination takes place.

The program outlined above can be designed and conducted at the school counseling level by effectively joining the academic student-planning domain with the individual career planning concerns of the high school seniors approaching completion of their high school program of studies. The key to this approach is the requirement of a systematic self- examination and student preparation that would place students on a trajectory of improved performance in the EXHCOBA. The added advantage to this approach is that the students would also have an early opportunity to preview the actual standardized testing process and to realize the performance expectations upheld by the University of Sonora.

Definition of Performance Standards Expected at the University Level

The University of Sonora is an institution created by an act of State legislation approved in 1942 and revised in 1991. The current legal framework empowers the institution to design and implement professional career programs and to grant degrees upon completion of the requirements of the approved programs of study. Given the fact that the university is legally empowered to set academics requirements, it follows that the institution can set academic standards for admission and completion of the prescribed programs of study. It is then reasonable to propose that the academic authorities adopt performance standards that are both necessary and sufficient for promoting a systematic improvement of the academic processes at the student level. The establishment of adequate levels of academic proficiency is a complex decision making process that has been examined and documented professionally (Cizek, 2001).

A systematic effort aimed at determining sufficient performance levels for each career program at the University of Sonora can take as a departure point the traditionally adopted 60% level of performance to operationalize the basic level of student proficiency. This decision and its implications can be explored at the level of each individual career program either by assigning a 60% performance level to each of the subscales or else to the total EXHCOBA score expected. The customary labels of Basic, Proficient and Advanced can then be defined based on the current minimum of 60%. A simple but effective starting point based on items correct is: 60% to 69% for the Basic level, 70% to 79 % for the Proficient level, and 80% and above for the Advanced level. While the scheme just described is not new, it is defensible to suppose that it is implicitly applied in most judgments of academic performance. The idea here is to employ the scheme as a starting point to then proceed to set realistic performance goals for graduating high school seniors and university program applicants. In principle the use of EXHCOBA and the psychometric properties of the instrument are a sound basis for this decision making process.

Design and Implementation of Alignment Studies

The high school system in Sonora periodically modifies its official curricular design and instructional implementation procedures. For example, the largest state high school institution, Colegio de Bachilleres de Sonora (COBACH), has recently modified all curricular content standards (Direccion Academica COBACH, 2004). The implementation of institutional curricular re-design programs would be most profitable when enacted in line with the framework of evaluating student performance with standardized instruments as the EXHCOBA examination. The results of the statistical analysis sections of this study are already a basis to begin the design of alignment studies at this level. Alignment is defined as a property of the relationship between a set of curricular content standards and the psychometric scales employed to assess the actual student performance expected from academic content standards (Webb, 1999). The present situation in Sonora requires that at least pilot alignment studies be conducted since the use of standardized testing instruments to assess students is a reality in the state since 1997.

The design and conduction of this type of studies can be implemented by a joint task force composed academic experts from the Universidad de Sonora and the Colegio de Bachilleres de Sonora.

Recommendations

Academic authorities at the University of Sonora and High School COBACH level can begin to consider the enactment of the lines of action outlined in the previous section. In particular, the design and implementation of an EXHCOBA test preparation program at the high school level is at this point essential. The consistently observed low levels of performance are sufficiently known, therefore, systematic programs to remediate the baseline observed levels of student performance should be made a priority.

The design of a program for a school counseling intervention that addresses adequate test preparation and students' self appraisal of academic performance can be planned during the spring of 2005. A piloting application of the program could then follow for implementation with a sample from the senior class of 2005 during the fall semester. After piloting and adjustments are complete the Test Preparation Program would be ready for statewide implementation by the fall 2006 semester.

The program outlined above needs to be considered first by the academic authorities of the Colegio de Bachilleres de Sonora as this institution represents the official high school state system. Once underway, the program can be extended to the remaining high schools in the state including those that belong to the private sector of education.

At the university level the existing program of Tutorias Academicas, originally designed to improve student's academic performance, can benefit considerably from employing the EXHCOBA diagnostic information to guide the professional school counseling process in place. Early detection of academic deficit is easily accomplished by examining the performance of admitted applicants in each separate subscale of the instrument. Once the most noticeable deficits are identified, individualized interventions can be applied to assist the individual student in overcoming these obstacles to academic success. Therefore, the use of EXHCOBA as a diagnostic tool can be extended to inform current academic practice beyond its customary application in the admission, selection, and placement of students in professional career programs.

Conclusions

The use of the EXHCOBA examination should progress towards becoming a statewide testing program. The status of current practice in Sonora provides a modest but sufficient basis for the definition of academic standards in higher education. The process can evolve by a series of technically informed policy decisions that would ultimately result in a formal standardized testing program for gradual implementation at the state level. Educational testing is never an end in itself; it is a tool to guide the improvement of academic practice and student performance. The EXHCOBA testing system employed with a process of gradual definition of academic standards can provide the technical basis for attaining realistic goals of academic improvement in the Sonoran system of higher education. The three-stage methodology employed in this study serves as a benchmarking process with which progress towards academic standards setting can be monitored.

APPENDIX I

Program file for exploratory factor analysis on test items 1 through 60.

```
>TITLE
EFA1.TSF - EFA DATA FULL-INFORMATION ITEM FACTOR ANALYSIS

>PROBLEM    NITEMS=60, RESPONSE=3;
>COMMENTS

        EXHCOBA SUB-TEST 1A LANG - MATH BASIC ABIL
        Full-information item factor analysis
        VARIMAX rotation
        Data layout: COLUMN1 TO 60 Item Responses

>NAMES      ITEM1,ITEM2,ITEM3,ITEM4,ITEM5,ITEM6,ITEM7,ITEM8,
        ITEM9, ITEM10,ITEM11,ITEM12,ITEM13,ITEM14,ITEM15,
        ITEM16,ITEM17,ITEM18,ITEM19,ITEM20,ITEM21,ITEM22,
        ITEM23,ITEM24,ITEM25,ITEM26,ITEM27,ITEM28,ITEM29,
        ITEM30,ITEM31,ITEM32,ITEM33,ITEM33,ITEM34,ITEM35,
        ITEM36,ITEM37,ITEM38,ITEM39,ITEM40,ITEM41,ITEM42,
        ITEM43,ITEM44,ITEM45,ITEM46,ITEM47,ITEM48,ITEM49,
        ITEM50,ITEM51,ITEM52,ITEM53,ITEM54,ITEM55,ITEM56,
        ITEM57,ITEM58,ITEM59,ITEM60;

>RESPONSE ' ','0','1';

>KEY 111111111111111111111111111111111111111111111111111111111111;

>TETRACHORIC NDEC=3, LIST;

>FACTOR    NFAC=1,NROOT=3,ROTATE=VARIMAX, RESIDUAL, SMOOTH;
>FULL      CYCLES=20;
>TECHNICAL   NOADAPT;
>SAVE      SMOOTH, ROTATED, PARM;
>INPUT     FILE='EFA1.DAT' NIDCHAR=20;
(20A1,T1,60A1)
>STOP;
```

Program file for items 61 through 130

```
>TITLE
EFA2.TSF -  DATA FULL-INFORMATION ITEM FACTOR ANALYSIS

>PROBLEM    NITEMS=70, RESPONSE=3;
>COMMENTS
        EXHCOBA SUB-TEST 1B BASIC KNOWLEDGE 4 AREAS
        SPAN. MATH. NATSC. SOCS.
        Full-information item factor analysis
        VARIMAX rotation
        Data layout:
        COLUMNS  1 TO 70 Item Responses

>NAMES      ITEM1,ITEM2,ITEM3,ITEM4,ITEM5,ITEM6,ITEM7,ITEM8,
        ITEM9,ITEM10,ITEM11,ITEM12,ITEM13,ITEM14,ITEM15,
        ITEM16,ITEM17,ITEM18,ITEM19,ITEM20,ITEM21,ITEM22,
        ITEM23,ITEM24,ITEM25,ITEM26,ITEM27,ITEM28,ITEM29,
        ITEM30,ITEM31,ITEM32,ITEM33,ITEM34,ITEM35,ITEM36,
        ITEM37,ITEM38,ITEM39,ITEM40,ITEM41,ITEM42,ITEM43,
        ITEM44,ITEM45,ITEM46,ITEM47,ITEM48,ITEM49,ITEM50,
        ITEM51,ITEM52,ITEM53,ITEM54,ITEM55,ITEM56,ITEM57,
        ITEM58,ITEM59,ITEM60,ITEM61,ITEM62,ITEM63,ITEM64,
        ITEM65,ITEM66,ITEM67,ITEM68,ITEM69,ITEM70;

>RESPONSE ' ','0','1';

>KEY 111111111111111111111111111111111111111111111111111111111111
   1111111111;

>TETRACHORIC      NDEC=3, LIST;

>FACTOR          NFAC=3, NROOT=4, ROTATE=VARIMAX, RESIDUAL,
SMOOTH;
>FULL            CYCLES=20;
>TECHNICAL       NOADAPT;
>SAVE            SMOOTH, ROTATED, PARM;
>INPUT           FILE='EFA2.DAT' NIDCHAR=20;
(30A1,T1,70A1)
>STOP;
```

Program file for items 131 through 190

```
>TITLE
EFA3.TSF - EFA DATA FULL-INFORMATION ITEM FACTOR ANALYSIS

>PROBLEM    NITEMS=60, RESPONSE=3;
>COMMENTS
         EXHCOBA SUB-TEST 2 SERIES
         CAREER KNOWLEDGE AREAS 1-3
         VARIMAX rotation
         Data layout: COLUMN1 TO 60 Item Responses

>NAMES      ITEM1,ITEM2,ITEM3,ITEM4,ITEM5,ITEM6,ITEM7,ITEM8,
         ITEM9, ITEM10,ITEM11,ITEM12,ITEM13,ITEM14,ITEM15,
         ITEM16,ITEM17,ITEM18,ITEM20,ITEM21,ITEM22,ITEM23,
         ITEM24,ITEM25,ITEM26,ITEM27,ITEM28,ITEM29,ITEM30,
         ITEM31,ITEM32,ITEM33,ITEM33,ITEM34,ITEM35,ITEM36,
         ITEM37,ITEM38,ITEM39,ITEM40,ITEM41,ITEM42,ITEM43,
         ITEM44,ITEM45,ITEM46,ITEM47,ITEM48,ITEM49,ITEM50,
         ITEM51,ITEM52,ITEM53,ITEM54,ITEM55,ITEM56,ITEM57,
         ITEM58,ITEM59,ITEM60;

>RESPONSE ' ','0','1';

>KEY 111111111111111111111111111111111111111111111111111111111111;

>TETRACHORIC NDEC=3, LIST;

>FACTOR    NFAC=5, NROOT=10, ROTATE=VARIMAX, RESIDUAL, SMOOTH;
>FULL      CYCLES=20;
>TECHNICAL NOADAPT;
>SAVE      SMOOTH, ROTATED, PARM;
>INPUT     FILE='SER1E.DAT' NIDCHAR=20;
(20A1,T1,60A1)
>STOP;
```

APPENDIX II

Programming for confirmatory factor analysis of Model 1

```
>TITLE
CONFIRMATORY FACTOR ANALYSIS ON EXHCOBA DATA

>PROBLEM NITEMS=60, RESPONSE=3;

>COMMENTS
      EXHCOBA SUB-TEST 1A
      CONFIRM ONE GENERAL FACTOR AND 2 ITEM
      GROUP FACTORS AS AREAS: (1) LANG (2) MATH
      DATA layout: COLUMNS 1 TO 60 ITEM RESPONSES

>NAMES     ITEM1,ITEM2,ITEM3,ITEM4,ITEM5,ITEM6,ITEM7,ITEM8,
        ITEM9, ITEM10,ITEM11,ITEM12,ITEM13,ITEM14,ITEM15,
        ITEM16,ITEM17,ITEM18,ITEM19,ITEM20,ITEM21,ITEM22,
        ITEM23,ITEM24,ITEM25,ITEM26,ITEM27,ITEM28,ITEM29,
        ITEM30,ITEM31,ITEM32,ITEM33,ITEM33,ITEM34,ITEM35,
        ITEM36,ITEM37,ITEM38,ITEM39,ITEM40,ITEM41,ITEM42,
        ITEM43,ITEM44,ITEM45,ITEM46,ITEM47,ITEM48,ITEM49,
        ITEM50,ITEM51,ITEM52,ITEM53,ITEM54,ITEM55,ITEM56,
        ITEM57,ITEM58,ITEM59,ITEM60;

>RESPONSE ' ','0','1';
>KEY 111111111111111111111111111111111111111111111111
   111111111111;
>TETRACHORIC NDEC=3,LIST;
>BIFACTOR NIGROUPS=3, LIST=3, CYCLES=20
       IGROUPS=(1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,
         2,2,2,2,2,2,2,2,2,2,2,2,2,2,2,2,2,2,2,2,3,3,3,
         3,3,3,3,3,3,3,3,3,3,3,3,3,3,3,3,3),
       CPARMS=(0.1,0.1,0.1,0.1,0.1,0.1,0.1,0.1,0.1,0.1,
            0.1,0.1,0.1,0.1,0.1,0.1,0.1,0.1,0.1,0.1,
            0.1,0.1,0.1,0.1,0.1,0.1,0.1,0.1,0.1,0.1,
            0.1,0.1,0.1,0.1,0.1,0.1,0.1,0.1,0.1,0.1,
            0.1,0.1,0.1,0.1,0.1,0.1,0.1,0.1,0.1,0.1,
            0.1,0.1,0.1,0.1,0.1,0.1,0.1,0.1,0.1,0.1);
         LIST=3,
         NDEC=3, RESIDUAL, SMOOTH;
>SAVE RESIDUAL, SMOOTH;
>INPUT    FILE='CFA1.DAT' NIDCHAR=20;
(20A1,T1,60A1)
>STOP
```

Programming for CFA of Model 2

```
>TITLE
CONFIRMATORY FACTOR ANALYSIS ON EXHCOBA DATA
>PROBLEM NITEMS=70, RESPONSE=3;
>COMMENTS
EXHCOBA SUB-TEST 2-SERIES 1
CONFIRM ONE GENERAL FACTOR AND 4 ITEM
GROUP FACTORS AS AREAS:(1)SPAN,(2)MATH,(3)NATSC
(4)SOCS
DATA layout: COLUMNS 1 TO 70 ITEM RESPONSES

>NAMES    ITEM1,ITEM2,ITEM3,ITEM4,ITEM5,ITEM6,ITEM7,ITEM8,
        ITEM9,ITEM10,ITEM11,ITEM12,ITEM13,ITEM14,ITEM15,
        ITEM16,ITEM17,ITEM18,ITEM19,ITEM20,ITEM21,ITEM22,
        ITEM23,ITEM24,ITEM25,ITEM26,ITEM27,ITEM28,ITEM29,
        ITEM30,ITEM31,ITEM32,ITEM33,ITEM34,ITEM35,ITEM36,
        ITEM37,ITEM38,ITEM39,ITEM40,ITEM41,ITEM42,ITEM43,
        ITEM44,ITEM45,ITEM46,ITEM47,ITEM48,ITEM49,ITEM50,
        ITEM51,ITEM52,ITEM53,ITEM54,ITEM55,ITEM56,ITEM57,
        ITEM58,ITEM59,ITEM60,ITEM61,ITEM62,ITEM63,ITEM64,
        ITEM65,ITEM66,ITEM67,ITEM68,ITEM69,ITEM70;

>RESPONSE ' ','0', '1';
>KEY 111111111111111111111111111111111111111111111111
   1111111111111111111111;
>TETRACHORIC NDEC=3, LIST;
>BIFACTOR NIGROUPS=4, LIST=3, CYCLES=30
       IGROUPS=(1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,
         2,2,2,2,2,2,2,2,2,2,2,2,2,2,2,3,3,3,3,3,3,3,3,
         3,3,3,3,3,3,3,4,4,4,4,4,4,4,4,4,4,4,4,4,4,4,4,
         4,4,4,4),
         CPARMS=(0.1,0.1,0.1,0.1,0.1,0.1,0.1,0.1,0.1,0.1,
             0.1,0.1,0.1,0.1,0.1,0.1,0.1,0.1,0.1,0.1,
             0.1,0.1,0.1,0.1,0.1,0.1,0.1,0.1,0.1,0.1,
             0.1,0.1,0.1,0.1,0.1,0.1,0.1,0.1,0.1,0.1,
             0.1,0.1,0.1,0.1,0.1,0.1,0.1,0.1,0.1,0.1,
             0.1,0.1,0.1,0.1,0.1,0.1,0.1,0.1,0.1,0.1
             0.1,0.1,0.1,0.1,0.1,0.1,0.1,0.1,0.1,0.1);

         LIST=3,
         NDEC=3, RESIDUAL,SMOOTH;
>SAVE RESIDUAL;
>INPUT    FILE='CFA2.DAT' NIDCHAR=20;
(20A1,T1,70A1)
>STOP
```

Programming for CFA of Model 3

```
>TITLE
CONFIRMATORY FACTOR ANALYSIS ON EXHCOBA DATA

>PROBLEM NITEMS=60, RESPONSE=3;

>COMMENTS
EXHCOBA SUB-TEST 2-SERIES 1
CONFIRM ONE GENERAL FACTOR AND 3 ITEM
GROUP FACTORS AS AREAS:(1)MATH,(2)SOCS, (3)ECON
DATA layout: COLUMNS 1 TO 60 ITEM RESPONSES

>NAMES     ITEM1,ITEM2,ITEM3,ITEM4,ITEM5,ITEM6,ITEM7,ITEM8,
       ITEM9,ITEM10,ITEM11,ITEM12,ITEM13,ITEM14,ITEM15,
       ITEM16,ITEM17,ITEM18,ITEM19,ITEM20,ITEM21,ITEM22,
       ITEM23,ITEM24,ITEM25,ITEM26,ITEM27,ITEM28,ITEM29,
       ITEM30,ITEM31,ITEM32,ITEM33,ITEM34,ITEM35,ITEM36,
       ITEM37,ITEM38,ITEM39,ITEM40,ITEM41,ITEM42,ITEM43,
       ITEM44,ITEM45,ITEM46,ITEM47,ITEM48,ITEM49,ITEM50,
       ITEM51,ITEM52,ITEM53,ITEM54,ITEM55,ITEM56,ITEM57,
       ITEM58,ITEM59,ITEM60;


>RESPONSE ' ', '0', '1';
>KEY 111111111111111111111111111111111111111111111111
   111111111111;
>TETRACHORIC NDEC=3, LIST;
>BIFACTOR NIGROUPS=3, LIST=3, CYCLES=30
      IGROUPS=(1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,
        2,2,2,2,2,2,2,2,2,2,2,2,2,2,2,2,2,2,2,2,3,3,3,
        3,3,3,3,3,3,3,3,3,3,3,3,3,3,3,3,3),
      CPARMS=(0.1,0.1,0.1,0.1,0.1,0.1,0.1,0.1,0.1,0.1,
          0.1,0.1,0.1,0.1,0.1,0.1,0.1,0.1,0.1,0.1,
          0.1,0.1,0.1,0.1,0.1,0.1,0.1,0.1,0.1,0.1,
          0.1,0.1,0.1,0.1,0.1,0.1,0.1,0.1,0.1,0.1,
          0.1,0.1,0.1,0.1,0.1,0.1,0.1,0.1,0.1,0.1,
          0.1,0.1,0.1,0.1,0.1,0.1,0.1,0.1,0.1,0.1);
        LIST=3,
        NDEC=3,RESIDUAL;
>SAVE RESIDUAL;
>INPUT    FILE='SER1C.DAT' NIDCHAR=20;
(20A1,T1,60A1)
>STOP
```

APPENDIX III

The Rasch modeling findings for the subscales in the career area knowledge are presented in this subsection:

a) Science – Engineering Program:

Table 22

Item Calibrations for EXHCOBA Items 191-210 Math-Calculus

ITEM	LOGIT	ERROR	INFIT MSQ	INFIT ZSTD	OUTFIT MSQ	OUTFIT ZSTD	CORR	DISCR
1	0.09	0.1	1.28	**6.51**	1.42	6.07	0.26	0.3
2	-0.25	0.1	1	0.01	0.97	-0.52	0.47	1.02
3	-0.66	0.1	1.02	0.58	0.99	-0.14	0.44	0.96
4	0.19	0.1	1.06	1.53	1.04	0.58	0.43	0.88
5	-1.26	0.1	0.89	**-2.49**	0.8	**-2.25**	0.51	1.22
6	1.51	0.12	1.1	1.52	1.18	1.36	0.35	0.88
7	-0.03	0.1	0.95	-1.2	0.93	-1.22	0.5	1.12
8	-0.78	0.1	0.87	**-3.55**	0.82	**-2.63**	0.54	1.33
9	-0.95	0.1	0.91	**-2.33**	0.85	-1.96	0.51	1.22
10	-0.3	0.1	0.87	**-3.56**	0.81	**-3.29**	0.55	1.35
11	0.43	0.1	0.95	-1.27	0.95	-0.78	0.5	1.11
12	0.61	0.1	0.97	-0.67	1.02	0.21	0.48	1.04
13	-0.37	0.1	0.89	-3.17	0.82	-3.06	0.54	1.32
14	0.17	0.1	1.22	**5.01**	1.26	3.86	0.32	0.5
15	0.76	0.1	0.93	-1.42	0.9	-1.29	0.51	1.12
16	0.63	0.1	1.03	0.6	1.05	0.71	0.44	0.94
17	-1.37	0.1	0.97	-0.68	1.08	0.73	0.43	1.04
18	-0.18	0.1	1.04	0.98	1.13	**2.13**	0.43	0.87
19	1.52	0.12	1.16	**2.24**	1.35	**2.58**	0.3	0.8
20	0.23	0.1	0.89	**-2.87**	0.84	**-2.69**	0.55	1.27

Note: Tables in this appendix are interpreted as follows: for **INFIT MSQ** and **OUTFIT MSQ** model expectation values are between 1 and 1.3. For **INFIT ZSTD** and **OUTFIT ZSTD** model expectation values range between -2 to + 2. Values departing from these limits are highlighted in bold.

CORR indicates the biserial correlation between the each dichotomously scored item and the total score for the item. Higher **CORR** values are an indication of scale unidimensionality. **DISCR** is an indication of the item's discrimination power.

Figure 19

Map of Persons to Items from EXCHOBA Items: 191-210 Math-Statistics

```
INPUT: 563 PERSONS, 20 ITEMS  MEASURED: 563 PERSONS, 20 ITEMS, 2 CATS       3.37
--------------------------------------------------------------------------------

       PERSONS MAP OF ITEMS
               <more>|<rare>
    4             .  +
                     |
                     |
                     |
                     |
                     |
                 .#  |
    3                +
                     |
                     |
                     |
               .###  |
                     |
                    T|
    2          .###  +
                     |
                     |
               ####  |T V196   V209
                     |
               .###  |
                     |
    1        .##### S+
                     |
             ######  |S V205
                     |  V202   V206
           .#######  |  V201
            .######  |  V210
                     |  V191   V194   V204
    0       #######  +M V197
                    M|  V208
          .########  |  V192   V200
        .##########  |  V203
                     |
           .#######  |S V193   V198
                     |
   -1   ###########  +  V199
                     |
          .######## S|  V195
                     |  V207
          .########  |T
                     |
                     |
   -2        .#####  +
                     |
                     |
                 .#  |
                    T|
                     |
                     |
   -3                +
                  #  |
                     |
                     |
                     |
                     |
                     |
   -4            .#  +
               <less>|<frequ>
 EACH '#' IS 5.
```

Table 24

Item Calibrations for EXHCOBA Items 231-250 Chemistry

ITEM	LOGIT	ERROR	INFIT MSQ	INFIT ZSTD	OUTFIT MSQ	OUTFIT ZSTD	CORR	DISCR
1	1.02	0.12	1.04	0.57	1.15	1.36	0.19	0.94
2	0.93	0.12	0.95	-0.75	0.95	-0.55	0.3	1.06
3	0.07	0.1	1	-0.08	0.97	-0.57	0.32	1.03
4	-0.36	0.09	0.96	-1.26	0.95	-1.38	0.37	1.17
5	-0.45	0.09	0.93	**-2.49**	0.9	**-2.7**	0.41	1.33
6	-0.59	0.09	1.09	**3.18**	1.09	**2.36**	0.27	0.64
7	-0.77	0.09	1	-0.17	0.99	-0.37	0.36	1.06
8	0.76	0.11	1.02	0.34	1.17	1.82	0.23	0.96
9	-0.39	0.09	0.98	-0.76	0.96	-1.06	0.36	1.12
10	0.02	0.1	1.06	1.55	1.11	1.97	0.25	0.83
11	0.34	0.1	1.02	0.51	0.99	-0.12	0.28	0.97
12	0.75	0.11	0.97	-0.44	1.01	0.13	0.28	1.03
13	-0.8	0.09	0.96	-1.48	0.96	-1.21	0.4	1.2
14	-0.28	0.09	1.03	1.05	1.03	0.76	0.3	0.9
15	-0.57	0.09	1	-0.14	1.02	0.55	0.35	1.02
16	1.14	0.12	0.99	-0.07	0.98	-0.17	0.24	1.01
17	0.08	0.1	1.03	0.81	1	0.07	0.29	0.95
18	-0.45	0.09	0.97	-1.07	0.96	-0.98	0.37	1.15
19	0.17	0.1	0.99	-0.37	1	-0.02	0.32	1.04
20	-0.62	0.09	1	-0.08	1.01	0.23	0.35	1.03

Note: Tables in this appendix are interpreted as follows: for **INFIT MSQ** and **OUTFIT MSQ** model expectation values are between 1 and 1.3. For **INFIT ZSTD** and **OUTFIT ZSTD** model expectation values range between -2 to + 2. Values departing from these limits are highlighted in bold.

CORR indicates the biserial correlation between the each dichotomously scored item and the total score for the item. Higher **CORR** values are an indication of scale unidimensionality. **DISCR** is an indication of the item's discrimination power.

Figure 20

Map of Persons to Items from EXCHOBA Items: 231-250 Chemistry

```
INPUT: 563 PERSONS, 20 ITEMS  MEASURED: 563 PERSONS, 20 ITEMS, 2 CATS  3.37
----------------------------------------------------------------------

       PERSONS MAP OF ITEMS
               <more>|<rare>
    2
                     |
                     |
                     |
                  .  |
                     |
                     |
                  .  |T
                     |  V246
    1                +  V231
                  .  |  V232
                    T|  V238
                 .#  |  V242
                     |S
                     |
                ###  |
                     |  V241
               ####  |  V249
                     |  V233   V247
    0         .#### S+M V240
                     |
            .######  |
                     |  V244
                     |  V234   V235   V239
      .############  |  V248
                     |S V236   V245   V250
       .########### M|
                     |  V237   V243
         .#########  |
   -1                +
                     |
         .#########  |T
                     |
                     |
            .###### S|
                     |
                     |
                     |
             .#####  |
   -2                +
                     |
                    T|
                .##  |
                     |
                     |
                     |
                     |
                     |
                     |
   -3                +
                  .  |
                     |
                     |
                     |



   -4           .##  +
               <less>|<frequ>
 EACH '#' IS 7.
```

Table 25

Item Calibrations for EXHCOBA Items 251-270 Physics

ITEM	LOGIT	ERROR	INFIT MSQ	INFIT ZSTD	OUTFIT MSQ	OUTFIT ZSTD	CORR	DISCR
1	-0.73	0.09	1.01	0.27	0.99	-0.18	0.37	1
2	0.27	0.09	0.97	-0.89	0.96	-0.87	0.36	1.11
3	0.8	0.1	1.02	0.35	1.01	0.11	0.28	0.97
4	-0.68	0.09	1.02	0.52	1	0.04	0.36	0.97
5	0.63	0.1	1.06	1.38	1.08	1.2	0.25	0.87
6	0.62	0.1	1.02	0.53	0.98	-0.37	0.3	0.97
7	-0.04	0.09	1.11	**3.83**	1.13	**3.03**	0.24	0.53
8	0.02	0.09	1.1	**3.47**	1.19	**4.16**	0.23	0.54
9	0.25	0.09	0.9	**-3.08**	0.87	**-2.89**	0.43	1.35
10	-0.22	0.09	0.96	-1.59	0.97	-0.7	0.39	1.19
11	0.33	0.09	0.98	-0.45	0.97	-0.57	0.34	1.05
12	0.35	0.09	0.98	-0.71	0.94	-1.17	0.35	1.1
13	-0.31	0.09	0.98	-0.68	0.97	-0.65	0.38	1.11
14	0.85	0.1	0.98	-0.43	1.01	0.09	0.31	1.04
15	-0.69	0.09	0.91	**-3.15**	0.88	**-2.98**	0.46	1.36
16	-0.52	0.09	1	0.14	1.01	0.13	0.36	0.99
17	-0.75	0.09	1.07	**2.13**	1.16	**3.4**	0.3	0.75
18	-0.32	0.09	0.98	-0.73	1	-0.06	0.37	1.08
19	-0.34	0.09	0.86	-5.19	0.83	-4.71	0.49	1.63
20	0.47	0.1	1.09	2.33	1.13	2.21	0.23	0.75

Note: Tables in this appendix are interpreted as follows: for **INFIT MSQ** and **OUTFIT MSQ** model expectation values are between 1 and 1.3. For **INFIT ZSTD** and **OUTFIT ZSTD** model expectation values range between -2 to + 2. Values departing from these limits are highlighted in bold.

CORR indicates the biserial correlation between the each dichotomously scored item and the total score for the item. Higher **CORR** values are an indication of scale unidimensionality. **DISCR** is an indication of the item's discrimination power.

Figure 21

Map of Persons to Items from EXCHOBA Items: 251-270 Physics

```
INPUT: 563 PERSONS, 20 ITEMS  MEASURED: 563 PERSONS, 20 ITEMS, 2 CATS

       PERSONS MAP OF ITEMS
               <more>|<rare>
    3             .  +
                     |
                     |
                     |
                     |
                     |
                     |
    2                +
                     |
                     |
                     |
                 .#  |
                    T|
                 .#  |
    1                +T
                 .#  |  V253   V264
              .####  |
                    S|S V255   V256
           .#######  |  V270
                     |  V252   V259   V261   V262
             .#####  |
    0      ########  +M V257   V258
                     |
       .########### M|  V260   V263   V268   V269
       .###########  |
                     |S V266
           .#######  |  V251   V254   V265   V267
             ######  |
   -1                +T
              .#### S|
                     |
               .###  |
                     |
                     |
                ### T|
   -2                +
                     |
                  .  |
                     |
                     |
                     |
                     |
   -3             .  +
                     |
                     |
                     |
                     |
                     |
                     |
   -4            .#  +
               <less>|<frequ>
 EACH '#' IS 7.
```

b) Law and Humanities Program:

Table 26

Item Calibrations for EXHCOBA Items 151-170 Social Science

ITEM	LOGIT	ERROR	INFIT MSQ	INFIT ZSTD	OUTFIT MSQ	OUTFIT ZSTD	CORR	DISCR
1	-0.05	0.09	0.94	**-2.54**	0.93	**-2.46**	0.38	1.36
2	-0.19	0.09	1	-0.13	0.99	-0.3	0.31	1.03
3	-0.68	0.09	0.98	-0.57	0.98	-0.58	0.34	1.07
4	-1.45	0.11	0.97	-0.5	0.93	-0.89	0.37	1.05
5	-0.46	0.09	1.06	**2.02**	1.08	**2.24**	0.24	0.74
6	-0.71	0.09	1.01	0.33	1.02	0.48	0.3	0.96
7	0.23	0.09	1.01	0.52	1.01	0.39	0.28	0.93
8	1.03	0.1	1.03	0.73	1.05	0.76	0.21	0.93
9	0.49	0.09	1	-0.12	0.99	-0.32	0.29	1.02
10	1.55	0.11	1.06	0.87	1.15	1.61	0.14	0.92
11	-0.33	0.09	0.94	**-2.34**	0.93	**-2.2**	0.39	1.3
12	-0.74	0.09	1.03	0.9	1.06	1.2	0.28	0.9
13	-0.7	0.09	1.03	0.78	1.03	0.79	0.29	0.92
14	-0.24	0.09	1.01	0.39	1.02	0.5	0.3	0.95
15	0.32	0.09	0.92	**-2.94**	0.92	**-2.43**	0.38	1.37
16	0.46	0.09	1	-0.02	0.99	-0.13	0.29	1.01
17	1.09	0.1	1.03	0.75	1.06	0.98	0.2	0.92
18	-0.61	0.09	1.01	0.16	1.03	0.69	0.31	0.98
19	0.68	0.09	1	0.12	1	0	0.27	0.99
20	0.3	0.09	0.96	-1.71	0.95	-1.59	0.35	1.23

Note: Tables in this appendix are interpreted as follows: for **INFIT MSQ** and **OUTFIT MSQ** model expectation values are between 1 and 1.3. For **INFIT ZSTD** and **OUTFIT ZSTD** model expectation values range between -2 to + 2. Values departing from these limits are highlighted in bold.

CORR indicates the biserial correlation between the each dichotomously scored item and the total score for the item. Higher **CORR** values are an indication of scale unidimensionality. **DISCR** is an indication of the item's discrimination power.

Figure 22

Map of Persons to Items from EXCHOBA Items: 151-170 Social Sciences

```
INPUT: 582 PERSONS, 20 ITEMS  MEASURED: 582 PERSONS, 20 ITEMS, 2 CATS
----------------------------------------------------------------------

       PERSONS MAP OF ITEMS
               <more>|<rare>
    3                +
                     |
                     |
                     |
                     |
                  .  |
                     |
                     |
    2                +
                     |
                     |
                     |
                  .  |T V160
                    T|
                .##  |
                     |  V167
    1         .####  +  V158
                     |
             .#####  |S
                    S|  V169
            .######  |  V159   V166
                     |  V165
        .##########  |  V157   V170
                     |
    0     .######## M+M V151
                     |  V152
      .############  |  V164
                     |  V161
           ########  |  V155
                     |  V153   V168
              ##### S|S V156   V162   V163
                     |
   -1          ####  +
                     |
                 .#  |
                    T|
                 .#  |T V154
                     |
                     |
                  .  |
   -2                +
                     |
                     |
                  .  |
                     |
                     |
                     |
                     |
   -3                +
                  .  |
                     |
                     |
                     |
                     |
                     |
                     |
   -4             .  +
               <less>|<frequ>
 EACH '#' IS 8.
```

Table 27

Item Calibrations for EXHCOBA Items 271-290 Language

ITEM	LOGIT	ERROR	INFIT MSQ	INFIT ZSTD	OUTFIT MSQ	OUTFIT ZSTD	CORR	DISCR
1	-0.83	0.1	0.96	-0.75	0.96	-0.54	0.42	1.07
2	-0.1	0.09	0.99	-0.27	0.96	-0.83	0.39	1.05
3	-0.67	0.1	0.89	**-2.71**	0.82	**-2.86**	0.49	1.25
4	-0.03	0.09	0.97	-1.05	0.96	-0.84	0.4	1.12
5	0.92	0.09	0.95	-1.55	0.92	-1.4	0.39	1.16
6	0.05	0.09	1.01	0.29	1	-0.07	0.37	0.98
7	-0.47	0.09	0.94	-1.54	0.96	-0.69	0.43	1.14
8	-1.18	0.11	0.95	-0.93	0.92	-0.92	0.44	1.08
9	-0.07	0.09	1.07	**2.35**	1.07	1.4	0.32	0.76
10	-1.86	0.13	0.97	-0.33	0.91	-0.65	0.43	1.03
11	-0.1	0.09	1.08	2.5	1.14	2.85	0.3	0.7
12	-0.39	0.09	1.02	0.56	1.09	1.53	0.36	0.92
13	1.06	0.09	1	0.02	1.01	0.21	0.33	0.99
14	-0.17	0.09	0.98	-0.63	1.01	0.16	0.39	1.06
15	0.12	0.09	1.07	**2.47**	1.08	1.76	0.31	0.72
16	-0.04	0.09	0.96	-1.3	0.96	-0.88	0.41	1.14
17	1.6	0.1	1.07	1.35	1.18	2.03	0.22	0.86
18	-0.02	0.09	0.92	**-2.71**	0.98	-0.35	0.44	1.26
19	0.72	0.09	1.04	1.39	1.1	2.01	0.3	0.82
20	1.46	0.1	1.07	1.48	1.11	1.31	0.24	0.87

Note: Tables in this appendix are interpreted as follows: for **INFIT MSQ** and **OUTFIT MSQ** model expectation values are between 1 and 1.3. For **INFIT ZSTD** and **OUTFIT ZSTD** model expectation values range between -2 to + 2. Values departing from these limits are highlighted in bold.

CORR indicates the biserial correlation between the each dichotomously scored item and the total score for the item. Higher **CORR** values are an indication of scale unidimensionality. **DISCR** is an indication of the item's discrimination power.

Figure 23

Map of Persons to Items from EXCHOBA Items: 151-170 Language

```
INPUT: 582 PERSONS, 20 ITEMS  MEASURED: 582 PERSONS, 20 ITEMS, 2 CATS
--------------------------------------------------------------------

       PERSONS MAP OF ITEMS
               <more>|<rare>
    4                +
                     |
                     |
                     |
                     |
                  .  |
                     |
    3                +
                     |
                     |
                     |
                  .  |
                     |
                     |
    2           .## T+
                     |
                     |T
                ###  |  V287
                     |  V290
            .######  |
                    S|
    1     .########  +  V283
                     |S V275
          #########  |  V289
                     |
          .########  |
            ####### M|
                     |  V285
    0  .###########  +M V274   V276   V286   V288
                     |  V272   V279   V281   V284
            .######  |
            .######  |  V277   V282
                    S|
              #####  |  V273
                     |S V271
   -1           .##  +
                     |  V278
                 .#  |
                    T|
                  #  |
                     |T
                     |  V280
   -2             .  +
                     |
                     |
                  .  |
                     |
                     |
                     |
   -3                +
                     |
                  .  |
                     |
                     |
                     |
                     |
   -4            .#  +
               <less>|<frequ>
 EACH '#' IS 7.
```

Table 28

Item Calibrations for EXHCOBA Items 291-310 Humanities

ITEM	LOGIT	ERROR	IN.MSQ	INFIT ZSTD	OUTFIT MSQ	OUTFIT ZSTD	CORR	DISCR
1	-0.92	0.1	0.96	-0.84	0.95	-0.75	0.38	1.08
2	0.78	0.09	1.06	1.72	1.06	1.05	0.27	0.83
3	-0.67	0.09	0.96	-0.97	0.96	-0.77	0.38	1.09
4	0.3	0.09	1.09	**3.12**	1.11	**2.75**	0.25	0.61
5	0.3	0.09	1.01	0.49	1.01	0.36	0.33	0.94
6	-0.37	0.09	0.98	-0.7	0.97	-0.58	0.37	1.08
7	0.35	0.09	1.09	**3.11**	1.11	**2.6**	0.24	0.61
8	-1.37	0.11	1.02	0.26	0.98	-0.27	0.32	0.99
9	-0.01	0.09	1.01	0.39	1	0.04	0.34	0.97
10	0.65	0.09	0.91	**-2.96**	0.88	**-2.73**	0.44	1.32
11	0.69	0.09	1.02	0.54	1	0	0.32	0.96
12	0.49	0.09	1	-0.12	0.98	-0.48	0.35	1.03
13	-0.03	0.09	0.98	-0.55	1.01	0.22	0.36	1.06
14	0.6	0.09	0.98	-0.58	0.96	-0.78	0.36	1.07
15	-0.67	0.09	0.95	-1.38	0.93	-1.22	0.4	1.14
16	0.08	0.09	1.03	1.11	1.07	1.75	0.31	0.85
17	-1.27	0.1	0.97	-0.51	0.93	-0.91	0.36	1.05
18	-0.28	0.09	0.99	-0.33	0.98	-0.52	0.36	1.05
19	1.26	0.1	1.06	1.3	1.1	1.32	0.24	0.88
20	0.11	0.09	0.93	**-2.74**	0.93	-1.93	0.42	1.33

Note: Tables in this appendix are interpreted as follows: for **INFIT MSQ** and **OUTFIT MSQ** model expectation values are between 1 and 1.3. For **INFIT ZSTD** and **OUTFIT ZSTD** model expectation values range between -2 to + 2. Values departing from these limits are highlighted in bold.

CORR indicates the biserial correlation between the each dichotomously scored item and the total score for the item. Higher **CORR** values are an indication of scale unidimensionality. **DISCR** is an indication of the item's discrimination power.

Figure 24

Map of Persons to Items from EXCHOBA Items: 291-310 Humanities

```
INPUT: 582 PERSONS, 20 ITEMS  MEASURED: 582 PERSONS, 20 ITEMS, 2 CATS
----------------------------------------------------------------------

       PERSONS MAP OF ITEMS
               <more>|<rare>
    4             .  +
                     |
                     |
                     |
                     |
                     |
                  .  |
    3                +
                     |
                     |
                     |
                  .  |
                     |
                     |
    2                +
                  #  |
                    T|
               .###  |
                     |T
                     |  V309
              #####  |
    1       .######  +
                    S|
        ###########  |S V292   V300   V301
                     |  V304
          .#########  |  V302
        .##########  |  V294   V295   V297
                    M|  V306   V310
    0  .###########  +M V299   V303
        .##########  |
                     |  V308
           .########  |  V296
                     |
            .####### S|S V293   V305
                     |  V291
   -1         .####  +
               .###  |
                     |  V307
                     |T V298
                .## T|
                     |
                  .  |
   -2                +
                     |
                     |
                  .  |
                     |
                     |
                     |
   -3                +
                  .  |
                     |
                     |
                     |
                     |
                     |
   -4             .  +
               <less>|<frequ>
 EACH '#' IS 6.
```

c) Sociology and Psychology Programs:

Table 29

Item Calibrations for EXHCOBA Items 131-150 Math-Statistics

ITEM	LOGIT	ERROR	INFIT MSQ	INFIT ZSTD	OUTFIT MSQ	OUTFIT ZSTD	CORR	DISCR
1	-0.39	0.09	1	-0.01	0.97	-0.47	0.44	1.01
2	-0.5	0.09	0.97	-0.94	0.97	-0.5	0.47	1.08
3	0.82	0.11	0.91	-1.41	0.83	-1.55	0.45	1.11
4	0.16	0.1	1.09	2.01	1.1	1.22	0.35	0.84
5	-0.8	0.09	0.9	**-3.13**	0.84	**-3.13**	0.53	1.31
6	1.42	0.13	1.08	0.96	1.16	0.95	0.28	0.93
7	-0.57	0.09	0.93	-2.13	0.9	-1.84	0.5	1.2
8	-0.68	0.09	0.94	-1.95	0.9	-1.99	0.5	1.2
9	-0.46	0.09	0.99	-0.15	1.05	0.91	0.44	0.99
10	1.38	0.13	1	0.01	1.05	0.28	0.34	0.99
11	-0.63	0.09	1.06	1.82	1.17	**2.95**	0.39	0.8
12	0.12	0.1	0.87	**-3.04**	0.78	**-3.14**	0.53	1.26
13	1.21	0.12	1.09	1.16	1.12	0.78	0.29	0.91
14	-0.54	0.09	1.03	0.84	1.06	1.05	0.42	0.92
15	-0.85	0.09	0.86	**-4.32**	0.82	-3.6	0.55	1.4
16	0.51	0.1	0.97	-0.57	0.88	-1.34	0.44	1.06
17	-0.63	0.09	1.08	**2.37**	1.14	**2.48**	0.38	0.75
18	0.12	0.1	1.04	0.79	1.07	0.9	0.39	0.93
19	1.29	0.12	1.14	1.75	1.25	1.53	0.24	0.86
20	-0.98	0.09	1.1	**2.76**	1.11	**2.04**	0.38	0.74

Note: Tables in this appendix are interpreted as follows: for **INFIT MSQ** and **OUTFIT MSQ** model expectation values are between 1 and 1.3. For **INFIT ZSTD** and **OUTFIT ZSTD** model expectation values range between -2 to + 2. Values departing from these limits are highlighted in bold.

CORR indicates the biserial correlation between the each dichotomously scored item and the total score for the item. Higher **CORR** values are an indication of scale unidimensionality. **DISCR** is an indication of the item's discrimination power.

Figure 25

Map of Persons to Items from EXCHOBA Items: 131-150 Math-Statistics

```
INPUT: 626 PERSONS, 20 ITEMS  MEASURED: 626 PERSONS, 20 ITEMS, 2 CATS
----------------------------------------------------------------------

       PERSONS MAP OF ITEMS
               <more>|<rare>
    4             .  +
                     |
                     |
                     |
                     |
                  .  |
                     |
    3                +
                     |
                     |
                     |
                  .  |
                     |
                     |
    2             .  +
                     |
                     |
                  .  |T
                    T|  V136   V140
                 .#  |  V143   V149
                     |
    1          .###  +
                     |S V133
               .###  |
                     |  V146
                .##  |
                    S|
             .#####  |  V134   V142   V148
    0         #####  +M
                     |
           .#######  |
          .########  |  V131   V132   V139
                     |  V137   V141   V144   V147
          .########  |  V138
                    M|S V135   V145
   -1 .############  +  V150
                     |
        ###########  |
                     |
        .##########  |T
                     |
                     |
   -2      .####### S+
                     |
                     |
            .######  |
                     |
                     |
                     |
   -3                +
             ###### T|
                     |
                     |
                     |
                     |
                     |
   -4            .#  +
               <less>|<frequ>
 EACH '#' IS 6.
```

Table 30

Item Calibrations for EXHCOBA Items 151-170 Social Sciences

ITEM	LOGIT	ERROR	INFIT MSQ	INFIT ZSTD	OUTFIT MSQ	OUTFIT ZSTD	CORR	DISCR
1	-0.29	0.08	0.94	**-2.41**	0.93	**-2.2**	0.38	1.31
2	-0.17	0.08	0.98	-0.78	0.98	-0.51	0.33	1.1
3	-0.57	0.09	1.01	0.23	1.01	0.16	0.31	0.98
4	-1.64	0.1	0.98	-0.4	0.92	-0.97	0.37	1.05
5	-0.55	0.09	1.02	0.7	1.04	1.17	0.29	0.91
6	-0.84	0.09	1.01	0.29	1.01	0.3	0.31	0.98
7	0.32	0.09	1.04	1.33	1.04	1.17	0.25	0.85
8	0.74	0.09	1.04	1.01	1.04	0.75	0.24	0.92
9	0.43	0.09	1.05	1.74	1.06	1.56	0.23	0.81
10	1.64	0.11	1	0.06	1.01	0.08	0.22	0.99
11	-0.28	0.08	0.95	**-2.19**	0.94	**-2.17**	0.38	1.29
12	-0.44	0.09	1.02	0.71	1.02	0.52	0.3	0.93
13	-0.59	0.09	0.98	-0.62	0.97	-0.91	0.34	1.09
14	-0.2	0.08	1.03	1.41	1.06	**2.09**	0.27	0.79
15	0.62	0.09	0.96	-1.31	0.94	-1.31	0.33	1.13
16	0.38	0.09	0.92	**-2.87**	0.9	**-2.81**	0.39	1.32
17	1.06	0.1	1.09	1.83	1.14	**2.08**	0.15	0.83
18	-0.68	0.09	1.03	1.02	1.04	0.93	0.29	0.9
19	0.73	0.09	1	-0.1	0.99	-0.15	0.28	1.01
20	0.3	0.09	0.96	-1.3	0.95	-1.44	0.34	1.16

Note: Tables in this appendix are interpreted as follows: for **INFIT MSQ** and **OUTFIT MSQ** model expectation values are between 1 and 1.3. For **INFIT ZSTD** and **OUTFIT ZSTD** model expectation values range between -2 to + 2. Values departing from these limits are highlighted in bold.

CORR indicates the biserial correlation between the each dichotomously scored item and the total score for the item. Higher **CORR** values are an indication of scale unidimensionality. **DISCR** is an indication of the item's discrimination power.

Figure 26

Map of Persons to Items from EXCHOBA Items: 151-170 Social Sciences

```
INPUT: 626 PERSONS, 20 ITEMS  MEASURED: 626 PERSONS, 20 ITEMS, 2 CATS
-----------------------------------------------------------------------

       PERSONS MAP OF ITEMS
               <more>|<rare>
    2                +
                  .  |
                     |
                     |
                     |  V160
                     |
                  .  |T
                     |
                     |
                .## T|
                     |
                     |  V167
    1                +
               .###  |
                     |
                     |S V158   V169
             .#####  |
                    S|  V165
                     |
          .########  |  V159   V166
                     |  V157   V170
        .##########  |
                     |
                     |
    0 .############  +M
                     |
                    M|  V152   V164
      #############  |  V151   V161
                     |
        .##########  |  V162
                     |
                     |  V153   V155   V163
           ########  |  V168
                     |S
                    S|  V156
            .######  |
   -1                +
                     |
                     |
              .####  |
                     |
                     |
                 .# T|T
                     |
                     |  V154
                     |
                     |
                  .  |
   -2                +
                     |
                     |
                     |
                     |
                  .  |
                     |
                     |

   -3            .#  +
               <less>|<frequ>
 EACH '#' IS 7.
```

Table 31

Item Calibrations for EXHCOBA Items 271-290 Language

ITEM	LOGIT	ERROR	INFIT MSQ	INFIT ZSTD	OUTFIT MS	OUTFIT ZSTD	CORR	DISCR
1	-0.89	0.1	0.98	-0.42	0.95	-0.76	0.46	1.05
2	-0.08	0.09	1.03	0.85	1.02	0.46	0.38	0.93
3	-0.68	0.1	0.97	-0.71	0.93	-1.19	0.46	1.09
4	-0.01	0.09	0.98	-0.71	0.96	-0.83	0.41	1.1
5	0.66	0.09	0.96	-1.32	0.94	-1.23	0.38	1.15
6	0.21	0.09	0.98	-0.63	0.98	-0.38	0.39	1.08
7	-0.42	0.09	0.95	-1.32	0.92	-1.59	0.45	1.14
8	-1.3	0.11	0.98	-0.38	0.88	-1.33	0.49	1.06
9	0.12	0.09	1.11	**3.85**	1.13	**3.02**	0.3	0.57
10	-1.66	0.12	0.95	-0.58	0.9	-0.89	0.52	1.06
11	-0.03	0.09	1.09	**2.98**	1.13	**2.8**	0.32	0.67
12	-0.63	0.09	1.03	0.77	1.07	1.15	0.4	0.93
13	0.96	0.09	1	0.09	1.09	1.68	0.33	0.98
14	-0.42	0.09	0.95	-1.49	0.9	-2.01	0.46	1.17
15	0.28	0.09	1.05	1.73	1.08	1.99	0.33	0.79
16	-0.04	0.09	0.93	**-2.52**	0.9	**-2.49**	0.45	1.28
17	1.55	0.1	1.01	0.2	1	-0.03	0.28	0.99
18	0.17	0.09	0.93	**-2.74**	0.89	**-2.76**	0.44	1.33
19	0.82	0.09	0.99	-0.44	0.98	-0.32	0.35	1.06
20	1.39	0.1	1.13	**2.82**	1.23	**2.91**	0.2	0.73

Note: Tables in this appendix are interpreted as follows: for **INFIT MSQ** and **OUTFIT MSQ** model expectation values are between 1 and 1.3. For **INFIT ZSTD** and **OUTFIT ZSTD** model expectation values range between -2 to + 2. Values departing from these limits are highlighted in bold.

CORR indicates the biserial correlation between the each dichotomously scored item and the total score for the item. Higher **CORR** values are an indication of scale unidimensionality. **DISCR** is an indication of the item's discrimination power.

Figure 27

Map of Persons to Items from EXCHOBA Items: 271-290 Language

```
INPUT: 626 PERSONS, 20 ITEMS  MEASURED: 626 PERSONS, 20 ITEMS, 2 CATS
-----------------------------------------------------------------------

       PERSONS MAP OF ITEMS
               <more>|<rare>
    4                +
                     |
                     |
                     |
                     |
                  .  |
                     |
    3                +
                     |
                     |
                     |
                 .#  |
                     |
                     |
    2           .## T+
                     |
                     |
              .####  |T V287
                     |  V290
           .#######  |
                    S|
    1   .##########  +  V283
                     |S V289
       .###########  |  V275
                     |
      .############  |
        .########## M|  V276   V285
                     |  V279   V288
    0   .##########  +M V274   V281   V286
                     |  V272
         .#########  |
          .########  |  V277   V284
                    S|  V282
               .###  |  V273
                     |S V271
   -1           ###  +
                     |
                .##  |  V278
                    T|
                  .  |T
                     |  V280
                     |
   -2             .  +
                     |
                     |
                  .  |
                     |
                     |
                     |
   -3                +
                     |
                  .  |
                     |
                     |
                     |
                     |
   -4          .###  +
               <less>|<frequ>
 EACH '#' IS 6
```

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