هيئة تقويم التعليم والتدريب
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اعتماد
NCAAA

Key Learning Outcomes for Statistics Programs

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Introduction

Based on the mandate of the Education and Training Evaluation Commission (ETEC), by virtue of Council of Ministers decision No. 108, dated 14/2/1440 AH, which included the Commission competencies amongst which is "building systems for evaluation and accreditation - including institutional and programmatic - in education and training, encompassing rules, standards, frameworks and indicators and related terms, procedures, approval, and application" and with the same concern to build and develop high-quality national academic programs, the ETEC worked on preparing specialized academic standards for Statistics Programs. This document aims to contribute to the establishment of minimum requirements for Bachelor's programs in Statistics specialization to achieve the academic quality of programs and to ensure that graduates are highly qualified in the field of Statistics, possessing the knowledge, skills, and values required by the labor market, and national trends, in line with the best practices required for the academic and professional of the field.

Goals

The purpose of this work is to develop the minimum of knowledge units (KUs) in the field of Statistics, specifying a set of Specialized Learning Outcomes (SLOs) students are expected to acquire after completing their studies. This document lays the foundations for the design of the academic program and the study plans. It facilitates selecting the appropriate teaching methods and the proper evaluation strategies and tools, which should contribute toward aligning the academic programs with the labor market.

Methodology

This document describes minimum General and Specific Knowledge Units (GKUs & SKUs) in the Statistics field. The Learning Outcomes (LOs) of each Knowledge Unit (KU) set the threshold for what the students are expected to learn and be able to do after successfully completing that Knowledge Unit. Educational institutions should take into account the depth and breadth of these Knowledge Units so that learning outcomes integrate communication skills and values into the curriculum. Institutions can also offer additional knowledge units that are consistent with their objectives. It should also be noted that the knowledge unit is not necessarily an independent course; one or more courses can cover a single knowledge unit. Likewise, one course could also cover one or more knowledge units entirely or partially.

The methodology follows the following phases:

I- Survey and benchmarking:

- Benchmarking with International learned society and professional body.
- Benchmarks with top-rated international and local Universities.
- Identification of national labor market requirements.
- Incorporating specialists and experts' input from different sectoral groups.

II - Preparation of the contents of the Specialized Standards document:

- Identifying Program Key Learning Outcomes (KLOs).
- Defining the general characteristics of the curriculum.
- Development of General Knowledge Units (GKUs) and Specific Knowledge Units (SKUs) for each GKU.
- Formulation of Specialized Learning Outcomes (SLOs) for each Specific Knowledge Unit (SKU).
- Determine the minimum topics required for each Specific Knowledge Unit (SKU).
- Describe the methodology for aligning academic content with the National Qualification Framework (NQF).

The Knowledge Units (KUs) are derived from analyzing several high-ranked QS Universities and international regularity bodies/associations (see Appendix A).

The ETEC developed this document in cooperation and coordination with different entities in the field of statistics and with the involvement of various stakeholders from government bodies, the private sector, and academia.

Scope and Uses

This document covers the Bachelor's degree programs in Statistics. The document can be applied to Statistics programs offered by public and private higher education institutions in Saudi Arabia.

Terms

Education and Training Evaluation Commission (ETEC): competent and independent body aimed at evaluating, assessing, and accrediting qualifications in education and training in both public and private sectors, raising the quality and efficiency of those qualifications and ensuring they contribute to the national economy and development.

National Qualifications Framework (NQF): A comprehensive and uniform structure for building, organizing, and categorizing qualifications into levels based on learning outcomes.

Learning Outcomes (LOs): Description of what a learner is expected to know, understand, and be able to do, which is represented in their behavior at the end of a specific educational program.

Key Learning Outcomes (KLOs): The minimum required Learning Outcomes (LOs) in the discipline students are expected to obtain.

Knowledge Units (KUs): mandatory multiple related topics that must be included in an institution's degree program.

Essential Knowledge Units (EKUs): knowledge units necessary for future learning in a given discipline.

General Knowledge Units (GKUs): Knowledge Units that should be introduced to students majoring in a discipline.

Specific Knowledge Units (SKUs): Knowledge Units derived from a General Knowledge Unit (GKU).

Specialized Learning Outcomes (SLOs): Learning Outcomes (LOs) for a Specific Knowledge Unit (SKUs).

Key Learning Outcomes

Key Learning Outcomes (KLOs) describe the essential knowledge, skills, and values that graduates of the Statistics undergraduate program will be able to demonstrate once they complete the program.

On successful completion of a bachelor's degree in Statistics, graduates should be able to:

KLO1: identify problems from a statistical perspective.

KLO2: choose an appropriate data collection and analysis method.

KLO3: formulate problems using mathematical and statistical tools.

KLO4: demonstrate proficiency in statistical software.

KLO5: describe, analyze, interpret data and make proper inferences.

KLO6: solve problems in the context of probability and mathematical statistics.

KLO7: communicate effectively with a wide range of audiences.

KLO8: work autonomously and/or as a member of a multidisciplinary team.

KLO9: conform to professional and ethical norms in making statistical judgements.

Curriculum General Criteria

Based on the benchmarking study of leading universities (Appendix A) and analyzing all Knowledge Units (KUs) and skills using statistics programs, it is found that these KUs are grouped into the following categories:

1. Essential knowledge units: 20 credit hours
2. General knowledge and skills units: 60 credit hours

Each group consists of different subgroups, which are essential in typical statistics. To show the importance of each of the subgroups, a range of allocated credit hours in typical statistics is shown in the next section.

Knowledge Units

The following table provides an overall view of the curriculum distribution of Knowledge Units: essential, general, specialized and others. The tables also provide general recommendations on each knowledge unit's acceptable range of credit hours.

Essential Knowledge Units (EKU)

They are calculated based on a minimum of [120] credits. This part of the knowledge units should not be used in standardized tests.

Table 1: Essential Knowledge Unit of Statistics

#	EKU	Description	Minimum Requirements
1	Mathematics	Fundamental mathematical concepts, including, but not limited to, functions and models, limits and derivatives, differentiation rules, and integration rules, with applications	14
2	English	Academic writing, reading, speaking, and listening.	6

Program Core Knowledge Units

Percentages are calculated based on a minimum of credits for the statistics program.

Table 2: Generalized and Specialized Knowledge Units of statistics

#	GKU	Weight	SKU	Weight
1	Mathematics	5%	1.1. Linear Algebra	5
2	Mathematical Statistics	30%	2.1. Probability	10
			2.2. Statistical Inference	20
3	Applied Statistics	38%	3.1 Descriptive Statistics	10
			3.2 Regression Analysis	10
			3.3 Sampling	8
			3.4 Project/Field Training	10
4	Computer Science and Statistical Software	27%	4.1. Statistical Software	15
			4.2 Programming, Simulation and Modeling	12

Appendix (A): International Practices Analysis

The KUs are derived from the ten universities listed below, as well as guidance from:

1. American Statistical Association Curriculum Guidelines

Table A1: International and local universities considered in analyzing statistics program requirements

#	University	Department name	QS University Ranking 2023
1	Columbia University	Statistics	10
2	National University of Singapore (NUS)	Department of Statistics & Data Science	14
3	University of Toronto	Statistical Sciences	17
4	Cornell University	Statistics and Data Science	18
5	Duke University	Statistical Science	25
6	University College London	Statistical Science	34
7	McGill	Mathematics and Statistics	51-100
8	North Carolina State	Statistics	51-100
9	Pennsylvania State	Statistics	51-100
10	Texas A & M	Statistics	51-100

Required Subjects/Topics in Top International and Local Universities

The knowledge units and the associated topics were derived from experience with guidance from the ASA curriculum guidelines cited above.

Table A2: Statistics program required Subjects/Topics in elite International and local Universities.

GKUs	SKUs	1	2	3	4	5	6	7	8	9	10	Count	
												Total	Note
Mathematics	Linear Algebra	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	10	A
Mathematical Statistics	Probability	✓	✓	✓	✓	✓	✓	✓		✓		8	A
	Statistical Inference + methods	✓		✓	✓	✓	✓	✓	✓	✓	✓	9	A
Applied Statistics	Descriptive Statistics	✓	✓	✓	✓	✓		✓	✓	✓	✓	9	A
	Regression Analysis	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	10	A
	Design of Experiments								✓	✓	✓	3	C
	Multivariate Analysis											0	C
	Discrete Data Analysis					✓	✓					2	C
	Time Series Analysis		✓							✓		2	C
	Sampling	✓		✓		✓			✓	✓	✓	6	B
	Project/Field Training	✓	✓			✓	✓			✓	✓	6	B
Computer Science and Statistical Software	Statistical Software	✓	✓			✓	✓			✓	✓	6	B
	Database Management											0	C
	Programming, Simulation and Modeling	✓	✓	✓	✓		✓		✓	✓	✓	8	A

- Any specialized knowledge unit taught by 65 % or more of the universities should be considered an important SKU and recommended and Labeled "A."
- If the comparison showed that a particular SKU scored below 65% and was believed to be important, they should be further screened by applying another acceptance condition as defined in the FE exam by QIYAS and SCE. The SKUs that satisfy this condition are recommended and labeled by "B."
- SKUs not meeting the above conditions should not be recommended, labeled by "C," and eliminated from Specialized Learning Outcomes.
- The comparisons should be made based on the course descriptions. If no syllabus is available, a consensus should be made.

Justification for keeping Sampling, Project/Field Training and Statistical Software as required SKUs.

- Sampling was mentioned in several benchmark university programs as a part of an introductory statistics program. Moreover, quite a few of them have a sampling course among a group of electives. We strongly believe that an entire unit of sampling is appropriate.
- Project/Field Training, we believe, was not mentioned explicitly in many of the benchmark universities because most, if not all, of them, have a university-mandated internship program.
- Statistical Software appears in almost all applied courses where it is stated that analysis would be carried out using software. In many of them, several different statistical software and packages are mentioned.

Appendix (B): Alignment of Key Learning Outcomes of Statistics with NQF.

Alignment of the Key Learning Outcomes for Statistics with the NQF.

Statistics Key Learning Outcomes	NQF Learning Areas		
	Knowledge and understanding	Skills	Values, Autonomy, and Responsibility
1	✓		
2	✓		
3	✓		
4		✓	
5		✓	
6		✓	
7		✓	
8		✓	
9			✓

Appendix (C): Learning Outcomes and Topics for Knowledge Units

Essential Knowledge Unit (EKU): Mathematics

Description	Fundamental mathematical concepts include, but are not limited to, functions and models, limits and derivatives, differentiation rules, and integration rules with applications.
Topics	**The following topics must be included in this SKU:** 1. Limits 2. Methods of differentiation 3. Methods of integration 4. Applications of derivatives and integrals to real-world problems 5. Multiple integrals 6. Sequences and Series
Specialized Learning Outcome	**By completing this EKU, students should be able to:** 1. Compute derivatives of functions 2. Compute a definite integral. 3. Manipulate and evaluate multiple integrals. 4. Find the limits of sequences and series. **The table below maps the Specialized Learning Outcomes for the SKU to the KLOs**

SLOs	KLOs								
	KLO1	KLO2	KLO3	KLO4	KLO5	KLO6	KLO7	KLO8	KLO9
1						✓			
2						✓			
3						✓			
4						✓			
5						✓			

Essential Knowledge Unit (EKU2): English

Description	Fundamental reading and writing concepts and skills.
Topics	**The following topics must be included in this SKU:** 1. Reading comprehension and grammar 2. Writing effectively 3. Citing Sources 4. Communicating effectively
Specialized Learning Outcome	**By completing this EKU, students should be able to:** 1. Comprehend written text. 2. Write efficiently. 3. Communicate verbally and in written form. **The table below maps the Specialized Learning Outcomes for the SKU to the KLOs**

SLOs	KLOs								
	KLO1	KLO2	KLO3	KLO4	KLO5	KLO6	KLO7	KLO8	KLO9
1	✓								
2			✓						
3							✓		

General Knowledge Unit (GKU 1): Mathematics

Description	Fundamental concepts of linear algebra with applications

Specialized Knowledge Unit (SKU1.1): Linear Algebra

Description	This SKU covers matrices and their operations, types of matrices, elementary row operations, determinants and their elementary properties, the inverse of a matrix., linear systems of equations, vector spaces, linear independence, finite-dimensional spaces, subspaces, inner product spaces, linear transformations, kernel and image of a linear transformation, eigenvalues and eigenvectors of a matrix, diagonalization of a matrix and relative subjects.
Topics	**The following topics must be included in this SKU:** 1. Matrices, determinants and systems of linear equations. 2. Vector spaces, Inner product spaces and linear transformations. 3. Eigenvalues, eigenvectors and diagonalization
Specialized Learning Outcome	**By completing this SKU, students should be able to:** 1. Perform operations on a matrix, the determinant, and solve the system of linear equations using matrix form. 2. Demonstrate understanding of the concept of vector space. 3. Describe methods of diagonalization of a matrix. **The table below maps the Specialized Learning Outcomes for the SKU to the KLOs**

SLOs	KLOs								
	KLO1	KLO2	KLO3	KLO4	KLO5	KLO6	KLO7	KLO8	KLO9
1						✓			
2			✓						
3						✓			

General Knowledge Unit (GKU 2): Mathematical Statistics

Description	This GKU lays the mathematical foundation for applied statistics using knowledge from probability and specific mathematical techniques.

Specialized Knowledge Unit (SKU2.1): Probability

Description	This SKU covers an introduction to probability theory. It helps to understand the basic concepts of probability, basic principles, permutations and combinations, rules associated with probability, and probability distributions.
Topics	**The following topics must be included in this SKU:** 1. Set functions including set notation and basic elements of probability, events and Independence of events, Combinatorial probability, Conditional probability, Bayes Theorem, Random variables and distributions, Mode, median, percentiles and moments, Variance and measures of dispersion (including coefficient of variation), Moment generating functions and Transformations 2. Joint probability functions and joint probability density functions. Joint cumulative distribution functions. Conditional and marginal probability distributions and their moments. 3. Variance and measures of dispersion for conditional and marginal probability distributions; Covariance and correlation coefficients; Transformations and order statistics, Central Limit theorem
Specialized Learning Outcome	**By completing this SKU, students should be able to:** 1. Compute conditional probabilities directly and use Bayes' theorem to check for event independence. 2. Perform probability calculations relating to probability distributions for discrete and continuous random variables. 3. Compute Mathematical Expectation and Variance. 4. Demonstrate understanding of fundamental concepts in probability and their applications to solve real-life problems. **The table below maps the Specialized Learning Outcomes for the SKU to the KLOs**

SLOs	KLOs								
	KLO1	KLO2	KLO3	KLO4	KLO5	KLO6	KLO7	KLO8	KLO9
1						✓			
2						✓			
3						✓			
4			✓						

Specialized Knowledge Unit (SKU2.2): Statistical Inference

Description	This SKU provides the conceptual and mathematical basis for statistical methods. It provides a solid foundation in statistical theory, which should prove important in solving practical problems.
Topics	**The following topics must be included in this SKU:** 1. Demonstrate understanding of basic theoretical knowledge about fundamental principles for statistical inference 2. Discrete and continuous random variables and their distributions 3. Sampling Distributions related to the normal distribution 4. Methods of Point and Interval Estimation. Properties of estimators and sufficient statistics. 5. Hypothesis testing; Neyman-Person Lemma, Most Powerful Tests and Generalized Likelihood Ratio Test. 6. Introduction to Bayesian statistics.
Specialized Learning Outcome	**By completing this SKU, students should be able to:** 1. Explain random variables and their distributions. 2. Construct unbiased estimators, method of moment estimators, and maximum likelihood estimators. 3. Construct interval estimators. 4. Perform statistical tests of hypotheses. 5. Explain and apply Bayes' estimation principles. **The table below maps the Specialized Learning Outcomes for the SKU to the KLOs**

SLOs	KLOs								
	KLO1	KLO2	KLO3	KLO4	KLO5	KLO6	KLO7	KLO8	KLO9
1			✓						
2					✓				
3					✓				✓
4						✓	✓		✓
5	✓								

General Knowledge Unit (GKU3): Applied Statistics

Description	Applied Statistics is a collection of methods applied to data used to understand, describe, analyze and help find solutions to real-world problems.

Specialized Knowledge Unit (SKU3.1): Descriptive Statistics

Description	Descriptive statistics is a set of methods used to summarize and describe the main features of a data set, such as its central tendency, variability, and distribution. These methods provide an overview of the data and help identify patterns and relationships.
Topics	**The following topics must be included in this SKU:** 1. Types of data 2. Graphical representation of data 3. Numerical methods to describe data: measures of central tendency, measures of variability, coefficient of variation, skewness 4. Use of software to perform descriptive statistics
Specialized Learning Outcome	**By completing this SKU, students should be able to:** 1. Distinguish between types of data. 2. Use appropriate software to visualize data. 3. Choose appropriate numerical methods to summarize data. 4. Compute numerical descriptive statistics. 5. Describe a set of data. **The table below maps the Specialized Learning Outcomes for the SKU to the KLOs**

SLOs	KLOs								
	KLO1	KLO2	KLO3	KLO4	KLO5	KLO6	KLO7	KLO8	KLO9
1	✓								
2				✓					
3		✓							
4						✓			
5							✓		

Specialized Knowledge Unit (SKU3.2): Regression Analysis

Description	Regression Analysis is a set of methods used to model and study the relationship between one dependent variable and several independent or explanatory variables.
Topics	**The following topics must be included in this SKU:** 1. Simple and Multiple Linear Regression, including Estimation and Testing of parameters. 2. Model Adequacy Checking 3. Transformations 4. Indicator Variables 5. Variable Selection and Model Building 6. Use of appropriate software.
Specialized Learning Outcome	**By completing this SKU, students should be able to:** 1. Explain the meaning of regression parameters. 2. Estimate regression parameters using least squares. 3. Apply diagnostic procedures to check model adequacy. 4. Understand the concept of indicator variables. 5. Build appropriate models. 6. Use appropriate statistical software. 7. Communicate results. **The table below maps the Specialized Learning Outcomes for the SKU to the KLOs**

SLOs	KLOs								
	KLO1	KLO2	KLO3	KLO4	KLO5	KLO6	KLO7	KLO8	KLO9
1			✓						
2					✓				
3					✓				
4			✓						
5					✓				✓
6				✓					
7							✓	✓	✓

Specialized Knowledge Unit (SKU3.3): Sampling

Description	Sampling is the selection of a subset from a population of interest. It is the process of studying the population by gathering and analyzing information.
Topics	**The following topics must be included in this SKU:** 1. Data collection 2. Questionnaire design 3. Sampling designs including simple random sampling, systematic, stratified and cluster sampling
Specialized Learning Outcome	**By completing this SKU, students should be able to:** 1. Identify the population of interest. 2. Choose the appropriate sampling scheme. 3. Apply the proper sampling scheme. 4. Contribute to questionnaire design. **The table below maps the Specialized Learning Outcomes for the SKU to the KLOs**

SLOs	KLOs								
	KLO1	KLO2	KLO3	KLO4	KLO5	KLO6	KLO7	KLO8	KLO9
1	✓								
2		✓							
3					✓				
4							✓	✓	✓

Specialized Knowledge Unit (SKU3.4): Project/Field Training

Description	A project is an extended essay in the form of a report that presents a statistical question or statement for analysis and evaluation, and the outcomes of this report are presented in a seminar. Field training is a collaboration program between the academic body that offers the program and organizations of public and private sectors in which students receive training.
Topics	**The following topics must be included in this SKU:** 1. Problem-solving, time management, and collaboration skills. 2. Scientific writing of a comprehensive statistical report/dissertation. 3. Presentation skills. 4. Professional and ethical norms in statistics.
Specialized Learning Outcome	**By completing this SKU, students should be able to:** 1. Formulate statistical problems using cumulative statistical knowledge. 2. Describe, analyze, interpret data and make proper inferences. 3. Communicate effectively with a wide range of audiences. 4. Work autonomously and/or as a member of a group. 5. Adhere to professional and ethical norms in statistics. **The table below maps the Specialized Learning Outcomes for the SKU to the KLOs**

SLOs	KLOs								
	KLO1	KLO2	KLO3	KLO4	KLO5	KLO6	KLO7	KLO8	KLO9
1			✓						
2					✓				
3							✓		
4								✓	
5									✓

General Knowledge Unit (GKU4): Computer Science and Statistical Software

Description	Statistical software is a collection of specialized computer programs for statistical computing and analysis. On the other hand, computer science is a vast field of study which deals with programming, computation, information, and automation. Statistics and computer science intersect typically in programming and subject matter related to data and information.

Specialized Knowledge Unit (SKU4.1): Statistical Software

Description	This SKU covers the required knowledge and skills to use statistical software professionally.
Topics	**The following topics must be included in this SKU:** 1. Introduction to Microsoft Excel. 2. Introduction to other statistical software. 3. Introduction to business intelligence software and data-based dashboards. 4. Introduction to the level of measurements and factors. 5. Introduction to data cleaning, manipulation and transformation. 6. Data organization, visualization and description. 7. Inferential data analysis.
Specialized Learning Outcome	**By completing this SKU, students should be able to:** 1. Demonstrate proficiency in at least one statistical software. 2. Describe, analyze, interpret data and apply statistical inferential methods to data. 3. Calculate probability and critical values from important probability distributions (e.g., normal distribution, binomial distribution, etc.). **The table below maps the Specialized Learning Outcomes for the SKU to the KLOs**

SLOs	KLOs								
	KLO1	KLO2	KLO3	KLO4	KLO5	KLO6	KLO7	KLO8	KLO9
1				✓					
2					✓				
3						✓			

Specialized Knowledge Unit (SKU4.2): Programming, Simulation and Modeling

Description	Programming is the process of building executable computer programs to perform particular computations. On the other hand, simulation and modeling are the use of statistical models as a basis for simulations to generate data utilized for inferential evaluation, theoretical verification, or decision-making.
Topics	**The following topics must be included in this SKU:** 1. Introduction to programming. 2. Simulating data from various probability distributions. 3. Introduction to Monte Carlo simulation techniques. 4. Verifying statistical theories (e.g., the central limit theorem, assumptions of a regression model, etc.) via data analysis generated from simulations. 5. Introduction to the effects of violating model assumptions on statistical aspects (e.g., estimation efficiency, power of statistical test, etc.).
Specialized Learning Outcome	**By completing this SKU, students should be able to:** 1. Demonstrate proficiency in statistical software specialized in statistical computing and programming. 2. Describe, analyze, interpret simulated data and make proper inferences about statistical aspects (e.g., estimation efficiency, power of statistical test, etc.) 3. Solve problems in the context of probability and distribution theory via Monte Carlo simulation techniques. 4. Identify problems of violating statistical assumptions from a statistical perspective. **The table below maps the Specialized Learning Outcomes for the SKU to the KLOs**

SLOs	KLOs								
	KLO1	KLO2	KLO3	KLO4	KLO5	KLO6	KLO7	KLO8	KLO9
1				✓					
2					✓				
3						✓			
4	✓								