Teaching Guide

Identifying Data				2020/21
Subject (*)	Design and Analysis of Experiments		**Code**	614493010
Study programme	Mestrado Universitario en Técnicas Estadísticas (Plan 2019)			
Descriptors				
Cycle	**Period**	**Year**	**Type**	**Credits**
Official Master's Degree	2nd four-month period	First	Optional	5
Language	Spanish			
Teaching method	Face-to-face			
Prerequisites				
Department	Matemáticas			
Coordinador		**E-mail**		
Lecturers		**E-mail**		
Web	http://dm.udc.es/staff/jose_vilar/			
General description	This subject provides an introduction to the basic principles of the experimental planning process and a broad range of statistical models to deal with data coming from planned designs. Particular emphases is put on: (i) evaluating the pros and cons of various design strategies, and (ii) discussing the applicability of the statistical procedures according to the pursued objectives and the structural assumptions behind data. Statistical software is also used to complement the practical and theoretical learning.			
Contingency plan	1. Modifications to the contents 2. Methodologies *Teaching methodologies that are maintained *Teaching methodologies that are modified 3. Mechanisms for personalized attention to students 4. Modifications in the evaluation *Evaluation observations: 5. Modifications to the bibliography or webgraphy			

Study programme competences / results	
Code	**Study programme competences / results**
A2	Capacidade para comprender, formular, formular e resolver aqueles problemas susceptibles de ser abordados a través de modelos da estatística e da investigación operativa.
A4	Coñecer algoritmos de resolución dos problemas e manexar o software axeitado.
A6	Realizar inferencias respecto aos parámetros que aparecen no modelo.
A9	Obter os coñecementos precisos para unha análise crítica e rigorosa dos resultados.
A10	Complementar a aprendizaxe dos aspectos metodolóxicos con apoio de software.
B6	Capacidade para iniciar a investigación e para participar en proxectos de investigación que poden culminar na elaboración dunha tese doutoral.
B10	Capacidade de identificar e resolver problemas
B11	Capacidade de integrarse nun equipo multidisciplinar para a análise experimental
B12	Adquirir destreza para o desenvolvemento de software
B13	Capacidade de análise estatística crítica das mostras, as formulacións e resultados
C1	Ser capaz de identificar un problema da vida real.

C2	Dominar a terminoloxía científica-metodolóxica para comprender e interactuar con outros profesionais.
C3	Habilidade para traballar os aspectos metodolóxicos da investigación en colaboración con outros colegas a través do Campus Virtual co foro.
C4	Habilidade para realizar a análise estatística con ordenador.
C5	Escoller o deseño máis axeitado para responder á pregunta de investigación.
C6	Utilizar as técnicas estatísticas máis axeitadas para analizar os datos dunha investigación.
C7	Planificar, analizar e interpretar os resultados dunha investigación considerando tanto os aspectos teóricos coma os metodolóxicos.
C8	Habilidade de xestión administrativa do proceso dunha investigación.
C9	Comunicación e difusión dos resultados das investigacións.
C10	Lectura con xuízo crítico de artigos científicos dende unha perspectiva metodolóxica.

Learning outcomes		
Learning outcomes	**Study programme competences / results**	
To be able of planning experiments following a set of suitable stages, identifying all sources of variation, specifying the experimental procedure and the anticipated difficulties, and formulating proper mathematical models.	AC2 AC9	BJ6 BJ10 BJ11	CJ1 CJ2 CJ3 CJ5 CJ7 CJ8
To use statistical software fluently.	AC4 AC10	BJ12	CJ4
To acquire capability to take part from a multidisciplinary team by working on experimental analysis.		BJ11	CJ8 CJ9
To be able of performing a critical review of the attained results.	AC9	BJ10 BJ13	CJ10
To obtain knowledge on the basic principles of the design of experiments.	AC4 AC6	BJ6 BJ10 BJ11	CJ1 CJ2 CJ5 CJ6
To manage a broad range of suitable design structures to be able of describing properly the performance of data coming from experimental planning processes.	AC2 AC6 AC10	BJ11 BJ13	CJ1 CJ5 CJ6 CJ7
To know a range of statistical techniques to analyze data coming from the experimental planning processes. Specifically, knowlegede on how performing inference on model parameters.	AC4 AC6 AC10	BJ13	CJ5 CJ6
To know specific procedures to perform a critical and rigorous analysis of the results.	AC2 AC9	BJ13	CJ2 CJ10
To complete the learning process with the support of statistical software.	AC4 AC10	BJ12	CJ4

Contents	
Topic	**Sub-topic**
1. Basic principles of experimental design.	1.1. Introduction: Advantages of planning an experiment. Variability sources.
	1.2. Basic principles in experimental design.
	1.3. Step by step guide to the experimental planing process. A real example.
	1.4. Some standard experimental designs.

2. Designs with one source of variation.	2.1. Introduction.
	2.2. Randomization. Model for a completely randomized design: Estimation of parameters, one-way analysis of variance, inference on contrasts and means.
	2.3. Methods of multiple comparisons.
	2.4. Checking the adequacy of the model.
	2.5. Alternative approaches.
3. Designs with several sources of variation.	3.1. Introduction.
	3.2. Randomization. The meaning of interaction. Complete model. Main effects model.
	3.3. Estimation, analysis of variance, inference on contrasts.
	3.4. Sample sizes.
	3.5. Checking the adequacy of the model.
4. Analysis of covariance.	4.1. Introduction.
	4.2. Mathematical models.
	4.3. Estimation, analysis of variance, inference on contrasts.
	4.3. Checking the adequacy of the model.
5. Random effects models and mixed models.	5.1. Random effects: variance components. Examples.
	5.2. Mathematical models for random effects models: Estimation and analysis of variance.
	5.3. Sample sizes.
	5.4. Checking the adequacy of the model.
	5.5. Mixed models: los mixtos: Estimation and analysis of variance.
6. Block designs.	6.1. Basic concepts.
	6.2. Complete block designs: Models, estimatin, analysis of variance, inference on contrasts.
	6.3. Incomplete block designs: Balanced incomplete block designs; group divisible designs; cyclic designs. Models, estimation, analysis of variance, inference on contrasts.
	6.4. Row-column design: Latin square designs, Youden designs, cyclic and other row-column designs. Models, estimation, analysis of variance, inference on contrasts.
	6.5. Alternative approaches.
7. Nested designs.	7.1. Introduction.
	7.2. Nested designs in two stages..
	7.3. Nested designs in m stages.
	7.4. Models including both nested and crossing sources of variation.
8. Split-plot dsigns.	8.1 Introduction: Motivation and examples.
	8.2. Mathematical modrls.
	8.3. Estimation and analysis of variance with complete blocks.
9. Designs with repeated measures.	9.1. Introduction: Experimental setup.
	9.2. Dependence structures for repeated measures.
	9.3. Mauchly's test of sphericity.
	9.4. Univariate and multivariate analysis.
10. Factorial designs at two levels.	10.1. Two levels designs with two factors.
	10.2. Two levels designs with three factors.
	10.3. Two levels designs for k factors.
	10.4. Adding centerpoints in a general design at two levels.
	10.5. Algorithm of Yates.

Planning

Methodologies / tests	Competencies / Results	Teaching hours (in-person & virtual)	Student?s personal work hours	Total hours
Guest lecture / keynote speech	A2 A4 A6 A9 B6 B10 B11 B13 C1 C2 C3 C5 C6 C7 C9 C10	20	30	50
Problem solving	A2 A6 A9 A10 B10 B11 B12 B13 C2 C4 C5 C6 C7 C9 C10	16	24	40
Case study	A2 A6 A9 A10 B6 B10 B11 B12 B13 C1 C2 C3 C4 C5 C6 C7 C8 C9 C10	0	25	25
Objective test	A10 B10 B13 C1 C2 C4 C5 C6 C9	3	0	3
Personalized attention		7	0	7

(*)The information in the planning table is for guidance only and does not take into account the heterogeneity of the students.

Methodologies	
Methodologies	Description
Guest lecture / keynote speech	Lectures addressed to present the main theoretical and methodological concepts. Additional learning resources will be employed, such as slides showing real study cases and the use of statistical software (mainly R packages).
Problem solving	Lectures addressed to solve exercises and practical cases, where students will have an active role and will be gradually introduced in the manage of statistical software. Besides references, lists of exercises and questionnaires will be also provided.
Case study	Students should develop one or two practical works related to the subject contents.
Objective test	Final exam on the theoretical and practical contents of the subject. This exam consists in answering a list of short questions and/or solving some longer exercises in a reasoned way.

Personalized attention	
Methodologies	Description
Problem solving Case study	a) Tutorial sessions where students can receive personalized support to clarify doubts and solve exercises. b) Tutorial sessions during the development of the practical works. In these sessions, students can receive personalized support to solve doubts, correct mistakes and overcome possible difficulties in the application of theoretical concepts to the study case. Personalize advice may be also received via online, by means of e-mail, virtual platform,... Part-time students are not required to defend their works in class, but these works must be provided to the teachers for their assessment. Part-time students can also receive personalized assistance using both face-to-face and virtual approaches.

Assessment			
Methodologies	Competencies / Results	Description	Qualification
Case study	A2 A6 A9 A10 B6 B10 B11 B12 B13 C1 C2 C3 C4 C5 C6 C7 C8 C9 C10	Assessment of practical cases.	30

Objective test	A10 B10 B13 C1 C2 C4 C5 C6 C9	Exam for assessment of knowledge consisting of two parts: (i) Test of knowledge about key concepts for planning and analyzing an experiment (nearly one hour), and (ii) Solving one or two practical exercises with help of the statistical software (nearly two hours).	70
Others			

Assessment comments
To attain a satisfactory final assessment is required to pass the two aforementioned evaluations (study case and objective test). These requirements hold for both opportunities (May and July). Whether the practical works are not completed in May, they must be provided in July. This also applies to the part-time students.

Sources of information	
Basic	- Dean, A. y Voss, D. (1999). Design and Analysis of Experiments. Springer Texts in Statistics, Springer-Verlag, New York - Montgomery, D.C. (2009). Design and Analysis of Experiments. 7a Ed.. J. Wiley and Sons. - Kuehl, R.O. (2001). Diseño de Experimentos. Principios estadísticos para el diseño y análisis de investigaciones. 2a Ed.. Thomson Learning.
Complementary	- Berger, P.D. y Maurier, R.E. (2002). Experimental Design With Applications in Management, Engineering, and the Sciences. Belmont, CA: Duxbury Press - Box, G.E.P., Hunter, W.G. y Hunter, J.S. (2005). Statistics for Experimenters: Design, Innovation, and Discovery. 2a. Ed. Wiley, New York. - Coob, G.W. (1998). Introduction to Design and Analysis of Experiments. Springer-Verlag - Cox, D. y Reid, N. (2000). The Theory of the Design of Experiments. Monographs on Statistics and Applied Probability. Chapman &amp; Hall CRC Press - Gibbons, J.D. y Chakraborti, S. (1992). Nonparametric Statistical Inference, 3a. Ed.. Marcel Dekker, New York - Prat, A., Tort-Martorell, X., Groma, P. y Pozueta, L. (1997). Métodos estadísticos. Control y mejora de la calidad. Edicions UPC (Universitat Politécnica de Catalunya) Vikneswaran (2005) An R companion to "Experimental Design"URL http://CRAN.R-project.org/doc/contrib/Vik-neswaran-ED-companion.pdf.Vikneswaran (2005) An R companion to "Experimental Design"URL http://CRAN.R-project.org/doc/contrib/Vik-neswaran-ED-companion.pdf.

Recommendations
Subjects that it is recommended to have taken before
Subjects that are recommended to be taken simultaneously
Modelos de Regresión/614427105
Control Estatístico da Calidade/614427121
Subjects that continue the syllabus
Other comments
To obtain a satisfactory assessment of this subject is highly recommended regular attendance and active participation at lectures. It is also important to complete exercises and practical applications proposed in the development of the classes, in particular when lectures cannot be regularly attended. Previous knowledge of the basic principles of statistical inference and of the R package eases the learning of the subject. Also, solving questionnaires and list of exercises and taking advantage of the personalized tutorial sessions will be particularly helpful.