Course guide
240055 - 240055 - Statistical Techniques for Quality

Last modified: 16/05/2023

Unit in charge: Barcelona School of Industrial Engineering
Teaching unit: 715 - EIO - Department of Statistics and Operations Research.

Degree: BACHELOR'S DEGREE IN INDUSTRIAL TECHNOLOGY ENGINEERING (Syllabus 2010). (Compulsory subject).

Academic year: 2023 **ECTS Credits:** 3.0 **Languages:** Catalan

LECTURER

Coordinating lecturer: Lluís Marco Almagro

Others: Jesus Corral López
Martí Font Valverde
Sara Fontdecaba Rigat
Jan Graffelman
Pere Grima Cintas
Lluís Marco Almagro
Xavier Puig Oriol
Lourdes Rodero de Lamo
Josep Anton Sánchez Espigares
Xavier Tort-Martorell Llabrés

PRIOR SKILLS

One must know the contents of the course "Statistics", specifically:
- Have a clear idea of variability
- Know probability distributions (such as normal, t-student, ...)
- Be able to perform a comparison of treatments (t-test)
- Know how to fit linear regression models.
- Know the software package MINITAB

DEGREE COMPETENCES TO WHICH THE SUBJECT CONTRIBUTES

Specific:
CEM6. Knowledge applied to quality control.
CETI6. Knowledge applied to manufacturing systems and processes, metrology and quality control.

Transversal:
07 AAT. SELF-DIRECTED LEARNING. Detecting gaps in one's knowledge and overcoming them through critical self-appraisal. Choosing the best path for broadening one's knowledge.
04 COE. EFFICIENT ORAL AND WRITTEN COMMUNICATION. Communicating verbally and in writing about learning outcomes, thought-building and decision-making. Taking part in debates about issues related to the own field of specialization.
05 TEQ. TEAMWORK. Being able to work as a team player, either as a member or as a leader. Contributing to projects pragmatically and responsibly, by reaching commitments in accordance to the resources that are available.

TEACHING METHODOLOGY

The sessions of the course are based on:

- Lectures and participatory classes
- Problem-based learning
- Cooperative learning

This course requires an autonomous learning of the student before class (preparation of the session) and after class.

LEARNING OBJECTIVES OF THE SUBJECT

The purpose is that the student knows the most relevant statistical tools to improve industrial and service processes, framed within the improvement quality methodology Six Sigma.

Specifically, at the end of the course students will be able to:

- Address an improvement project following the steps of the Six Sigma methodology.
- Select designs to analyze the behavior of a product or process in both the mean and variance transmitted by uncontrollable factors.
- Analyze the effect of control factors and noise factors on the response of interest and select the most robust conditions.
- Conduct capacity studies to characterize the variability of a process and compare it with specifications.
- Use control charts for continuous and discrete variables to know when to act on a process to keep the variability in its minimum level.
- Validate measurement systems using R&R studies.
- Understand the main concepts in reception control.
- Perform nonparametric and parametric reliability analysis.

STUDY LOAD

Type	Hours	Percentage
Hours medium group	30,0	40.00
Self study	45,0	60.00

Total learning time: 75 h

CONTENTS

Statistics and Quality. Basic Tools. Six Sigma Process Improvement Methodology

Description:
Relationship between statistics and quality. Brief history of quality control and management. Decisions driven by data: statistical thinking. Basic tools for quality improvement: data sheets, histograms, Pareto diagrams, cause-and-effect diagrams, scatterplots, stratification. Key ideas in the Six Sigma methodology. Six Sigma Organization. Phases of the Six Sigma methodology: define, measure, analize, improve, control. Case studies.

Specific objectives:
At the end of the course the students will be able to:

- Describe the importance of statistics in quality.
- Apply basic (mainly graphical) tools for quality improvement.
- Describe how the Six Sigma improvement methodology works.
- Develop an improvement project following the phases of the Six Sigma methodology.

Related activities:
Reflective exercises on the importance of data-driven decisions.
Application of basic tools using MINITAB.
Solving practical cases following the Six Sigma methodology.

Related competencies :
CEM6. Knowledge applied to quality control.
04 COE. EFFICIENT ORAL AND WRITTEN COMMUNICATION. Communicating verbally and in writing about learning outcomes, thought-building and decision-making. Taking part in debates about issues related to the own field of specialization.
07 AAT. SELF-DIRECTED LEARNING. Detecting gaps in one's knowledge and overcoming them through critical self-appraisal. Choosing the best path for broadening one's knowledge.
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Full-or-part-time: 12h
Practical classes: 6h
Guided activities: 2h
Self study : 4h

Experimental Design and Robust Desing

Description:
The reasons behind the advancement of knowledge. Statistics as a tool of the scientific method. Relationship between statistics and quality. 2-level factorial designs. Blocking. Fractional factorial designs. Effect confounding. Relationship with linear regression models. Robust designs: control and noise factors. Design matrix, calculation and interpretation of the effects. Metrics and methods of analysis: product and augmented matrix.

Specific objectives:
At the end of the course the students will be able to:
- Select designs to analyze the behavior of a product or process mean and variance transmitted by uncontrollable factors.
- Analyze the effect of control and noise factors in the response of interest and select the most robust conditions.
- Explore the region of interest of the experimental variables that maximize (minimize) the response and study the nature of the surface.
- Design and implement real experiments following a sequential strategy, from the experimental plan approach to drawing final conclusions.
- Work in teams to agree on decisions and solve problems together.

Related activities:
- Problems, cases and exercises with and without MINITAB
- Application of experimental design to a real case in teams. Design, implementation and analysis of the experiment. Drawing conclusions, presentation of the report
- Independent learning reading cases and extensions of the techniques suggested in the literature

Related competencies :
CEM6. Knowledge applied to quality control.
04 COE. EFFICIENT ORAL AND WRITTEN COMMUNICATION. Communicating verbally and in writing about learning outcomes, thought-building and decision-making. Taking part in debates about issues related to the own field of specialization.
07 AAT. SELF-DIRECTED LEARNING. Detecting gaps in one's knowledge and overcoming them through critical self-appraisal. Choosing the best path for broadening one's knowledge.
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Full-or-part-time: 12h
Practical classes: 6h
Guided activities: 2h
Self study : 4h

Capability studies. Statistical Process Control

Description:
Concept of capability. Cp and Cpk index. Interpretation of capability indices. Difference between short and long term. Conditions for SPC to be useful. Stages in the implementation of SPC: data collection, reference model and measurement alarms. Risk of false alarm and detection power. Rational subgroup. ARL concept. Xbar-R charts. I-MR Charts. P, NP, C and U Charts. Pros and cons of these graphs. Selection of appropriate control charts given the variable to be monitored.

Specific objectives:
At the end of the course the students will be able to:
- Understand and explain why the variability is the enemy of quality.
- Use graphical techniques to detect the most important sources of variability of a system.
- Perform capability studies to characterize the variability of a process and compare it to the specifications.
- Use control charts for continuous and discrete variables to know when to act on a process to keep the variability in its minimum level.

Related activities:
- Resolution of cases with MINITAB
- Implement statistical process control in a real process, given the nature of the process and its associated costs

Related competencies :
CEM6. Knowledge applied to quality control.
CETI6. Knowledge applied to manufacturing systems and processes, metrology and quality control.
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Full-or-part-time: 9h
Practical classes: 4h
Guided activities: 2h
Self study : 3h

R&R studies, reception inspection, reliability

Description:
Concept of error in measuring. R&R studies for variables and attributes. Reception inspection. Buyer and seller risks, interpretation and calculation of the characteristic curve. Existing standards. Extension to other situations of sampling, interpretation of the data sheet of a survey. Reliability: tests for reliability, censored data, exponential and Weibull distributions

Specific objectives:
After completing the course the students will be able to:
- Validate measurement systems.
- Design an incoming inspection plan based on the desired quality level and buyer and seller risks
- Understand the utility and also the complexity of reliability studies
- Perform simple reliability studies

Related activities:
Validation of a measurement system
Design of an incoming reception plan
Using MINITAB for reliability studies

Related competencies :
CEM6. Knowledge applied to quality control.
CETI6. Knowledge applied to manufacturing systems and processes, metrology and quality control.
07 AAT. SELF-DIRECTED LEARNING. Detecting gaps in one's knowledge and overcoming them through critical self-appraisal. Choosing the best path for broadening one's knowledge.
05 TEQ. TEAMWORK. Being able to work as a team player, either as a member or as a leader. Contributing to projects pragmatically and responsibly, by reaching commitments in accordance to the resources that are available.

Full-or-part-time: 12h
Practical classes: 6h
Guided activities: 2h
Self study : 4h

ACTIVITIES

PRACTICAL CASES, PROBLEMS AND EXERCISES

Description:
Students will solve (individually or in groups) cases, problems and exercises about the course contents

Specific objectives:
Consolidate the self-studied concepts and those introduced in the classes and develop the ability to apply this knowledge to gradually more complex real situations

Material:
Students will have the MINITAB software package, statements of cases and exercises; and after its resolution, in many cases, a standard solution

Related competencies :
CEM6. Knowledge applied to quality control.
CETI6. Knowledge applied to manufacturing systems and processes, metrology and quality control.

Full-or-part-time: 2h 30m
Self study: 2h 30m

FOLLOW-UP

Description:
Answer to questions about the material covered in the subject

Specific objectives:
Motivate the study of the subject
Check the understanding of the main concepts.

Material:
Explanations and online questionnaires

Delivery:
Response to questionnaires with immediate feedback

Related competencies :
CEM6. Knowledge applied to quality control.
CETI6. Knowledge applied to manufacturing systems and processes, metrology and quality control.
07 AAT. SELF-DIRECTED LEARNING. Detecting gaps in one's knowledge and overcoming them through critical self-appraisal. Choosing the best path for broadening one's knowledge.

Full-or-part-time: 2h 30m
Self study: 2h 30m

TEAM WORK

Description:
Students will plan, implement and analyze an experiment. Teachers will support the student with the project. The project will be done in groups.

Specific objectives:
To apply statistical tools to a real case. Measure real data.

Material:
This work is a practical application of a big part of the course material and therefore the material is that used during the course as well as the additional references.

Delivery:
A written report and a video explaining all the work steps and the conclusions

Related competencies :
CEM6. Knowledge applied to quality control.
CETI6. Knowledge applied to manufacturing systems and processes, metrology and quality control.
05 TEQ. TEAMWORK. Being able to work as a team player, either as a member or as a leader. Contributing to projects pragmatically and responsibly, by reaching commitments in accordance to the resources that are available.

Full-or-part-time: 12h
Guided activities: 12h

PAPER

Description:
Study of a paper related with the topics covered in the subject

Specific objectives:
Deepen some aspect of statistical techniques for quality control and improvement,
Confront a scientific paper (in English)

Material:
The article, which is provided through the intranet, and all course materials.

Delivery:
The form of presentation of the results of the paper study will be announced on the intranet, and will depend on the availability of sessions each semester. The final exam may include questions about the papers.

Related competencies :
CETI6. Knowledge applied to manufacturing systems and processes, metrology and quality control.
CEM6. Knowledge applied to quality control.
07 AAT. SELF-DIRECTED LEARNING. Detecting gaps in one's knowledge and overcoming them through critical self-appraisal. Choosing the best path for broadening one's knowledge.
05 TEQ. TEAMWORK. Being able to work as a team player, either as a member or as a leader. Contributing to projects pragmatically and responsibly, by reaching commitments in accordance to the resources that are available.
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Full-or-part-time: 4h
Guided activities: 4h

PARTIAL EXAM

Description:
Exam that will cover all the contents up to this point.

Specific objectives:
Evaluate the knowledge acquired up to this point

Delivery:
The exam itself.

Related competencies :
CETI6. Knowledge applied to manufacturing systems and processes, metrology and quality control.
CEM6. Knowledge applied to quality control.
07 AAT. SELF-DIRECTED LEARNING. Detecting gaps in one's knowledge and overcoming them through critical self-appraisal. Choosing the best path for broadening one's knowledge.
04 COE. EFFICIENT ORAL AND WRITTEN COMMUNICATION. Communicating verbally and in writing about learning outcomes, thought-building and decision-making. Taking part in debates about issues related to the own field of specialization.

Full-or-part-time: 4h
Theory classes: 2h
Self study: 2h

FINAL EXAM

Description:
Exam that will cover all the contents in the course.

Specific objectives:
Evaluate the knowledge acquired during the course

Delivery:
The exam itself.

Related competencies :
CEM6. Knowledge applied to quality control.
CETI6. Knowledge applied to manufacturing systems and processes, metrology and quality control.
07 AAT. SELF-DIRECTED LEARNING. Detecting gaps in one's knowledge and overcoming them through critical self-appraisal. Choosing the best path for broadening one's knowledge.
04 COE. EFFICIENT ORAL AND WRITTEN COMMUNICATION. Communicating verbally and in writing about learning outcomes, thought-building and decision-making. Taking part in debates about issues related to the own field of specialization.

Full-or-part-time: 5h
Theory classes: 2h
Self study: 3h

GRADING SYSTEM

The course grade will be calculated from the following formula:
Mark = 0,50 ContinuousEvaluation + 0,50 SynthesisTests

For those students with the right to perform the re-evaluation exam, the course grade will be calculated from the following formula:
Mark = 0,25 ContinuousEvaluation + 0,75 Re-evaluationExam

EXAMINATION RULES.

The current regulations at UPC and ETSEIB

BIBLIOGRAPHY

Basic:
- Prat Bartés, A. [et al.]. Métodos estadísticos : control y mejora de la calidad [on line]. 2a ed. Barcelona: Edicions UPC, 2004 [Consultation: 09/09/2022]. Available on: https://upcommons.upc.edu/handle/2099.3/36342. ISBN 8483017865.
- Box, George E. P. Statistics for experimenters : design, innovation, and discovery. 2nd. Hoboken: John Wiley & Sons, 2005. ISBN 0471718130.
- Montgomery, Douglas C. Statistical quality control : a modern introduction. 7th. Hoboken: Wiley, 2013. ISBN 9781118322574.
- Kenett, Ron; Shelemyahu Zacks; Daniele Amberti. Modern Industrial Statistics: with applications in R, MINITAB and JMP [on line]. 2nd ed. Sussex: Wiley, 2014 [Consultation: 08/09/2020]. Available on: https://onlinelibrary.wiley.com/doi/book/10.1002/9781118763667. ISBN 9781118456064.
- Grima, Pere ; Marco, Lluís ; Tort-Martorell, Xavier. Estadística con Minitab : aplicaciones para el control y la mejora de la calidad. Madrid: Garceta, 2011. ISBN 9788492812394.

Complementary:
- Montgomery, Douglas C; George C. Runger. Probabilidad y Estadística aplicadas a la Ingeniería. 2a. México: Limusa, 2002. ISBN 9789681859152.
- Hahn, Gerald J; Necip Doganaksoy. The Role of Statistics in Business and Industry [on line]. Hoboken, N.J: Wiley, 2008 [Consultation: 07/10/2020]. Available on: https://ebookcentral.proquest.com/lib/upcatalunya-ebooks/detail.action?docID=819142. ISBN 9780471218746.
- Hoerl, Roger W.; Ronald D. Snee. Statistical thinking: improving business performance. 3rd ed. New York: Wiley, 2020. ISBN

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