Postgraduate Certificate
Quantum Computing

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Postgraduate Certificate
Quantum Computing

- Modality: **online**
- Duration: **12 weeks**
- Certificate: **TECH Technological University**
- Dedication: **16h/week**
- Schedule: **at your own pace**
- Exams: **online**

Website: **www.techtitute.com/in/engineering/postgraduate-certificate/quantum-computing**

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01

Introduction

Quantum Computing is set to be the tool that will help solve some of society's biggest challenges in healthcare, automotive, security, etc. As engineers, knowledge and specializing in this disruptive technology is a winning bet. This program analyzes the speed of processing and its ability to solve complex problems in the face of the challenges facing the world of computing today. This 100% online program addresses in which situations a quantum advantage could be achieved, in the context of advanced analytics and artificial intelligence. All this, in an understandable way to introduce the engineers who take it in what is undoubtedly the future of computing in the coming years.

Quantum Computing has arrived to revolutionize the communication sector. Specialize in this constantly evolving industry and achieve success"

Knowledge and specialization in quantum computing is a winning bet. It is today and will undoubtedly be even more so in the future. Quantum theory can be applied to various sciences and factors, such as Artificial Intelligence, cryptography, cybersecurity, machine learning, *Blockchain*, error correction, IoT, biotechnology, medicine, among other areas.

A key area of interest and where quantum computing is proving to be most efficient is in the field of *Machine Learning*. This Postgraduate Certificate shows its application in real proactive, predictive and prescriptive problems. Students who acquire knowledge now, in quantum technologies, will be the leaders in programming in the near-term future.

In the course of 6 weeks, the graduates will deepen their understanding of the field of application of Quantum Computing, understanding the industrial benefits it brings, so they will be positioned at the technological forefront and will be able to lead ambitious projects in the present and in the future. In addition, they will have the best study methodology 100% online, which eliminates the need to attend classes in person or to have a predetermined schedule.

This **Postgraduate Certificate in Computer Quantum** contains the most complete and up-to-date program on the market. The most important features include:

- Case studies presented by experts in Computing Quantum
- The graphic, schematic, and practical contents with which they are created, provide practical information on the disciplines that are essential for professional practice
- Practical exercises where self-assessment can be used to improve learning
- Its special emphasis on innovative methodologies
- Theoretical lessons, questions to the expert, debate forums on controversial topics, and individual reflection assignments
- Content that is accessible from any fixed or portable device with an Internet connection

Completion of this Postgraduate Certificate will place Engineering and Industry 4.0 professionals at the forefront of the latest developments in the sector"

You are facing an emerging market where, due to its complexity and immaturity, obtaining the right knowledge and advice will give you a competitive advantage in the labor market"

Knowledge and specialization in Quantum Computing at TECH is a winning bet.

You will observe the latest advances in Quantum Computing and you will be able to put them into practice.

The program includes, in its teaching staff, professionals from the sector who bring to this program the experience of their work, in addition to recognized specialists from prestigious reference societies and universities.

The multimedia content, developed with the latest educational technology, will provide the professional with situated and contextual learning, i.e., a simulated environment that will provide immersive education programmed to learn in real situations.

This program is designed around Problem-Based Learning, whereby the professional must try to solve the different professional practice situations that arise during the academic course. For this purpose, students will be assisted by an innovative interactive video system created by renowned and experienced experts.

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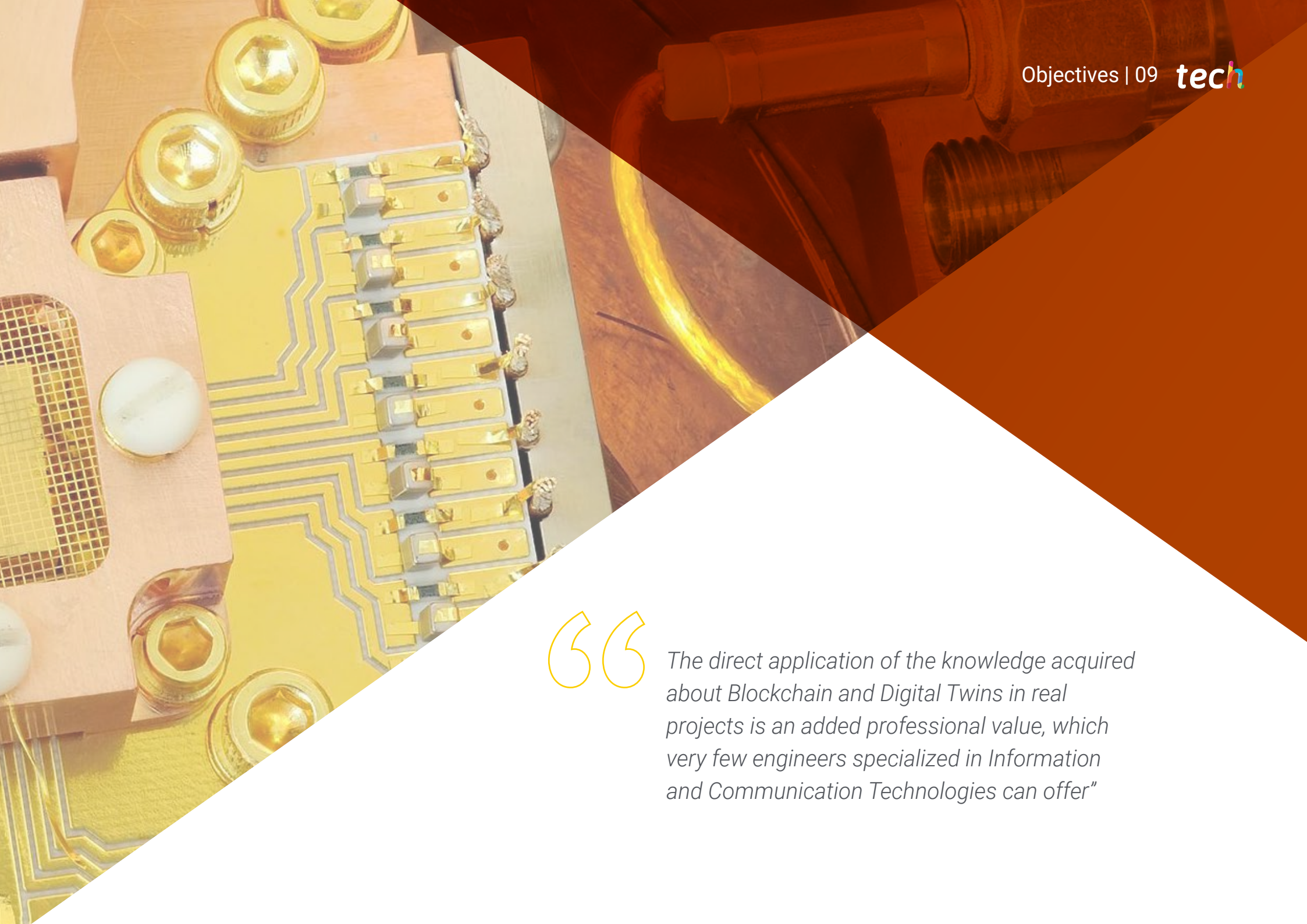
Objectives

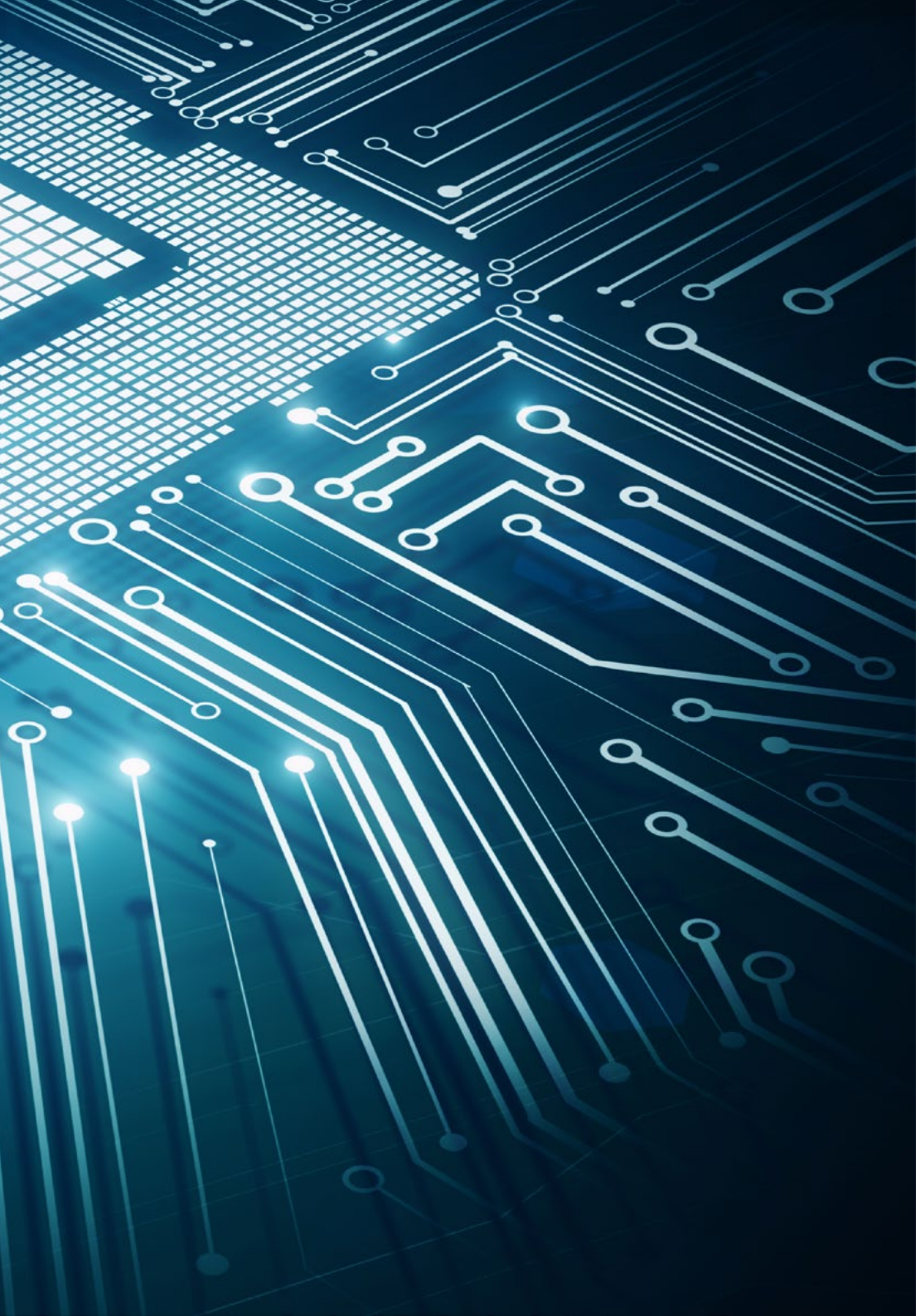
The Postgraduate Certificate in Quantum Computing aims to provide comprehensive training in quantum techniques for professional Information and Communication Technology (ICT) engineers. This qualification shows what benefits current and future quantum technologies can provide to machine learning, focusing on algorithms such as Kernel-based models, optimization and convolutional networks.



The direct application of the knowledge acquired about Blockchain and Digital Twins in real projects is an added professional value, which very few engineers specialized in Information and Communication Technologies can offer"

General Objectives

- Demonstrate the differences between quantum computing and classical computing
- Analyze the mathematical foundations of quantum computing
- Determine the main quantum operators and develop operational quantum circuits
- Analyze the advantages of quantum computing in examples of quantum "type" problem solving
- Develop and demonstrate the advantages of quantum computing in application solving examples (games, examples, programs)
- Demonstrate the different types of projects achievable with classical *Machine Learning* techniques and the state of the art in quantum computing
- Develop the key concepts of quantum states as a generalization of classical probability distributions, and thus to be able to describe quantum systems of many states
- Analyze how to encode classical information in quantum systems
- Determine the concept of "Kernel Methods" used in classic *Machine Learning* algorithms
- Develop and implement learning algorithms for classical ML models in quantum models, such as PCA, SVM, neural networks, etc
- Implement DL model learning algorithms on quantum models, such as GANs



Specific Objectives

- Analyze the need for quantum computing and identify the different types of quantum computers currently available
- Specify the fundamentals of quantum computing and its characteristics
- Examine the applications of quantum computing, advantages and disadvantages
- Determine the basic fundamentals of quantum algorithms and their internal mathematics
- Examine Hilbert space of dimension 2n, n-Qubits, states, quantum gates and their reversibility
- Demonstrating Quantum Teleportation
- Analyze Deutsch's Algorithm, Shor's Algorithm and Grover's Algorithm
- Develop examples of applications with quantum algorithms
- Analyze quantum computing paradigms relevant to machine learning
- Examine the various ML algorithms available in quantum computing, both supervised and unsupervised
- Determine the different DL algorithms available in quantum computing
- Understand the use of the quantum *Fourier* Transform in indicator integration for quantum ML models, as well as for feature selection
- Develop pure quantum algorithms for solving optimization problems optimization problems
- Generate specialized knowledge on hybrid algorithms (quantum computation and classical computation) to solve learning problems
- Implementing learning algorithms on quantum computers
- Establish the current status of QML and its immediate future

03

Course Management

Experts in the field of Quantum Computing meet in this Postgraduate Certificate to teach the graduate, through theoretical and practical analysis, the management of knowledge and data through this technology. Obtaining the right knowledge and advice will be essential in order to take advantage of the developments that are taking place and will take place in the coming years.

The strength of this program is that it combines theoretical fundamentals with experimental applicability and reality in today's industry"

Management

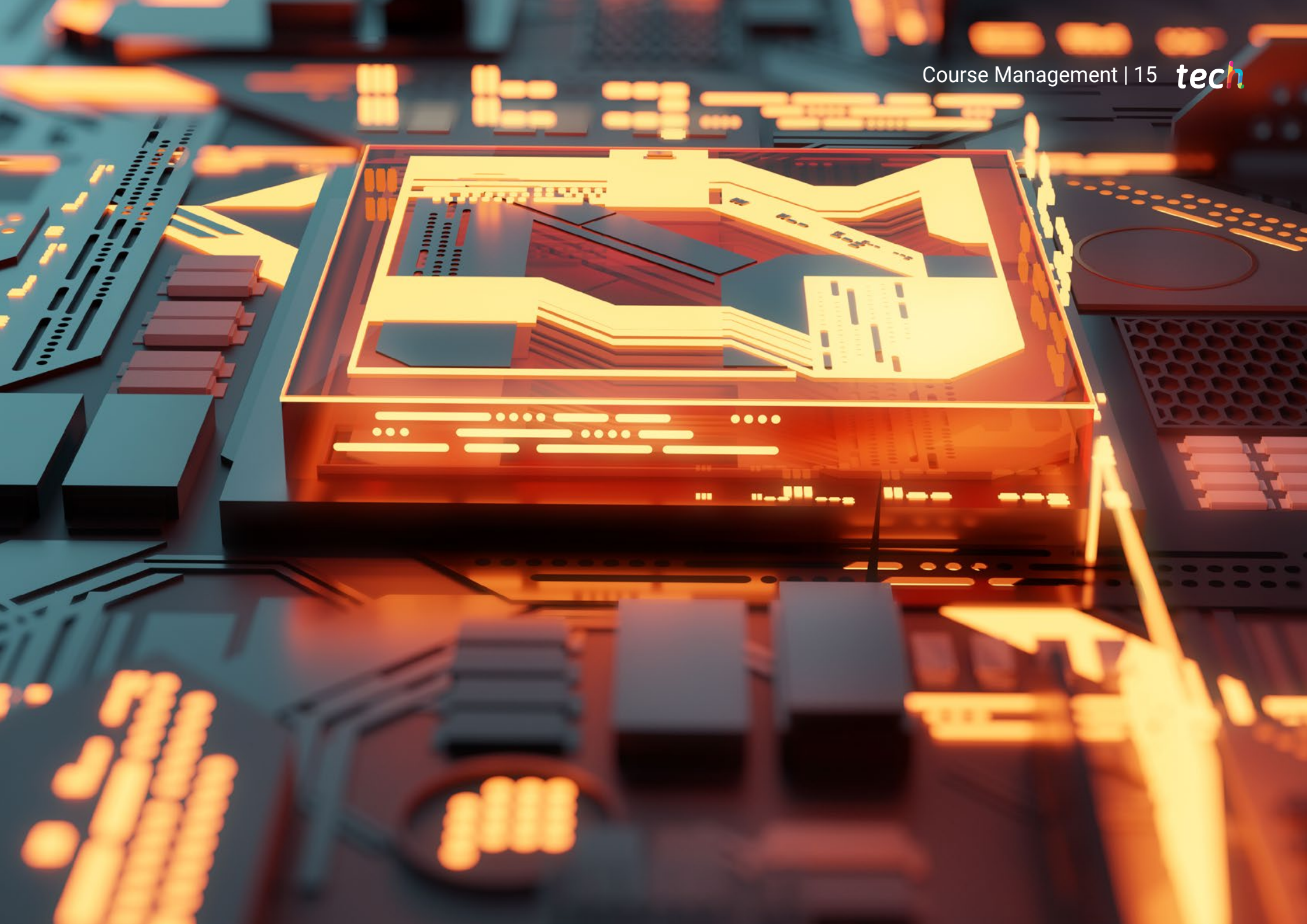
Mr. Molina Molina, Jerónimo

- Head of the Artificial Intelligence Department at Ibermática
- IA Engineer & Software Architect at NASSAT - Internet Satellite in Motion
- Senior Consultant at Hexa Ingenieros. Introducer of Artificial Intelligence (ML and CV)
- Expert in Artificial Intelligence-Based Solutions in the fields of Computer Vision, ML/DL and NLP
- Postgraduate Diploma in Business Creation and Development (Bancaixa - FUNDEUN Alicante
- Computer Engineer, University of Alicante
- Professional Master's Degree in Artificial Intelligence from the Catholic University of Avila
- Executive MBA (European Business Campus Forum)

Professors

Dr. Moreno Fernández de Leceta, Aitor

- Head of the Artificial Intelligence Department at Ibermática
- PeopleSoft Analyst at CEGASA INTERNATIONAL
- PhD in Artificial Intelligence from the University of the Basque Country
- Postgraduate Diploma in Advanced Artificial Intelligence from the National University of Remote Education
- Professional Master's Degree in Computer Engineering from the University of Deusto
- Certificate in Computational Neuroscience from the University of Washington
- Certificate in Quantum Computing, Simulation Theory and Programming



04

Structure and Content

The curriculum offered by this training covers a broad perspective on Quantum Computing, a technology that has advanced rapidly in both theory and practice in recent years and with it, the hope for potential impact on real-world applications. This Postgraduate Certificate explores in depth, both at a theoretical and practical level, the conception, development and applications, focusing on quantum machine learning.

This Postgraduate Certificate will give you the necessary concepts and tools to get into this exciting technology"

Module 1. *Quantum Computing*. A New Model of Computing

1.1. Quantum Computing
- 1.1.1. Differences with Classical Computing
- 1.1.2. Need for Quantum Computing
- 1.1.3. Quantum Computers Available: Nature and Technology

1.2. Applications of Quantum Computing
- 1.2.1. Quantum Computing vs. Classical La Computing Applications
- 1.2.2. Contexts of Use
- 1.2.3. Application in Real Cases

1.3. Mathematical Foundations of Quantum Computing
- 1.3.1. Computational Complexity
- 1.3.2. Double Slit Experiment. Particles and Waves
- 1.3.3. Intertwining

1.4. Geometric Foundations of Quantum Computing
- 1.4.1. Qubit and Complex Two-Dimensional Hilbert Space
- 1.4.2. Dirac's General Formalism
- 1.4.3. N-Qubits States and Hilbert Space of Dimension 2n

1.5. Mathematical Fundamentals of Linear from Algebra
- 1.5.1. The Domestic Product
- 1.5.2. Hermitian Operators
- 1.5.3. *Eigenvalues* and *Eigenvectors*

1.6. Quantum Circuits
- 1.6.1. Bell States and Pauli Matrices
- 1.6.2. Quantum Logic Gates
- 1.6.3. Quantum Control Gates

1.7. Quantum Algorithms
- 1.7.1. Reversible Quantum Gates
- 1.7.2. Quantum *Fourier* Transform
- 1.7.3. Quantum Teleportation

1.8. Algorithms Demonstrating Quantum Supremacy
- 1.8.1. Deutsch´s Algorithm
- 1.8.2. Shor´s Algorithm
- 1.8.3. Grover´s Algorithm

1.9. Quantum Computer Programming
- 1.9.1. My First Program on Qiskit (IBM)
- 1.9.2. My First Program on Ocean (Dwave)
- 1.9.3. My First Program on Cirq (Google)

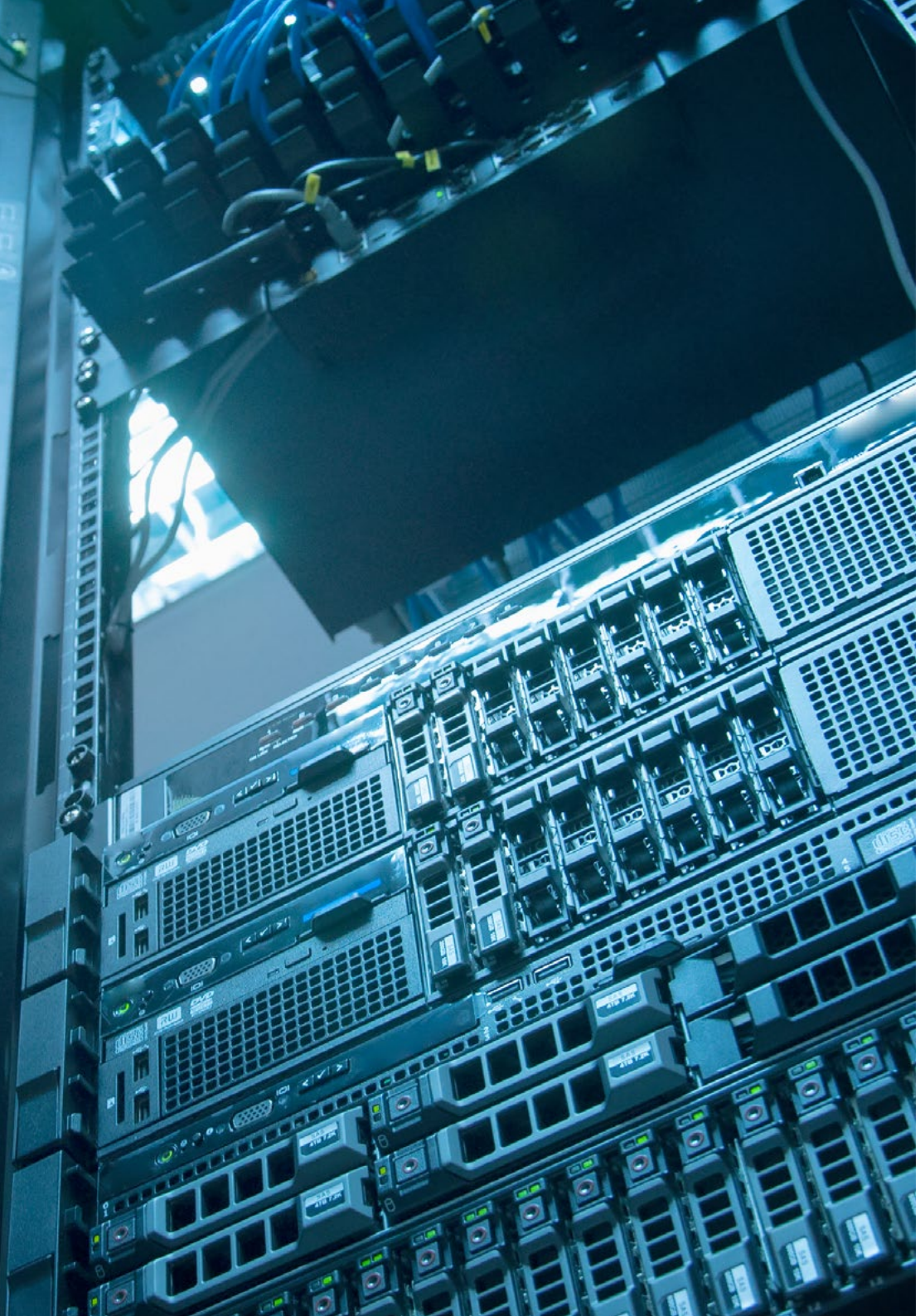
1.10. Application on Quantum Computers
- 1.10.1. Creation of Logical Gates
  - 1.10.1.1. Creation of a Quantum Digital "Adder"
- 1.10.2. Creation of Quantum Games
- 1.10.3. Secret Key Communication between Bob and Alice

Module 2. *Quantum Machine Learning*. Future Artificial Intelligence

2.1. Classical *Machine Learning* Algorithms
- 2.1.1. Descriptive, Predictive, Proactive and Prescriptive Models
- 2.1.2. Supervised and Unsupervised Models
- 2.1.3. Feature Reduction, PCA, Covariance Matrix, SVM, Neural Networks
- 2.1.4. ML Optimization: Gradient Descent

2.2. Classical *Deep Learning* Algorithms
- 2.2.1. Boltzmann Networks. The *Machine Learning* Revolution
- 2.2.2. *Deep Learning* Models. CNN, LSTM, GANs
- 2.2.3. *Encoder-Decoder* Models
- 2.2.4. Signal Analysis Models. *Fourier Analysis*

2.3. Quantum Classifiers
- 2.3.1. Quantum Classifier Generation
- 2.3.2. Amplitude Coding of Data in Quantum States
- 2.3.3. Encoding of Data in Quantum States by Phase/Angle
- 2.3.4. High-Level Coding



2.4. Optimization Algorithms
- 2.4.1. *Quantum Approximate Optimization Algorithm* (QAOA)
- 2.4.2. *Variational Quantum Eigensolvers* (VQE)
- 2.4.3. *Quadratic Unconstrained Binary Optimization* (QUBO)

2.5. Optimization Algorithms Examples:
- 2.5.1. PCA with Quantum Circuits
- 2.5.2. Optimization of Stock Packages
- 2.5.3. Optimization of logistics routes

2.6. *Quantum Kernels Machine Learning*
- 2.6.1. *Variational Quantum Classifiers*. QKA
- 2.6.2. *Quantum Kernels Machine Learning*
- 2.6.3. Classification Based on *Quantum Kernel*
- 2.6.4. *Clustering* Based on *Quantum Kernel*

2.7. *Quantum Neural Networks*
- 2.7.1. Classical Neural Networks and "Perceptron"
- 2.7.2. Quantum Neural Networks and "Perceptron"
- 2.7.3. Quantum Convolutional Neural Networks

2.8. Advanced *Deep Learning* (DL) Algorithms
- 2.8.1. *Quantum* Boltzmann *Machines*
- 2.8.2. *General Adversarial Networks*
- 2.8.3. *Quantum Fourier Transformation, Quantum Phase Estimation* and Quantum Matrix

2.9. *Machine Learning Use Case*
- 2.9.1. Experimentation with VQC (*Variational Quantum Classifier*)
- 2.9.2. Experimentation with *Quantum Neural Networks*
- 2.9.3. Experimentation with qGANS

2.10. Quantum Computing and Artificial Intelligence
- 2.10.1. Quantum Capacity in ML Models
- 2.10.2. *Quantum Knowledge Graphs*
- 2.10.3. The Future of Quantum Artificial Intelligence

05

Methodology

This academic program offers students a different way of learning. Our methodology uses a cyclical learning approach: **Relearning.**

This teaching system is used, for example, in the most prestigious medical schools in the world, and major publications such as the **New England Journal of Medicine** have considered it to be one of the most effective.

Discover Relearning, a system that abandons conventional linear learning, to take you through cyclical teaching systems: a way of learning that has proven to be extremely effective, especially in subjects that require memorization"

Case Study to contextualize all content

Our program offers a revolutionary approach to developing skills and knowledge. Our goal is to strengthen skills in a changing, competitive, and highly demanding environment.

At TECH, you will experience a learning methodology that is shaking the foundations of traditional universities around the world"

You will have access to a learning system based on repetition, with natural and progressive teaching throughout the entire syllabus.

The student will learn to solve complex situations in real business environments through collaborative activities and real cases.

A learning method that is different and innovative

This TECH program is an intensive educational program, created from scratch, which presents the most demanding challenges and decisions in this field, both nationally and internationally. This methodology promotes personal and professional growth, representing a significant step towards success. The case method, a technique that lays the foundation for this content, ensures that the most current economic, social and professional reality is taken into account.

> *Our program prepares you to face new challenges in uncertain environments and achieve success in your career"*

The case method is the most widely used learning system in the best faculties in the world. The case method was developed in 1912 so that law students would not only learn the law based on theoretical content. It consisted of presenting students with real-life, complex situations for them to make informed decisions and value judgments on how to resolve them. In 1924, Harvard adopted it as a standard teaching method.

What should a professional do in a given situation? This is the question that you are presented with in the case method, an action-oriented learning method. Throughout the program, the studies will be presented with multiple real cases. They will have to combine all their knowledge and research, and argue and defend their ideas and decisions.

Relearning Methodology

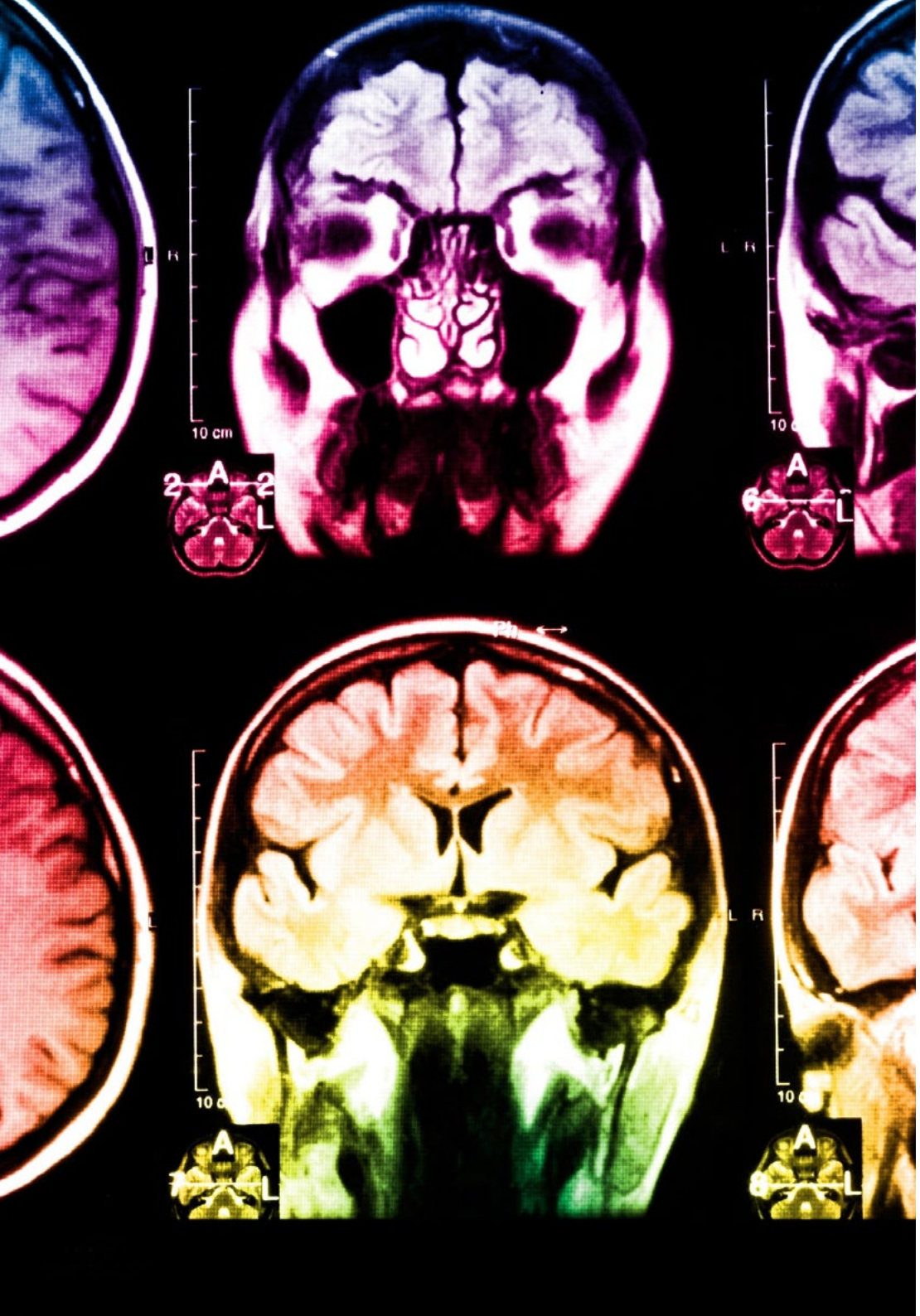
TECH effectively combines the Case Study methodology with a 100% online learning system based on repetition, which combines 8 different teaching elements in each lesson.

We enhance the Case Study with the best 100% online teaching method: Relearning.

In 2019, we obtained the best learning results of all online universities in the world.

At TECH, you will learn using a cutting-edge methodology designed to train the executives of the future. This method, at the forefront of international teaching, is called Relearning.

Our university is the only one in the world authorized to employ this successful method. In 2019, we managed to improve our students' overall satisfaction levels (teaching quality, quality of materials, course structure, objectives...) based on the best online university indicators.



In our program, learning is not a linear process, but rather a spiral (learn, unlearn, forget, and re-learn). Therefore, we combine each of these elements concentrically. This methodology has trained more than 650,000 university graduates with unprecedented success in fields as diverse as biochemistry, genetics, surgery, international law, management skills, sports science, philosophy, law, engineering, journalism, history, and financial markets and instruments. All this in a highly demanding environment, where the students have a strong socio-economic profile and an average age of 43.5 years.

Relearning will allow you to learn with less effort and better performance, involving you more in your training, developing a critical mindset, defending arguments, and contrasting opinions: a direct equation for success.

From the latest scientific evidence in the field of neuroscience, not only do we know how to organize information, ideas, images and memories, but we know that the place and context where we have learned something is fundamental for us to be able to remember it and store it in the hippocampus, to retain it in our long-term memory.

In this way, and in what is called neurocognitive context-dependent e-learning, the different elements in our program are connected to the context where the individual carries out their professional activity.

This program offers the best educational material, prepared with professionals in mind:

Study Material

All teaching material is produced by the specialists who teach the course, specifically for the course, so that the teaching content is highly specific and precise.

These contents are then applied to the audiovisual format, to create the TECH online working method. All this, with the latest techniques that offer high quality pieces in each and every one of the materials that are made available to the student.

Classes

There is scientific evidence suggesting that observing third-party experts can be useful.

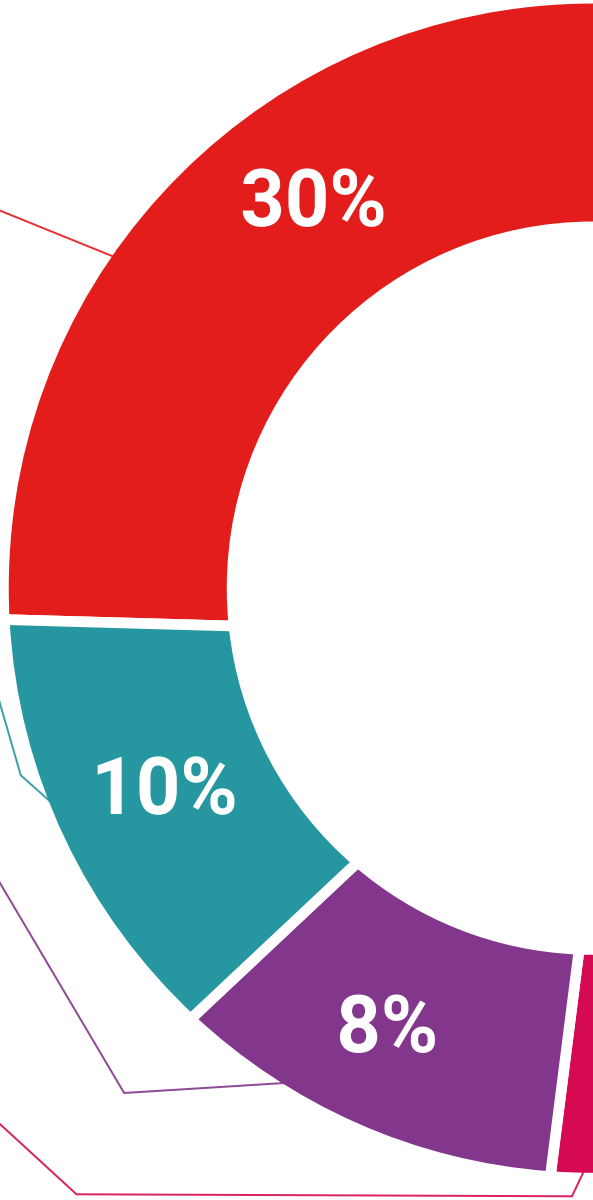
Learning from an Expert strengthens knowledge and memory, and generates confidence in future difficult decisions.

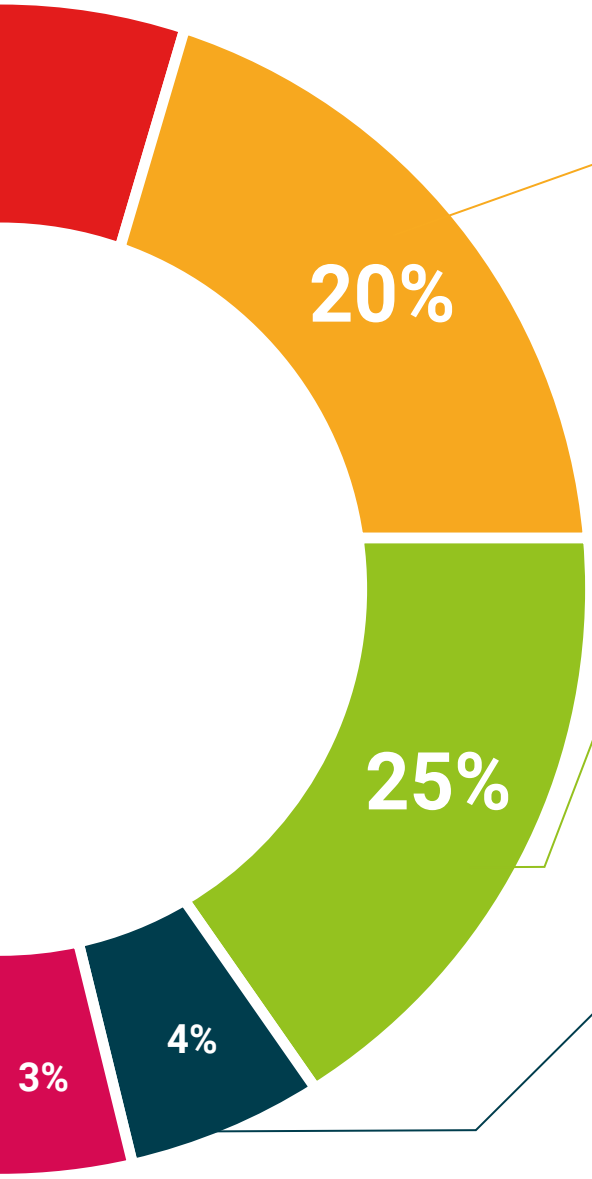
Practising Skills and Abilities

They will carry out activities to develop specific skills and abilities in each subject area. Exercises and activities to acquire and develop the skills and abilities that a specialist needs to develop in the context of the globalization that we are experiencing.

Additional Reading

Recent articles, consensus documents and international guidelines, among others. In TECH's virtual library, students will have access to everything they need to complete their course.





Case Studies

Students will complete a selection of the best case studies chosen specifically for this program. Cases that are presented, analyzed, and supervised by the best specialists in the world.

Interactive Summaries

The TECH team presents the contents attractively and dynamically in multimedia lessons that include audio, videos, images, diagrams, and concept maps in order to reinforce knowledge.

This exclusive educational system for presenting multimedia content was awarded by Microsoft as a "European Success Story".

Testing & Retesting

We periodically evaluate and re-evaluate students' knowledge throughout the program, through assessment and self-assessment activities and exercises, so that they can see how they are achieving their goals.

06

Certificate

The Postgraduate Certificate in Quantum Computing guarantees students, in addition to the most rigorous and up-to-date education, access to a Postgraduate Certificate issued by TECH Technological University.

Successfully complete this program and receive your university qualification without having to travel or fill out laborious paperwork"

This **Postgraduate Certificate in Computer Quantum** contains the most complete and up-to-date program on the market.

After the student has passed the assessments, they will receive their corresponding **Postgraduate Certificate** diploma issued by **TECH Technological University** via tracked delivery*.

The certificate issued by **TECH Technological University** will reflect the qualification obtained in the Postgraduate Certificate, and meets the requirements commonly demanded by labor exchanges, competitive examinations, and professional career evaluation committees.

Title: **Postgraduate Certificate in Quantum Computing**

Official Nº of hours: **300 h.**


tech technological university

Awards the following

CERTIFICATE

to

Mr./Ms. _____, with identification number _____.

For having passed and accredited the following program

POSTGRADUATE CERTIFICATE

in

Quantum Computing

This is a qualification awarded by this University, equivalent to 300 hours, with a start date of dd/mm/yyyy and an end date of dd/mm/yyyy.

TECH is a Private Institution of Higher Education recognized by the Ministry of Public Education as of June 28, 2018.

June 17, 2020

Tere Guevara Navarro

Dean

This qualification must always be accompanied by the university degree issued by the competent authority to practice professionally in each country. Unique TECH Code: AFWORD23S techtitute.com/certificates

*Apostille Convention. In the event that the student wishes to have their paper certificate issued with an apostille, TECH EDUCATION will make the necessary arrangements to obtain it, at an additional cost.

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Postgraduate Certificate

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