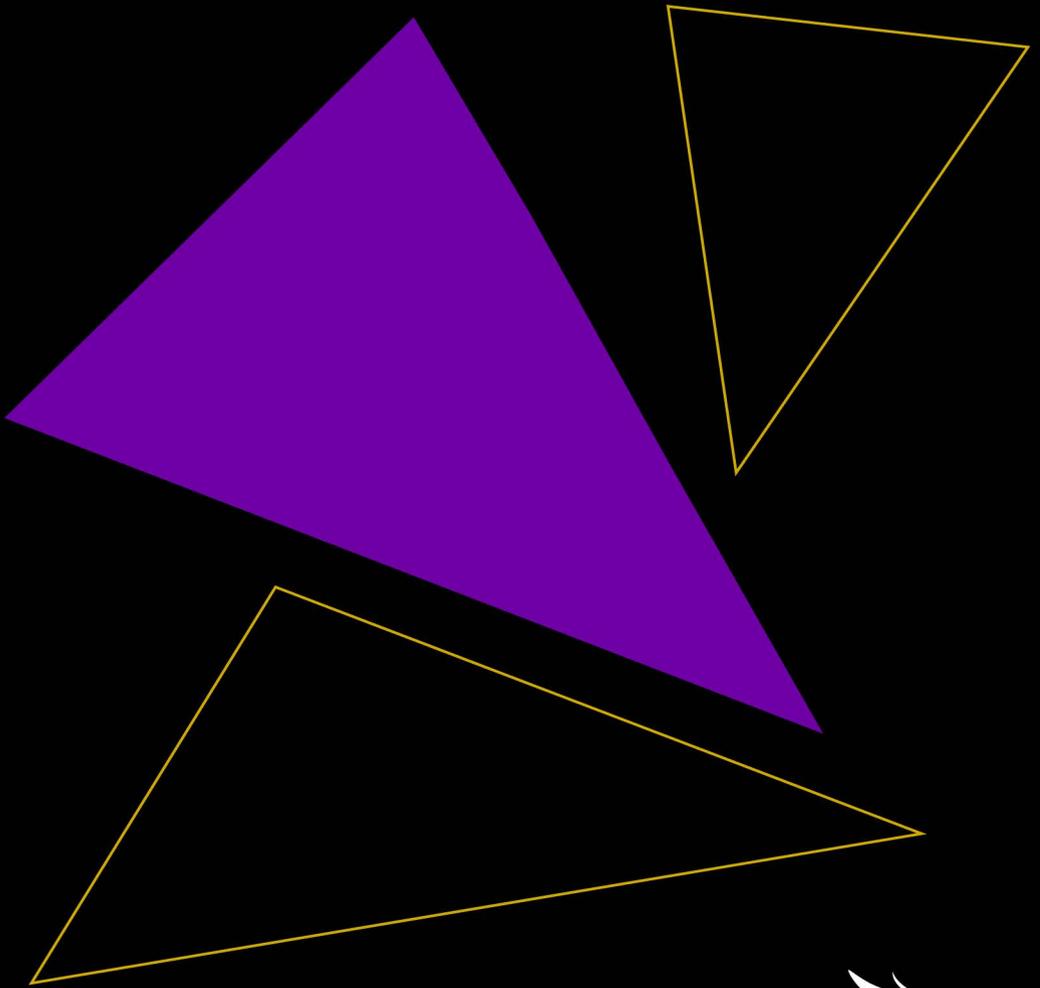


Desiderio García-Almeida
Lucas Pérez-Martín
Norberto Ramos-Calero
Essential Teaching Practices
in the Digital Era



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1. Conceptual Framework of Online Teaching and New Academic Environment

New trends are presented that make online learning increasingly relevant. In addition, the various modes of teaching are discussed in order to situate the online mode. This leads to address the concept, relevance and challenges of online teaching. In this sense, the TPACK model is referred to, which allows us to understand how the knowledge of the content of a subject, pedagogical techniques and technological tools are intertwined and useful to face online teaching. In the last part, artificial intelligence is presented from a general educational point of view to observe its role and the benefits and issues to be taken into account in its application.

Learning Goals

- ∞ To know the different types of teaching based on the technological embeddedness
- ∞ To be aware of the barriers that can limit the effectiveness of online teaching
- ∞ To understand the relevance of the lecturers' content, technological and pedagogical knowledge and their interactions to provide a high-quality online teaching
- ∞ To know the general possibilities that artificial intelligence can provide to education

1.1. Introduction

Online teaching has spread in many higher education institutions in recent years, and the trend is expected to grow in the coming decades. Several trends and events have pushed universities to offer courses completely or partially online, but three of them must be outlined due to its relevance: the Covid 19 pandemic, the increasing nontraditional student population, for which online education is a more interesting option, and climate change, since the online model is more sustainable.

Trends stemming from new types of learners and the more global reach of online studies are making the online model strategic to compete in the education market and provide a larger student base. In contrast to the limitations of local or even face-to-face learning with the mobility and associated costs that can be involved, there are clear advantages of online learning. While the face-to-face model and the socialization of students that it often entails retain great advantages, online teaching is evolving at a rapid pace and is increasingly being presented as a substitute product that attempts to emulate those traditional advantages associated with face-to-face situations.

The Covid-19 pandemic showed the need to know the fundamentals and main tools of online and virtual teaching, as well as to be prepared for a rapid transition from classical face-to-face teaching to hybrid forms of teaching processes or even fully digital, at least on a temporary basis. Thus, in view not only of the possible impact of future pandemics or local spread of infectious diseases, climatic or geological disasters, widespread transport crises and other major events that make face-to-face teaching impossible but also because it is a strategic option for many higher education institutions, it is necessary to be prepared to move from a face-to-face model of teaching and learning to a virtual model of teaching development. The remaining pages of this chapter aims to address online teaching and learning from a conceptual perspective, presenting its foundations.

1.2. Teaching modes

According to Nilson and Goodson (2021), several trends and developments (obviously the COVID-19 pandemic has been one of them) have pushed more traditional universities to put an increasing number of their courses and programmes fully or partially online. This means that faculty must be prepared to teach in a variety of modalities beyond face-to-face, including teaching to a lesser or greater extent in a digital format. Thus, these modes of teaching can be seen on a continuum of greater to lesser synchronicity with the extremes being

face-to-face teaching and fully virtual or online teaching, respectively. Nilson and Goodson (2021) explain this continuum with 5 modes of teaching, whose differences lie in the spatial and temporal dimensions and not in the pedagogy:

1. Face-to-face mode. Students meet their instructors at the same time and in the same place.
2. Remote mode. Learning that takes place outside the physical classroom (web conferencing).
3. Hybrid or blended mode. Courses that combine face-to-face classroom meetings with asynchronous online learning.
4. Hybrid-flex mode (hyflex). Courses that are taught by attending face-to-face classes, participating online, doing both, or watching the video of the class later.
5. Fully online mode. Students access all learning materials and activities via the Internet, either within a learning management system or a course website.

As became clear during the pandemic mentioned above and given the impossibility of continuing with the face-to-face mode of teaching, it is normally the academic authorities in higher education institutions (rector/president and dean) who, with their decisions and resolutions, largely decide the mode of teaching to be followed. However, it is also the instructors who, at their discretion, decide on specific aspects of teaching to be implemented. Thus, in many higher education institutions during the COVID-19 pandemic, initially the distance mode and the fully online mode were implemented, depending on the subject, and later, with the gradual and limited acceptance of the remote teaching, this model and the hybrid and hybrid-flexible ones acquired greater relevance.

Educational instructors who are effective in the face-to-face environment can be effective as online lecturers, but this is not automatic and does not happen quickly (Boettcher & Conrad 2016). According to Nilson and Goodson (2021), the pressure for instructors to develop more and more online courses as quickly as possible may leave insufficient time to learn how to use technology better. In 2020, in the midst of the race to distance learning driven by the COVID-19 pandemic, many faculty expressed negative experiences with unfamiliar technology, inexperience and lack of support. Due to faculty reservations and poor pedagogical training, many online instructors have yet to incorporate best teaching practices into their courses (Nilson & Goodson 2021).

1.3. Concept, relevance and challenges of online teaching

Integrating technology into a traditional learning environment helps develop meaningful learning experiences and promotes positive perspectives and relationships with technology (Adams 2019). In fact, Ko and Rossen (2017) indicate that it is not necessary to start from scratch to teach online, but rather the instructors apply what they already know and add new tools and techniques adapted to the virtual/online environment. However, this adaptation to online teaching is challenging and requires effort. As Adams (2019) points out, although technology has become a regular feature in most classrooms and has been incorporated into curriculum standards, technology integration and technology frameworks or models are characterised with barriers and limitations based on preconceived perceptions of technology, cultural aspects and access to technology. For Mishra and Koehler (2006) it is not just about looking at the technology but also focusing on how it is used.

Online education has been growing in recent decades faster than on-site courses in higher education institutions. Even before the COVID-19 pandemic, the growth was spectacular, for example a 39% increase in the number of students enrolled in online courses in the US in 2017 compared to the previous years (Jaschik & Lederman 2020). Accordingly, this increase also means that the number of faculty teaching online courses also increased. Right before the pandemic this trend was steady and resulted in a new high of 46 percent of faculty members in 2019 who had taught an online course, up from 39 percent in 2016 (Jaschik & Lederman 2020). In general, the number of instructors who show favourable opinions and fully support the increased use of educational technologies is also growing. Nevertheless, the COVID-19 pandemic was a solid turning point as the vast majority of university lecturers were forced to teach online education due to infection prevention and even homebound status. Many of these lecturers had never taught an online course before, and while many higher education institutions organised introductory courses to "survive" the online experience, these lecturers suddenly found themselves in a scenario for which they were unprepared. The students were not prepared either, starting with the lack of adequate equipment and facilities for this online education. With the end of the pandemic, most higher education institutions gradually returned to their face-to-face education schemes, but many observed that online education would offer great strategic opportunities. This has meant that the growth of online education in the post-pandemic period has continued from the pre-pandemic level. It shows the relevance of this

type of education to which many instructors have to become accustomed or are even recruited directly for this kind of courses.

Marr (2022) addresses the discussion of the two biggest trends in education, referring to its content and its process. Regarding what should be taught, apart from global citizenship skills (including awareness of the wider world, and sustainability), innovation and creativity skills, and interpersonal skills, it includes technological skills including data science and programming. But addressing how to teach in the future, Marr (2002) defends more digitalised content and online learning with more immersive tools, along with more personalised, self-directed, collaborative, problem-based and bite-sized learning. That immersive learning is seen with a technological orientation that implies using technologies like virtual and augmented reality to bring topics to life in the context of a certain field.

Thus, the development of online teaching is promising. However, there are several barriers that can become strategic constraints to its effective implementation and impact. These barriers come from the instructors, but also from the students. With respect to the instructors, the following should be mentioned:

Technological aspects. Many instructors embark on the preparation of an online course without knowledge of the technology required to deliver it. As will be discussed later, delivering an online course is more complex than simply transferring a face-to-face course offering in a digital format. The content of an online course must be embedded completely in digital tools, so mastering the technology in a high or advanced level is strongly recommended. In the 2020 rush to remote learning, many faculty aired their negative experiences with unfamiliar technology and inexperience, and from then on the trend has continued. Despite the fact that educational technology has become very friendly and highly intuitive, the development of competences regarding advanced tools is highly desirable to reach the potential that educational digital platforms offer. In addition, as Nilson and Goodson (2021) note, the push for faculty to develop more and more online courses as quickly as possible can leave inadequate time to learn how best to use the technology.

Pedagogical aspects. Only 44% of experienced online faculty believe that online instruction is just as effective as face-to-face teaching (Jaschik & Lederman 2020). This may be due to a lack of exploitation of the digital environment with a strong pedagogical basis oriented to this medium. In this sense, pedagogical knowledge must be adapted to online teaching in order to maximise the technical possibilities that this medium provides. From this perspective, trainers

need to develop strong didactic competences. Thus, a weak pedagogical training would entail that many online instructors do not incorporate the best teaching practices throughout their courses.

Institutional aspects. Educational institutions must invest not only in technological infrastructure but also in the development of their human capital. The training offer for their instructors in technological and pedagogical knowledge must be adequate and complete for the strategic ambitions of the institution. Consequently, it must offer strong technological and pedagogical support, especially at the beginning of the implementation of online teaching. Digital tutorials are required, but also an internal hotline service to provide customised support in real time. In addition, the workload must be balanced and rational, avoiding overloading instructors with a high number of courses to be taught and a high number of students to be attended. All the aspects related to the lack of competences and the tension derived from work overload generates faculty reservations and motivational problems. While many educational institutions are tempted to solve these problems solely through increased instructor salaries, the negative dynamics in online teaching tend to continue if teaching and training planning does not respond to the issues outlined above. Obviously, this does not mean that teaching effort should not be rewarded with competitive remuneration, in line with the importance that digital learning provision should have in the strategic positioning of the educational institution.

As far as students are concerned, two barriers are evident:

Relatively low level of graduates. In general, there is evidence that fewer students tend to complete online courses compared to those who complete face-to-face courses. This gap has been estimated in a 10-20% below. The reasons for this difference may lie in perceived student isolation and lack of motivation in the relative absence of group dynamics, as well as poor course preparation that does not provide sufficient stimuli to engage students and avoid boredom or lack of understanding.

Lack of socialisation and interpersonal skills development. Remote learning has been accused of relying too much on individual initiative and effort as opposed to the social interaction that traditional physical classroom environments provide. Thus, the lack of assimilation of citizenship and professional values may be a cause for concern. In the same vein, the development of competences related to leadership, teamwork, conflict management, negotiation and communication, especially non-verbal one, may be hampered. However, some competences can be developed in this kind of learning, such as the ability of working autonomously, organisation skills, competence for

searching information. This calls for special attention in the design of learning activities that simulate real-life situations to enable progress in these basic competences across many students' professional careers.

An interesting debate regarding the essence of online teaching is the one about the fees that students should pay for it. Squelch (2020) indicates that certain calls for fee reduction for online teaching, compared to face-to-face one, derive from the assumption that online education does not offer the same level of quality or standard, resulting in a worse learning experience for students. Moreover, the assumption that educational institutions offering online education reduce the costs related to physical infrastructure is another aspect to consider a lower level of fees. However, the investment on digital infrastructure, specific materials to develop, and a customised attention to students would make the case for even higher fees in this kind of teaching. Thus, the relative lower of higher fee structure for online teaching varies from the massive open online courses (i.e., MOOC) offered for free, to the more expensive online courses where an additional fee difference has to be paid.

1.4. The TPACK model

The identification of certain barriers in online teaching mentioned above can be linked to a conceptual perspective of the field of digital education. Research in the field of educational technology has often been criticised for its lack of theoretical underpinning (Mishra & Koehler 2006). Until mid-2000s the notion of a unifying conceptual framework was lacking in the educational technology literature. Nevertheless, there are consistent and relevant theoretical frameworks that allow for approaching the introduction of technological elements in the teaching context of higher education.

One such theoretical framework is that known as TPACK or "Technological pedagogical content knowledge". The roots of this model lie in Shuman's work (1985) who offered the traditional view of a good lecturer having constructed several types of knowledge. In particular, Shulman (1987) referred to content knowledge, pedagogical knowledge, and pedagogical content knowledge. Content knowledge is the knowledge and skills about the field or discipline to teach, pedagogical knowledge is the knowledge and skills to teach effectively and efficiently, while pedagogical content knowledge refers to the combination of those two categories, that is, the knowledge and abilities on how to teach a certain field of study in an effective way.

The TPACK model is a conceptual framework for educational technology by building on Shulman's formulation of 'pedagogical

content knowledge' and extending it to the dynamics of lecturers integrating technology into their combination of content and pedagogical knowledge. The development of the TPACK framework by Mishra and Koehler (2006) was a breakthrough since it provided a solid perspective based on prior knowledge. Based on the model, a high-quality teaching-learning process demands a thoughtful interweaving of all three key sources of knowledge: technology, pedagogy, and content.

In a more specific way, TPACK (see Figure 1) is defined as understanding the connections and interactions between content knowledge (subject matter to be taught), technological knowledge (computers, Internet, digital video, etc.) and pedagogical knowledge (teaching and learning practices, processes, strategies, procedures and methods) to enhance student learning (Koehler & Mishra 2006; Archambault & Barnett 2010). Underpinning this framework is the understanding that teaching is a very complex activity that draws on many types of knowledge, and that viewing these types of knowledge in isolation will not support good learning (Mishra & Koehler 2006). Consequently, according to this model a high-quality teaching-learning process requires a careful combination of the three key sources of knowledge: technology, pedagogy/didactics and content. Mishra and Koehler (2016) argue that there is no one-size-fits-all technological solution that fits all instructors, all courses or all ways of teaching. More specifically, Adams (2019) states that the TPACK model highlights areas of overlap between the three core components of technological implementation and integration into a learning environment. The combined TPACK competency represents an idealised state reflecting the intersection of content, pedagogy and technology incorporated into a learning environment in a meaningful and useful way for both learners and instructors (Adams 2019). From the technological point of view, the TPACK model is useful to provide insights on how the affordances of technology might be leveraged to improve teaching and learning (Archambault & Barnett 2010).

Teaching with high-quality standards calls for understanding the complex relationships and links between content, pedagogy and technology and developing appropriate strategies for the specific environment where teaching and learning take place. For Mishra and Koehler (2006), there is no single technological solution that applies for every instructor, every course, or every view of teaching, so the own development of specific solutions for every case is the real educational challenge.

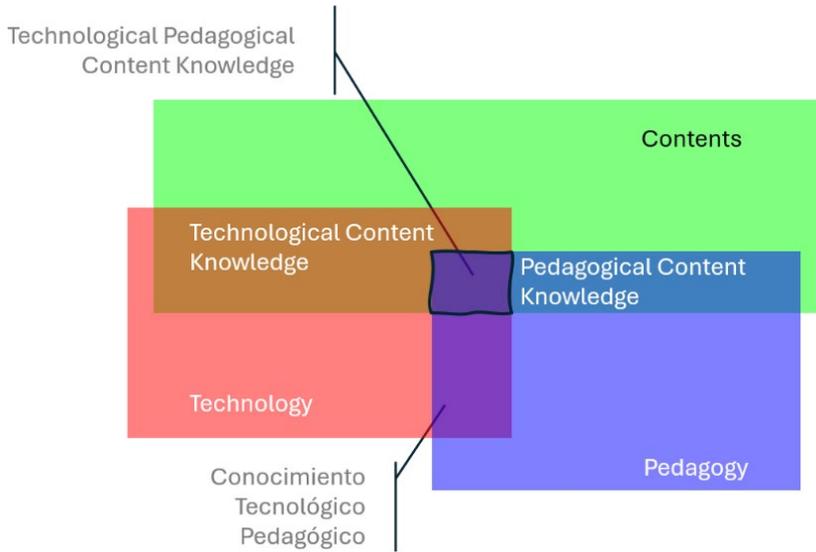


Figure 1. The TPACK model.

Source: Adapted from Mishra and Koehler (2006)

The courses and subjects to be taught entirely online are those that are likely to be characterised by a higher level of complexity, given that they totally renounce the classic face-to-face sessions. Following the TPACK model already introduced, the mastery of the subject matters, but also pedagogical and didactic knowledge that must be combined with technological knowledge. This technological knowledge must include both the learning management system used in the university (e.g. Moodle) and different technological tools that complement the learning management system. This enriches both teaching and evaluation, and it is therefore something to be considered in formal training programmes for educators as well as individually by each instructor. In order to have clear guidelines on the online delivery of courses and subjects, a model for preparing an online course and solid generic recommendations on virtual teaching are discussed in one of the next chapters of this book.

1.5. Artificial intelligence and education

For Holmeset et al. (2019), artificial intelligence (AI) is quite possibly the major driving technological force of the first half of the 21st century and will transform virtually every sector, and perhaps even human endeavours in general. Contrary to the frightening images of a

dystopian future in the media and popular fiction, where artificial intelligence systems dominate the world and are primarily used in warfare, artificial intelligence is improving human life in multiple fields such as transportation, service care, healthcare, public safety, entertainment, and education (Dignum 2018). Although there is no widely accepted definition of artificial intelligence (Wang 2019), this term can be defined as the activity dedicated to making machines intelligent, with intelligence being the quality that enables an entity to function properly and with foresight in its environment (Wang et al. 2015). According to Chen et al. (2020), artificial intelligence is a field of study and the resulting innovations and developments that have culminated in computers, machines and other artefacts that possess human-like intelligence, characterised by cognitive abilities, learning, adaptability and decision-making capabilities. To understand the most current bases that have allowed the widespread use of artificial intelligence, it is interesting to turn to the work of Goksel and Bozkurt (2019). For these authors, the historical journey of artificial intelligence began in the 1950s when the concept was first discussed as a broad and advanced term for computer intelligence. Between 1980 and 2010, machine learning technology was introduced and developed. After 2010, deep learning appeared in the technological world as an innovative technique for applying machine learning using neural networks to complete highly complex thinking tasks.

AI is already having a significant impact on education. AI-assisted education includes intelligent education, innovative e-learning, and data analytics and prediction (Chen et al. 2020). According to Holmes et al. (2019), artificial intelligence technologies have been investigated in educational contexts from the 1970s. Influential companies such as Amazon, Google and Facebook later invested millions of euros in the development of educational artificial intelligence products, joining multi-billion euro companies such as Knewton or Carnegie Learning, while the 15 million dollar Global Learning Prize already called for computer applications or software that enabled children to take control of their own learning, which is educational artificial intelligence by another name (Holmes et al. 2019).

There is a broad consensus that artificial intelligence and other technologies in which it is present can make people's lives easier and contribute to human progress (Goksel & Bozkurt 2019). Indeed, the potential of artificial intelligence in the field of education is staggering, as it can play a variety of roles in education, whether at the level of administration, teaching or learning. Chen et al. (2020) outline what artificial intelligence can do in each of these three areas:

1. *Administration*. Performing faster administrative tasks that consume much of lecturers' time, such as marking tests and providing feedback; identifying the learning styles and preferences of each of their students, helping them build a personalised learning plan; assisting instructors in decision-making and data-driven work; and providing feedback to and working with students quickly and directly.
2. *Teaching*. Anticipating the extent to which a student exceeds expectations in projects and exercises and the likelihood that they will drop out; analysing the syllabus and course material to propose personalised content; enabling teaching beyond the classroom and into higher education, supporting collaboration; tailoring the teaching method to each student based on their personal data; and helping instructors create personalised learning plans for each student.
3. *Learning*. Finding out students' learning deficiencies and addressing them at an early stage of education; personalising the selection of university subjects for students; predicting each student's career path by collecting study data; and detecting learning status and applying intelligent adaptive intervention to students.

In the education sector, the use and application of artificial intelligence has increased, going beyond the classical idea of artificial intelligence as a supercomputer to include embedded computer systems and even robots (Chen et al. 2020). The use of what Timms (2016) calls educational cobots (robot collaborators) will most likely soon become a reality, understanding these cobots as robots designed to assist lectures, combining the power of educational artificial intelligence with advances in the fields of robotics and the increasing development of sensors that monitor human actions and environments.

Intelligent education systems provide personalised and timely instruction and feedback to instructors and students. As the use of technology expands in education, researchers are trying to apply advanced artificial intelligence techniques, such as deep learning or data mining, to address complex issues and personalise the teaching method for each student (Chen et al. 2020). Goksel and Bozkurt (2019) provide a complementary view by analysing the research contributions of artificial intelligence from an educational perspective, concluding that the main topics addressed in the academic literature revolve around three areas: (1) adaptive learning, personalisation and learning styles, (2) expert systems and intelligent tutoring systems, and (3) artificial intelligence as a future component of educational processes.

In their review of academic literature and industry trends, Chassignol et al. (2018) attempt to identify the prospective impact of artificial technologies on the educational process and predict possible changes in the educational landscape. These authors find that developments are occurring in four categories: personalised educational content, innovative teaching methods, technology-enhanced assessment, and student-lecturer communication.

In order to understand the application of artificial intelligence in education, it is interesting to mention the educational domains or scenarios in which artificial intelligence-related techniques are applied (Chen et al. 2020):

1. Assessment of students and institutions: Adaptive learning methods and personalised learning approaches, as well as academic analysis.
2. Correction and assessment of papers and exams: Image recognition, computer vision, and prediction systems.
3. Personalised intelligent teaching: Data mining or Bayesian knowledge interference, intelligent teaching systems and learning analytics.
4. Smart schooling: Facial recognition, voice recognition, virtual laboratories, augmented reality, virtual reality, auditory and sensory technologies.
5. Remote online and mobile education: Perimeter computing, personalised virtual assistants, and real-time analytics.

While the above data show the benefits and potential that artificial intelligence provides and can continue to provide to education in multiple dimensions, it is necessary to address the ethical questions that this technology raises. Recent advances in AI bring with them real challenges in areas such as (mis)employment, privacy or autonomous weaponry that scientists and policy makers need to be aware of and able to respond to (Wooldridge 2017). In this line, ethical considerations come to the fore.

Dignum (2018) points out that, to ensure that the dystopian futures mentioned in the first paragraph of this section do not become a reality, artificial intelligence must be introduced in a way that fosters trust and understanding, and respects human and civil rights. There are several initiatives underway that address ethics and artificial intelligence (Boddington 2017): academics studying the ethical aspects of artificial intelligence, projects and even research institutions examining these aspects, initiatives in large and small companies and non-profit organisations, activities of certain individuals in some related

professions studying biases, and work streams of public administrations and professional associations.

In general, ethics and artificial intelligence are related on several levels (Dignum 2018):

1. Ethics from the design. The technical/algorithmic integration of ethical reasoning capabilities as part of the behaviour of the artificial autonomous system.
2. Ethics in the design. The normative and engineering methods that support the analysis and evaluation of the ethical implications of artificial intelligence systems as they integrate or replace traditional social structures.
3. Ethics for the design. The codes of conduct, standards and certification processes that ensure the integrity of developers and users as they research, design, build, employ and manage artificial intelligent systems.

For Goksel and Bozkurt (2019), education should not be satisfied with the idea that technology adaptation is positive by default, but it should take a critical stance before fully integrating artificial intelligence into educational processes. As part of this critical stance, firstly, it is necessary to develop an ethical policy and clearly define the ethical boundaries of how artificial intelligence would use human-generated data; secondly, the educational processes involving artificial intelligence must be tested in a continuous way to avoid automated processes and related pitfalls.

As part of these ethical precautions in everyday educational life, the use of a chat tool programmed with artificial intelligence can be mentioned. Thus, the ChatGPT tool has become very popular in 2023, and its academic application shows a wide range of advanced possibilities. However, its use by students raises important ethical questions, for example with regard to evaluation. Thus, work by lecturers to enable students to develop certain competences and allow them to be assessed can be carried out by these tools with minimal intervention (and developmental effort) by the student. These implications may require strict codes of conduct and thorough checks on authorship, or even the replacement or redesign of such assignments when it is impossible to verify the student's individual or group contribution and hence their competence development in a relevant field. Further analysis of AI will be shown later in some other parts of this book.

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2. Educational Neuroscience as a Basis for Online Teaching

The background to linking neuroscience and education is presented, and we look at where the benefits of its application in the field of education can come from. The groundwork is then laid for looking at the introduction of the findings from the brain and mind field in educational practice, analysing negatives attitudes towards its use and neuromyths, the universal principles of the science of the mind, brain and education and beliefs about individual aspects of learning common to broad spectrums of human variation, and cultural aspects. On this basis, six practical guidelines to integrate advances in educational neuroscience in online teaching are discussed.

Learning Goals

- ∞ To know the basic elements of educational neuroscience
- ∞ To avoid negative attitudes and neuromyths in the application of neuroeducation in education
- ∞ To be able to use some universal principles of the science of the mind, brain and education and beliefs about individual aspects of learning common to many people in the educational practice
- ∞ To adapt some neuroeducation-based guidelines for online teaching

2.1. Introduction

Neuroscience is a discipline with a lot of potential for education. In 2017, the OCDE already stated that the time was to use knowledge and insights about brain, cognition and behaviour on the educational domain (OCDE 2007). Nevertheless, many years later educators are not in a position to set up a course with the assurance of success that educational neuroscience was supposed to provide. Despite these great unfulfilled aspirations, some findings already shed light on educational approaches aimed at maximising learning from the brain and mind perspective. In the following pages, we will take a closer look at educational neuroscience. The content of the chapter closes by providing a series of guidelines for addressing with online education with the support of neuroeducation.

2.2. Basic approach to educational neuroscience

Neuroscience is becoming an umbrella science to address key questions regarding humanity, such as how humans develop and learn complex cultural skills, the motivations for their behaviour, their decision-making or even the influence of emotions on them (Ansari et al. 2017). In recent years, the relevance of physical and mental processes has been highlighted as a central approach to understand and stimulate learning from an understanding of the brain and mind of individuals. Thus, the terms neuroeducation, educational neuroscience or the field of mind, brain and education have become popular (Brault Foisy et al. 2020). Indeed, this emerging field that combines mind, brain and education seeks to synthesise research in biology, cognitive science and education to create a multidisciplinary science of learning that can guide educational policy and practice (Hinton et al. 2012). Sigman et al. (2014) state that as neuroscience achieves social diffusion and attracts media attention, the idea that education can benefit greatly from brain research is becoming increasingly popular.

Brain science has discovered a dazzling array of brain areas, cell types, molecules, cellular states, and mechanisms for computation and information storage (Marblestone et al. 2016). Poch Olivé (2001) already considered that the nervous system is the material support for knowledge, affectivity, and behaviour. Neurobiology is in charge of studying its maturation, which implies a process in which a series of anatomical changes, genetics and the capacity to integrate functions due to learning interact. The argument for linking neuroscience and education began to be established with three findings based on developmental neurobiology (Bruer 1997):

1. In infancy and late childhood there is an enormous increase in the number of synapses connecting neurons in the brain. These neural connections can be of great relevance in the achievement of learning. Following synaptic proliferation, known as synaptogenesis, there is a period of synapse elimination, known as synapse pruning.
2. There are critical experience-dependent periods in the development of sensory and motor systems.
3. Tests with mice in laboratories show that complex or enriched environments cause new synapses to form.

Südhof (2021) explains that synapses are assembled to form a neural circuit, and in these circuits synapses transfer information between neurons rapidly and transform this information during the transfer. It adds that the processes by which synapses fit together to form neural circuits and how the particularities of synaptic connections are achieved are largely unknown.

The human brain contains more than 100 trillion synaptic connections, which form all its neural circuits (Eroglu & Barres 2010). Neuroscientists have long been interested in how this complex synaptic network is woven during development and how it is remodelled during learning and disease. Evidence from neuroscience shows that there is a critical period for learning in early childhood that is somewhat related to growth and the disappearance or pruning of synapses and is established between birth and the age of ten (Bruer 1997). Thus, childhood experiences reinforced and maintained synapses that were repeatedly used, but unused synapses were eliminated. According to Bruer (1997), these moments of high synaptic density and the process of experience-based adjustment represent a critical period in a child's cognitive development when the brain is especially efficient in acquiring and learning a large number of skills, and it is during this period that children can benefit most from rich and stimulating learning environments.

As has been widespread since the late 1990s of the 20th century, it is necessary to establish caveats for the three central tenets that had initially guided the euphoria of the findings in neuroscience. Thus, it must be indicated that there appears to be (1) 'no significant connection between synaptogenesis and the ability to learn or the rate of learning'; (2) 'that critical periods do not constrain the experience-dependent brain change that occurs in social and educational environments'; and (3) that 'enriched environments in animal research do not present appropriate analogies to human learning, and that even in rodents enrichment affects the brain throughout their lives' (Bruer 2016: 15). Indeed,

Sigman et al. (2014) state that the idea has been advocated that the bridge from brain research to education is provided not by neuroscience but by cognitive psychology.

Nevertheless, findings in neuroscience continue to accumulate. Indeed, Ansari et al. (2017) indicate that the first two decades of the 21st century have witnessed tremendous growth in understanding how the human brain works and how this brain relates to how we think, feel and learn. Technological advances make research in biology and cognitive science more relevant to education than ever before (Hinton et al. 2012). This has led to calls from organisations such as the OECD to use evidence from the study of the human brain to influence what happens in classrooms (e.g., Ansari et al. 2017).

The brain is made up of networks of interconnected nerve cells called neurons and supporting glial cells. Recent studies have found that glial cells are important regulators of the synaptic connectivity shown above and that they occupy more than half of the human brain (Eroglu & Barres 2010). Hinton et al. (2012) explain the neural basis of learning, indicating that learning experiences translate into electrical and chemical signals that gradually modify the connections between neurons in particular areas of the brain; over time, these changes in neural connectivity can lead to significant reorganisation of brain areas involved in particular types of learning. In fact, learning experiences modify the connections between neurons in particular brain areas, which are progressively reorganised (Squire & Kandel 2009). Thus, each neuron receives many stimuli from other neurons and when learners have learning experiences certain connections are activated and others are not (Hinton et al. 2012). With evolution over time there is some selection of what is retained (and associated with the basis of memory), as connections that are more active in relation to incoming stimuli are strengthened, while those that are relatively less active are weakened or eliminated (Squire & Kandel 2009; Hinton et al. 2012). This connects to the experience-dependence finding noted above as a relevant finding in neurobiology.

2.3. Fundamental aspects of education from the brain and mind field

Research on neuroscience for education may be promising in the use of insights regarding the interaction between learning and development and in the internal and contextual factors that impact learning (Jolles & Jolles 2021). Based on the application of neuroscience in education, Tokuhama-Espinosa (2021) considers that the professional

development of instructors must be based on knowledge of four fundamental aspects: Universal principles of the science of the mind, brain, and education; beliefs about individual aspects of learning common to broad spectrums of human variation; cultural aspects denoting social influences on the recognition of patterns and categories and affective features of learning; and specific guidelines for classroom teaching. The study of these elements provides a sound basis for approaching the application of neuroscience knowledge on educational activities. Thus, these elements are discussed below, with the exception of the specific guidelines for education which will be addressed in the next section for the context of online teaching.

2.3.1. Attitudes and neuromyths

Attitudes are evaluative statements or judgments about people, objects or events. In a certain situation, individuals tend to behave in a certain way based on the attitudes they hold about key elements in the situation. Thus, a negative attitude to a certain educational approach will make a person to avoid its use. Those attitudes generated by false or incorrect information or knowledge create prejudices that would hamper correct positive behaviours. In educational neuroscience these ideas result in the mention to the so-called neuromyths.

Neuromyths are misconceptions about brain research and its application to education and learning (Macdonald et al. 2017). These misunderstandings about the mind and brain can cause problems due to wasted efforts and the use of wrong learning approaches. The Centre for Educational Research and Innovation (CERI) of the Organisation for Economic Co-operation and Development (OECD) documents several neuromyths that are prevalent and cannot be considered true under advanced research on education. This is the case for the five following aspects that are generally considered neuromyths and explained in detail by the OECD (OECD 2024):

- ⊗ Neuromyth 1: The brain is only plastic for certain kinds of information during specific ‘critical periods’-thereby the first three years of a child are decisive for later development and success in life.
- ⊗ Neuromyth 2: ‘Enriched environments’ enhance the brain’s capacity for learning.
- ⊗ Neuromyth 3: There is a visual, auditive and a haptic type of learning.
- ⊗ Neuromyth 4: We only use 10% of our brain.
- ⊗ Neuromyth 5: Myths about multilingualism, such as “Two languages compete for resources”, “Knowledge acquired in one

language is not accessible in the other language”, and “The first language must be spoken well, before the second language is learnt”.

These misconceptions frequently have been generated from some aspect of solid research, but they are incomplete, extrapolated beyond the evidence, or plain false. Since neuromyths are loosely based on scientific facts, they may have adverse effects on educational practice (Dekker et al. 2012).

2.3.2. Universal principles of neuroscience

In their interesting work based on data provided by 112 experts in educational neuroscience, Tokuhamma-Espinosa and Nouri (2020) put forward six universal principles of learning supported by research on mind, brain and education:

1. Singularity. Although the structure of most human brains is the same, no two brains are identical.
2. Different potentials. Each person's brain is differently prepared to learn different tasks.
3. Prior experience. The brain is efficient and economises effort and energy by ensuring that external stimuli are decoded and compared with existing memories.
4. Constant changes in the brain. The brain is a complex, dynamic and integrated system that is constantly changed by individual experiences.
5. Neuroplasticity. Neuroplasticity of the brain occurs throughout life, although there are marked differences in development according to age.
6. Need for memory and attention systems to achieve learning. There is no new learning without some form of memory and some form of attention, even if the learner is unaware of these processes.

In order to provide a more practical basis for the support that educational neuroscience can provide to university teaching, the importance of prior experience as an axiom in the context of learning should be highlighted. What has already been identified in the organisational and knowledge transfer literature at organisational and group level (e.g., Cohen & Levinthal 1990; García Almeida 2009), is also highlighted by analyses of the brain emphasising the mental need to build knowledge incrementally. Thus, all new learning passes through the filter of prior experience, so stimulating prior knowledge is one of the key triggers for new learning (Tokuhamma-Espinosa & Nouri 2020). Tokuhamma-Espinosa (2021) states that when something has to be learned that has nothing to do with what is already known, the brain

continues to crave a reference point, without which it may find itself in an infinite search loop. The reconstruction of information cited above is shown here by building foundational networks before trying to learn from learning more difficult ideas. As Tokuhamma-Espinosa (2021: xii) states, instructors "can help students navigate new learning through the use of analogy".

The most important contribution of neuroscience to education so far seems to lie in the highly adaptive nature of the brain, known as plasticity, which, according to several authors, may provoke a reconsideration of the prevailing philosophy of education. For Rees et al. (2016) there is ample evidence that the brain changes in structure, synaptic density, neurotransmission, interconnectivity and functioning throughout childhood and adolescence. It is also increasingly evident that the brain's plasticity makes it susceptible to the influence of experience and environment. According to Hinton et al. (2012), students' brains continually adapt to the environments in which they live and work, including educational institutions, home, work, and so on. Indeed, scientific evidence on brain plasticity has the potential to positively influence education at strategic, organisational, and individual levels (Rees et al. 2016).

2.3.3. Beliefs about mostly common individual aspects of learning

Neuroscience can also provide some advances that would posit between broad-based education for the masses and personalised learning for individuals (Jamaludin et al. 2019). For Blakemore and Frith (2005), educational neuroscience does not defend to perform an individual's brain scan for planning a lesson. However, it fosters understanding learning and how the new knowledge result into the design of the teaching-learning process (Jamaludin et al. 2019).

To that end, Tokuhamma-Espinosa and Nouri (2020) address the tenets or concepts that are valid to describe all people but with a large degree of human variation. This variation is generated by prior experiences, genetics or culture. In their empirical work, the tenets that were validated with an agreement score higher than 90% are presented below:

- ⊗ Tenet 1: Motivation influences learning.
- ⊗ Tenet 2: Emotions and cognition are mutually influential.
- ⊗ Tenet 3: Stress influences learning.
- ⊗ Tenet 4: Anxiety influences learning.
- ⊗ Tenet 5: Depression influences learning.

Progress in education is strengthened after deeply understanding tenets of learning and the way learning can be better designed to maximise the potential for optimal outcomes of every student (Jamaludin et al. 2019).

2.3.4. Cultural aspects in neuroeducation

There is clear evidence that sustained experiences may affect both brain structure and function (Park & Huang 2010). The human brain takes very long to develop its cortex, and the final neural configuration of the cortex heavily depends on the requirements of the brain in the interaction with the physical, social, and cultural environment of the individual (Rueda 2020).

Findings in cultural psychology show that there are differences in the way individuals process information based on cultural experiences. In their literature review, Park and Huang (2010) indicate that academic literature has found that there exist stable differences between East Asians and Westerners regarding attention, contextual processing, categorisation, and reasoning. These authors go on to state that there is evidence to assert that East Asians are more biased to process context, utilise categories less, and rely more on intuitive rather than formal reasoning processes. There are also some works that suggest that cultural values influence neural networks activated when recognising and thinking about self or others.

2.4. Neuroeducation-based guidelines for online teaching

Online teaching can benefit from the developments of educational neuroscience. Online teaching systems present an advantage compared to traditional classroom-based teaching in the way that it usually contains a knowledge repository that is easily accessible for students anytime and anywhere. The analysis of the academic literature (e.g. Doukakis et al. 2021) and the nature of online teaching makes possible to present the following guidelines for designing and implementing online courses:

7. Presentation of the contents in a global structure. The metaphor circuitry approach of the brain (Lakoff 2014) addresses domains of thought as embodied brain regions or structures. For Lakoff (2014), a domain is characterised by hierarchically structured schemas or mental structures that organise knowledge. These ideas result in the recommendation of designing the course with a progression strategy that links the units to address in a sequential or logical way. Consequently, the order of the course contents could have some underlying

logic that can explain its sequence. Explaining that logic in the first day of the course prepares the brain structure to be filled with the new knowledge.

8. Involvement of the student in the learning process. Students must be involved in the course development. Online courses provide positive tools such as private chats, group chats, and shared whiteboards in such ways that can be used for actively involving students and hence fostering their knowledge construction. This involvement favours the adoption of an active role in their learning process that allows for the retention of new knowledge and skills.
9. Linking new concepts to knowledge already covered. Course instructors should make the effort to analyse students' prior academic experiences and interests when joining the course. Though the process to gather this kind of information may be challenging, the sociodemographic data and prior cohorts of students can provide academic pathways for the majority of students and patterns about their interests and even expectations. Based on that knowledge, instructors could relate every major concept of the course to students' potential prior knowledge and interests. This connection can be used in the introduction of every new major concept. This way, the student can build the new content on top of already integrated knowledge. It favours the understanding of the new concept since the student is not lost in being exposed to something too novel to him/her that the 'liability of foreignness' prevents its fast absorption and integration with consolidated knowledge.
10. Activities to consider a new concept or idea using a multidimensional approach in a progressive way. Advances in neuroeducation suggest that a progression in the complexity of knowledge should be followed by initially posing simple questions or elements about a new concept. When this basic knowledge has been constructed by the student, more complex or advanced questions are added to allow a continuous progression in the level of learning. In order for this progressive construction of knowledge to be successful, there are also two relevant aspects to be used from a neuroeducational point of view: the use of analogies and examples, and the constant repetition of terms already exposed or presented in prior steps. In its search for connections with previous brain images, the use of examples facilitates the process of linking what is to be learned with already assimilated ideas, as they are associated

with already constructed knowledge that can be connected with new aspects that become evident. Practical activities support this in an excellent way. Analogies work along the same lines and facilitate learning in the same way. In addition, the repetition of the same relevant concept several times during learning sessions achieves its mental anchoring. This implies introducing elements of reinforcement of this initial knowledge during several sessions in order to consolidate it in subsequent steps; to avoid demotivation of the student due to the lack of novelty of the concept, it is recommended to use different approaches to the concept with different technologies (gamification, use of video, debates, etc.). Waiting to revisit new material until that knowledge is somewhat settled and interspersing the practice of one subject with another are additional aids in this view.

11. Exploitation of obstacles and mistakes. Students' mistakes and obstacles are an excellent opportunity to observe how teaching of a certain knowledge can be improved. Asking direct questions to students or the introduction of certain difficulties in practical activities pose challenges to show whether knowledge is being constructed in the expected way. In this way, errors or questions that indicate a lack of correct understanding become valuable feedback to identify and recognise the low effectiveness of pedagogical methods used. Such a mapping of pedagogical shortcomings enables the development of pedagogical improvements that give dynamism to the system and introduce a quality management approach to the learning system. The instructor should pay particular attention and reflect on how to address the identified learning "black spots", looking for prior knowledge built up by the learners in previous stages, come up with new examples, adopt a simpler step-by-step approach, etc. Overall, students should be encouraged to express their difficulties and the obstacles they are encountering, so it is extremely important to foster a culture of acceptance of mistakes in the course that does not punish failure or social ridicule. If such a climate of trust is not achieved, online teaching is particularly favourable to promoting alternative measures such as private communication between lecturer and student in the learning management software or by email.
12. Process to incorporate assessment in the learning process. Assessment becomes an excellent opportunity for learning.

More complex and lasting learning is achieved through self-assessment, where the learner sees for him/herself whether s/he is on-track in the construction of the expected knowledge. Another exceptional opportunity to reinforce learning is authentic assessment, since it involves bringing the knowledge to learn closer to the reality of the learner's current or future professional environment.

2.5. References

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3. Basic Principles to Design an Online Course

After reviewing the concept of instructional design referred to education, the online course designer's role and key skills and knowledge are presented. Then, process to design an online course is presented. In that line, the three phases of the online course design are explained, namely the information search and analysis, the setting of course goals and learning outcomes, and the design of the operational aspects of the course. The chapter finishes by presenting and commenting on 14 recommendations that can enhance effective instructional designs of online courses.

Learning Goals

- ∞ To evaluate and self-evaluate an individual's skills to design a successful online course
- ∞ To search for valid information and analyse it in order to set an online course
- ∞ To set goals and learning outcomes of an online course
- ∞ To design operational aspects of an online course
- ∞ To know relevant recommendations to design online courses

3.1. Introduction

One of the key aspects in the online teaching process is the course design. An effective course design conveys information about expectations, and it functions as a contract between lecturer and students (Eshtehardi 2017). The preparation of every course should pay attention to details but especially should integrate decisions about the goal of the course. Preparing an online course means more than copying the content of a face-to-face course into an online format, if available. In fact, converting a course to an online environment means adapting it to use some of the tools available in the new environment and to take advantage of some of the capabilities offered by online models. If it is a blended course, the conversion involves using the web to complement what the lecturer does in the face-to-face classroom. Nevertheless, if it is a course to be taught exclusively online, all the teaching would have to be recast in a new online format, bearing in mind that creating a completely new course to be taught online is both a challenge and an opportunity. In all these cases, the lecturer/instructor must reflect on the design and development of the course to provide a coherent and effective learning experience (Ko & Rossen 2017). Though there is not much research that advises how online course design competencies can be achieved (Gormley 2014), in the next sections a helpful orientation to design a course is provided.

3.2. Instructional design and designer in online courses

Instructional design refers to principles and procedures by which instructional materials, lessons, and whole systems can be developed in a consistent and reliable manner (Molenda et al. 2003). The purpose of instructional design is to make learning more effective and efficient. Its application to the educational field has had a significant positive impact, providing theoretical frameworks and methodological approaches to guide the process of designing courses.

The lecturer/professor is usually the active agent of instructional design of educational courses. Thus, many educators often holds the dual role of instructor and designer at the same time. The central agent in the instructional design process can be a sole individual, an individual leading a team, or a group of individuals who share the responsibility of planning and organising a course.

Based on the academic literature (e.g., Cuesta 2010; Savard et al. 2020), the instructor/lecturer should have several skills and knowledge that are relevant to face the challenge of designing a successful online

course in higher education. The most relevant aspects to consider in this domain are the following ones:

1. Clear vision and student orientation. The instructor should have an acute orientation to help students learn. This orientation should result in a vision on how that learning should translate in students with an improved set of skills, capabilities and knowledge that will help them in their personal or career development.
2. Leadership. The ability to influence and guide students in a significant way is a desired skill that help the instructional process by paving the way of accepting the different elements and tasks integrated in the course. It is also associated to mentorship and understanding that innovation and the willingness to implement strategies constitute the motor that facilitates processes within the virtual educational community.
3. Content, pedagogic and information technology competences. As reflected in the TPACK model, the student's learning experience can be enhanced if the instructor has got advanced knowledge in different domains. Thus, it is necessary to have outstanding knowledge about the field of the course to provide the best learning goals and outcomes, pedagogical knowledge to approach the learning process in the best way, and technological knowledge to embed those pedagogical tools in the technical environment of the teaching process.
4. Analytical skills. The process of creating an online course should begin with a deep analysis of the learning environment to provide information about the strengths and weaknesses of the teaching team and the opportunities and threats/barriers of the learning environment.
5. Communication skills. Due to the characteristics of online teaching, a relevant set of skills deal with providing students with clear instructions and selecting the most appropriate moments to intervene in discussions and to continuously have and foster interaction with students individually and in groups.
6. Time management skills. The lack of abilities to manage time often results in unrealistic planning of all the aspects to cover and implement in an online course. Moreover, time management should go beyond the basic requirement of the course to be extended to the analysis of the student's workload to further increase the likelihood of course success.
7. Cultural awareness. The need for cultural awareness is based on the increasing presence of students from different cultures than

the one of the instructors or the mainstream in the local area of the educational centre. Due to the opportunities that online courses provide for extending the attraction of students from the whole world and not a particular area, especially if major world languages are used in the course, students tend not to be embedded in the same, dominant culture where the institution is set. Thus, pedagogical resources have to be adapted to the cultural realities of the learners for whom they are intended.

3.3. Process to design an online course

Subject and course design has traditionally focused on content issues, such as what content to present, in what order and how deep, but one of the main drawbacks of this approach to design is that it focuses on what the lecturer does, thinks and talks about, rather than on the interaction and motivation of students with the fundamental concepts and skills to be learned during the course (Boettcher & Conrad 2016). These aspects are crucial in e-learning, as the role of the teacher takes a more central role, sometimes even disappearing from direct synchronous contact with the students. The characteristics of online learning call for a more through process than onsite teaching.

The way to design a fully online course should follow even more emphatically models such as Wiggins and McTighe's one (1998) that place the learner as the pivot around which course design should revolve. The model of "reverse design" presented by these authors consists of three stages: (1) identifying desired outcomes; (2) determining acceptable evidence; and (3) planning learning and instructional experiences. In the digital context, Ko and Rossen (2017) further concretise this overall process of designing a course in the virtual setting by proposing the following stages for converting or creating an online course: Analysis, Course goals and learning objectives/outcomes, and Design. As instructional design encompasses the whole design of the course, the first two steps refer to the strategic approach of the course, with the first step addressing the "Information search and analysis" and the second one dealing with "Course goals and learning outcomes". Moreover, it is more appropriate to refer to the third phase as "Design of the operational aspects". These three phases are discussed below:

3.3.1. Information search and analysis

Moving to offering a subject or course online requires certain information to be gathered. The analytical part in the design of an online

course allows for setting the stage to understanding the way in which the remaining elements of the course must be formulated to be successful in the learning process. The underlying goal of the analysis is that the instructor of the course makes the necessary decisions not based on mere subjective preferences but on solid knowledge of paramount aspects to guarantee the overall success of the course.

The initial analysis should deal with the constraints set by the institutional context. In that case, the educational framework of the course, such as its duration, the reason for its planned existence, and some other aspects that may have been decided as part of the creation of the academic degree or educational programme must be known beforehand as a starting point since they are compulsory for the implementation of the course. Apart from that, the basic aspects of the technological framework (e.g., learning management system to use, existence of technological support and its extent) are also relevant. If the educational centre offers orientation of students prior to online teaching and information to be provided to manage their expectations, the types of materials available to face-to-face students (access to labs, etc.), the support for the instructor to create and manage online course materials and activities, and resources or tools available to the instructors are also very valuable data to know.

Once the basic aspects that mark the main limits to be considered for designing the course are known, it is strategic to know the characteristics of the students who are going to enrol or participate in the course. In many educational contexts this information will not be available until the very beginning of the course. This implies that the instructional design process must be seen as a dynamic process in which new strategic or valuable information for the development of the course or simply feedback on the students must trigger modifications or fine-tuning in other elements that have probably already been designed based on erroneous or simply different premises. Often, in the first session, it is interesting to ask the students to introduce themselves by asking them a series of questions aimed at finding out fundamental details for the correct implementation of the course. These questions can be asked in a synchronous session, asking for oral answers from the students, or with comments in the video call chat. Obviously, and more so in asynchronous situations, it is also possible to promote the presentation of the students by referring to the aspects they are interested in knowing in the forum or other similar means of communication provided in the learning management system of the course. In the absence of such information, the most obvious approach

is to rely on previous situations if they exist or to assume certain assumptions based on the increased likelihood of their materialisation.

With regard to the characteristics of learners that tend to be most relevant, the previous chapter has already reviewed the fundamental aspects of learners that affect the learning process and even determine their success. In a summarised way, the most desired information about the students participating in the course is the total number of students enrolled, their degree of significant prior knowledge about the field of the course, their average age, if there is a uniform group of students or several identifiable groups, the proportion of working students, if the students are local or from other regions and countries, if they are familiar with the use of the learning management software used at the educational centre or not, etc. But a key element to know is the academic needs of these students. For Eshtehardi (2017), the needs analysis is actually the starting point for a course design. The information about the students' needs becomes key to define course objectives and to select relevant material for the syllabus.

Another relevant aspect is the characteristics of the instructors. Although there is usually a basic knowledge of the colleagues who are going to teach the course, it also helps to establish certain requirements or skills so that these teachers can implement the course designed with guarantees of success. In this sense, in the event of the possible incorporation of new teachers or permanent or temporary changes in the training team, the replacement of these people can be done in a way that minimises problems. In this sense, it helps to make explicit the basic knowledge of the field of knowledge of the course and the pedagogical and technological knowledge that will be necessary to carry out learning activities that have already been designed.

There are a number of additional aspects that should also be researched. Thus, it is very interesting to obtain and analyse information on similar courses offered by other educational institutions. However, the analysis of the environment and the search for employability for students requires identifying new trends and developments in the field, often with a multidisciplinary approach.

3.3.2. Course goals and learning outcomes

Educational objectives are a commitment between the actors involved (mainly lecturers and students) to achieve certain outcomes and take action. They are defined as goals, outcomes or specifications of desired future states. A directive view of educational objectives is associated with generic and broad objectives being translated into more operational objectives and so on, creating a chain. Objectives can

undoubtedly influence the behaviour of members in an organisation, especially when their achievement is part of the responsibilities of specific jobs. At a theoretical level, objectives legitimise and focus attention on certain outcomes and activities, provide a guide for the allocation of resources and efforts, constitute benchmarks for assessing performance and should motivate instructors to help achieve them and students to achieve them themselves.

The approach of setting course goals and learning outcomes fosters being very clear about the role of the course/subject in the whole programme (i.e. degree, etc.) and defining what the student is intended to achieve during the delivery of the course/subject. Explicit learning goals provide a valuable aid to guide students in their learning (Simon & Taylor 2009). That is so because students tend to think that the learning goals help them determine what they need to know. In case that more passive students who are not so self-determined and engaged, course goals are a powerful source of motivation if explained and connected with current or future needs of the students. Learning outcomes focus on the measurable cognitive, behavioural and attitudinal development of students as they interact with learning activities during the whole course. For Ashiem et al. (2007), learning outcomes are what students are expected to demonstrate in terms of knowledge, skills, and attitudes upon completion of a learning experience.

Setting course goals and learning outcomes involves reflecting on why students need what is being taught, and answering the question "so what? The answer provides meaning and relevance for the course content, and this should shape the teaching purpose, objectives, outcomes, competences and also the whole subject design. In this regard, it is a matter of laying the foundations for meaningful learning to be achieved. Sometimes goals are established at a national level, or at a local level or proposed and approved by national or regional agencies. These first steps in the definition of goals and results outcomes can be very positive since they provide coherence with the rest of courses offered in a certain educational programme and entail a quality evaluation, usually provided by independent experts selected by accreditation agencies. However, what is laid down by the assessment and accreditation agencies limits the inclusion of new goals in the course responding to dynamic adaptation of several aspects and emergent trends that could be identified.

The analysis carried out on the basis of the information gathered in the first stage of instructional design serves as a basis for setting realistic but effective goals and learning outcomes. Furthermore, while these aspects are often classically defined with a focus on

benchmarking or minimising change for the risks or comfort of routines already established in previous courses, the idea of what the course offers to learners requires that these elements be carefully considered. In fact, the inclusion of innovative objectives or outcomes that are not commonly found in courses of that subject matter could become additional elements of differentiation and satisfaction that boost the success of the course and even the training programme.

3.3.3. Design of the operational aspects

This step entails the reflection on the form and direction a lecturer wants the course or subject to take. The move to an online format offers opportunities to try new methods and approaches, as preserving the quality of the course does not require finding an exact translation of what has always been done in the past. As already discussed, course design has traditionally focused on content issues, such as the content to present, its order and its degree of depth and as a result teachers focus on covering the material and finishing the book. However, trends in higher education since the late 1990s have encouraged a focus on the learner, and this should also be ensured in online teaching.

The logical process of the instructional design of an online course call for reflecting on how the course goals and learning outcomes can be achieved in an effective and efficient way in the framework of the given learning environment. Each goal should be addressed by one or more learning activities. The instructional designer's pedagogical and technological knowledge acquires a significant relevance to approach it. Thus, though online activities that focus on the presentation of contents by the lecturer should not be discarded completely, the focus of the learning activities should be the active implication of the student in the learning process, since the academic literature on education has evidenced its effectiveness. In this regard, a lecture's presentation, whether synchronous or asynchronous if any, should include the support or complement of activities to involve the students. To that end, the technical possibilities of online teaching have to be used to enhance the student's motivation and consequently the learning effectiveness.

The online environment requires sound and relatively constant communication efforts directed by the lecturer. Online teaching should not fall into the trap of offering only communication mechanisms with a low level of richness of information. According to Daft and Lengel (1984), information richness is defined as the ability of information to change understanding over a time interval. Information richness is therefore related to the learning capacity provided by an act of communication (Daft & Lengel 1986), so that communication that

enables different perspectives to be overcome or ambiguous aspects to be clarified in order to modify understanding in a timely manner is considered rich in the specified sense. Conversely, communication with a low degree of richness will be that which fails to overcome different frames of reference, or which requires a considerable period of time to enable understanding. Thus, the mere use of text is associated with employing a mechanism with low level of richness of information; by contrast, face-to-face online sessions, videos, oral explanations, etc. are characterised by higher levels of richness of information and it fosters understanding in learning activities.

Time management and cultural awareness are two additional aspects that must be present in the definition of the operational learning activities. Novel approaches usually result in time-demanding activities, and their potential long duration and level of effort can introduce barriers in the student's motivation. At the same time, as a general approach of clear instructions for the learning activities is required, the lecturer's cultural biases or focus on a certain group of students can translate into misunderstandings that students who do not belong to the mainstream cultural group can experience with the consequent obstacles in their learning process.

3.4. Recommendations to design an online course

To complement this approach to design, it is of interest to provide some solid recommendations that can be applied in the process of converting or creating online teaching of a subject. Boettcher and Conrad (2016) establish 14 best practices for teaching-learning in the virtual and hybrid environment that contribute to achieving effective, efficient and satisfactory experiences for both teachers and students. These practices emerge from research and educational theories as well as experts, and are as follows:

8. Being present in the course. This implies that the learner wants to know the instructor and that the instructor cares about their learning. Since the learners cannot see the instructor in person, they want to see and hear him/her in his/her words and audio and/or video messages. This best practice is embodied in the abundant use of communication tools such as announcements, unit introductions, discussion forums, feedback, and other messages aimed at reassuring the student that the lecturer cares about their learning, questions and concerns.
9. Create a supportive community in the course. In a face-to-face environment it is assumed that a learning community develops

spontaneously as students usually have opportunities to get to know each other and build friendships; however, in digital environments it requires momentum and planning. This translates not only into the use of diverse and balanced dialogue patterns that go beyond the classic instructor-student relationship to encompass also dialogues between learners and even between learners and resources.

10. Develop a set of explicit workload and communication expectations for students and instructors. These expectations help to achieve work-life balance and also help to build good habits for students. Developing and communicating explicit expectations reduces uncertainty and encourages effective time and learning management.
11. Use a variety of individual, small group and large group learning experiences. Variety in this type of work allows students to draw on and develop their own skills and capacities. Initially students tend to respond positively to working with one or two students, but later and for more complex projects groups of four or five individuals work well.
12. Use synchronous and asynchronous activities. While early digital courses were basically asynchronous with no live interaction, in recent years it is very common to have a large percentage of synchronous experiences. Both options offer advantages: on the one hand, opportunities for participatory brainstorming in real time, and on the other hand, possibilities for reflection, planning and writing.
13. Soliciting informal feedback early in the course. This feedback, for example in the second week of a 15-week course, helps to introduce changes or activities that improve the course experience.
14. Prepare discussion prompts that invite reflection, response, questions and debate. This highlights the importance of the discussion forum as the central communication space of the learning community.
15. Think digitally for all course content. If the content is not accessible in digital format, additional barriers to access and use are being put in place. Connecting these resources to current events or encouraging the sharing of resources are also interesting possibilities for these courses.
16. Combine learning of core concepts with personalised learning. The teacher needs to identify the core concepts, questions and performance objectives of a course, but also mentor students through a set of increasingly complex and personalised

questions and projects that allow them to apply these core concepts and develop their own knowledge structures.

17. Plan a good final and closing activity for the course. End-of-course experiences often include reports and presentations that provide insights into the useful knowledge that students have built up in the course.
18. Continuous assessment by collecting evidence of learning. This type of assessment makes it possible to focus on what the student is doing and thinking throughout the course, and avoids placing all the weight of the assessment on a final activity or exam.
19. Rigorously connect content to core concepts and learning outcomes. Learning takes time and deep learning is about seeing and using concepts in different contexts, settings and relationships.
20. Develop and use a conceptual framework of the content for the course. In order that learners do not become overloaded and lost in the course development it is very useful to design a framework or conceptual map for the course and to get into the habit of using and referring to that map as the course progresses.
21. Design experiences that help students progress on their journey from novice to expert. This best practice suggests reflecting on strategies and approaches that assume that students want to develop knowledge, skills and expertise in a field of knowledge and do what is necessary to help them move towards that goal.

Additional recommendations to enhance effective instructional designs of online courses will be provided in the rest of the chapters of this work. Special attention should be given to the advances of neuroeducational approaches that are emerging as has been included in chapter 2, since that field is very promising.

3.5. References

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4. The Student Context and Types of Learners

In online education, it is crucial to understand the context in which we will conduct our teaching activities and the types of students we will encounter. Although online students may share some similarities with traditional in-person students, their approach to online learning can differ significantly from how they engage with face-to-face instruction. We must recognise and address the specific challenges of this form of education, mitigate its weaknesses, and leverage its strengths. Additionally, we must acknowledge that the profiles of online students may vary more than those in conventional settings. For instance, some students may be balancing academic responsibilities with work, family, or other personal obligations, leading them to pursue online education. These students are often highly motivated and resilient but may not be able to dedicate as much time to their studies as traditional students. In this chapter, we will explore these diverse student profiles and provide strategies for addressing them.

Learning Goals

- ∞ To understand the environment in which online teaching occurs.
- ∞ To know the different profiles of students with whom we will work in online teaching.
- ∞ To know how to deal with the different types of online teaching profiles.
- ∞ To know the specific profiles of online students.
- ∞ To know and take advantage of the strengths of online students to program teaching.
- ∞ To know and combat the weaknesses of online students.

4.1. Different learning profiles in digital settings

When approaching online teaching, we must recognise that it enhances the democratization of learning by providing access to higher education for students who, for various reasons, might otherwise be unable to pursue it. Our virtual classrooms will consist of students from a wide range of national, social, cultural, ethnic, and religious backgrounds. This diversity inherently distinguishes the online student body from that of traditional face-to-face education and necessitates a shift in how we approach and adapt to teaching in this medium. While this diversity enriches the educational experience, failure to account for it from the outset may result in frustration for both instructors and students.

4.1.1. The online teaching student profile

There are various types of students who participate in online education, and it is essential to consider these differences when designing instructional programs. In this section, we will present different categories of students, classified based on our experience with online teaching. Understanding these classifications allows us to tailor our instructional methods to meet the needs of different learners. We will categorize students according to their technological proficiency, external commitments, motivation levels, and prior experience

Based on their technological proficiency, students can be categorised as those with no prior technological knowledge, those with basic technological familiarity, regular users of technology, and those with advanced technological expertise. It is important to dispel the assumption that, because we are working with digital natives, all students will automatically navigate the platform with ease. This is not necessarily the case, as prior exposure to information technologies does not guarantee an immediate adaptation to the tools used in university-level teaching, such as Moodle (Acosta-Silva, 2017).

Students without technological knowledge will lack the key skills needed to use digital tools, and as such, they will require consistent technical support from the institution. This support should come in the form of clear, standardised instructions on how to use the necessary technology. At the start of the course, institutions should provide detailed guidelines or short asynchronous training modules that allow students to acquire the basic technological skills needed for online learning. These students should also be given time to acclimate to the digital environment in which they will be learning. Students with basic technological knowledge, as previously mentioned, may still be unfamiliar with the specific tools used in the course (Díaz-Arce & Loyola-Illescas, 2021). They will require a period of adjustment to

familiarise themselves with the platform, but should be able to adapt relatively quickly. Regular users of technology may find the transition smoother, but their adaptation may not always be immediate or seamless, as they may encounter challenges specific to educational platforms. Lastly, students with advanced technological proficiency will likely have no difficulty navigating the online sessions, although maintaining their engagement may require the instructor to incorporate modern, innovative pedagogical resources.

In terms of their external commitments and available time, students can be divided into those with no other obligations, those with moderate family or work responsibilities, and those with major professional or personal commitments that significantly limit their availability. Unemployed students, contrary to what one might assume, do not necessarily have more time to study; in online education, time management and organisation are far more critical than sheer availability. These students must develop a disciplined approach to the course, adhering to strict schedules and maintaining consistent study habits. Students with moderate family or work obligations can usually organise their time effectively, although there will be periods during the course when they may struggle to dedicate quality time to their studies. Finally, students with significant time constraints will face considerable challenges in maintaining steady performance, with periods of inactivity followed by bursts of focused, high-quality engagement, often enhanced by their professional or personal experience.

When it comes to motivation, students can be grouped into those with no motivation, those motivated simply to pass the course with minimal effort, students aiming for high grades, and professionals seeking to improve their work-related skills. Unmotivated students will require clear organisation and guidance from the instructor, along with discipline and rigor in completing follow-up activities. However, the instructor must not tailor their teaching to accommodate only this group. For students whose motivation is solely to pass the course, clearly defined rules regarding the course format and content are essential. Those motivated to achieve higher grades will require moderate effort, with guidance provided to enhance the quality of their responses and work. Finally, students seeking professional development will need learning that is meaningful, clear, and applicable, accompanied by constructive and enriching feedback. Their knowledge and experience can also be harnessed to elevate discussions and contribute to the overall learning environment in forums.

Lastly, in terms of prior experience, students may range from those with no background in either digital technology or the subject matter,

to those with basic or advanced digital skills, and those with paramount or advanced knowledge of the course content. Students with no prior training will need a gradual introduction to both the subject matter and the online learning environment. They will require opportunities to ask questions and improve their understanding, necessitating an adaptation period to the teaching system and course content. Students with basic digital training will need to adapt to the more advanced requirements of online education but should be able to gradually integrate into the course. Finally, students with both digital proficiency and knowledge of the subject will have an easier time succeeding, and their expertise can be utilised to enhance the learning dynamics. These students may require additional content to further develop their learning and maintain their engagement.

4.1.2. Methods to address these profiles

To effectively manage a diverse student profile in online education, instructors must avoid relying on approaches traditionally used in face-to-face teaching. Instead, they should focus on a comprehensive, adaptable method applicable to all students. Once a general approach is established, it must be tailored to address the specific concerns and needs of individual students. Initially, the method should be broad, but its application should be adjusted to each student's profile. From the outset, the instructor must clearly outline the rules regarding presentation, learning objectives, course tracking, feedback, and assessment. This clarity is crucial. As the course progresses and the instructor observes variations in student motivation and engagement, the practical application of these principles should be adjusted accordingly. A well-structured explanation will help maintain student motivation, and each student's unique profile will dictate their pace of progress. This is an inevitable reality in online education.

It must be made abundantly clear that while the method is established by the lecturer, its success depends on the student. The instructor is responsible for leading the course, providing information with clarity and simplicity, both in terms of academic content and course logistics. The lecturer must communicate when they will engage with students, when feedback will be given, and how the course will be structured—covering preparation, the progression of lessons, and assessment criteria. The instructor should also maintain consistent interaction with students, addressing their concerns without being constrained by them. When addressing a student's question, it is important to assess whether the issue might be shared by others who may not have spoken up due to shyness or time constraints and clarify

it publicly. However, care must be taken with group interactions, as they are not always positive or well-organised.

For effective communication with students, the course structure must be presented clearly and should include: 1) information about course requirements, 2) traditional reading materials on foundational content, 3) audiovisual materials that provide access to more complex content, 4) opportunities for interaction and dialogue among participants, 5) feedback and assessment with meaningful collaboration, and 6) a transparent evaluation process. Key aspects of the course development include the required tasks, the content provided, the deadlines for assignments, the dynamics of student participation, and the tools necessary to achieve course objectives. To ensure a satisfactory course experience, five key elements must be addressed: the course environment, student and lecturer participation, the study methods, the role of the student, and the role of the lecturer (Guevara Íñiguez et al. 2021).

Creating a positive teaching and learning atmosphere is essential. Students should leave each session—whether synchronous or asynchronous—feeling that they learned something valuable, even if indirectly, and that the session provided them with tools for further study. It is crucial to guide students through the learning process step by step, highlighting the differences between online and face-to-face learning. Instructors should aim to solve problems, not create them, by fostering a socio-affective environment conducive to learning. A personal introduction by the instructor can help set this tone. While academic qualifications are important, it is more crucial that students perceive the instructor as someone genuinely invested in their learning. Encouraging students to introduce themselves, sharing their interests, motivations, and relevant circumstances can also enhance engagement. Throughout the course, students should be encouraged to ask questions without fear, even if they make mistakes, no matter how significant.

The second key element is student participation. The instructor should clearly explain the course content, objectives, and key milestones, while actively inviting students to share any difficulties they may encounter. In synchronous sessions, debates can be encouraged to foster participation, while in asynchronous sessions, students should be motivated to ask questions privately, either in writing or orally, with encouragement and praise for those who do so.

In terms of teaching methods, the focus should remain on fundamental concepts, clearly distinguishing essential content from superficial topics. Online teaching does not lend itself to individualised interaction with each participant. Instead, the emphasis should be on key

materials, which should combine written, visual, and supplementary readings. Meaningful interaction comes from in-depth engagement with the most motivated students or those with professional experience. While the quality of materials is important, the flexibility, openness, and quality of subsequent interaction with students are even more so.

The role of the student is critical in the development of distance learning. While the lecturer's role is significant during the planning stage, the student's role is paramount during the learning process. Students must be clearly informed of their responsibilities, which include autonomous learning—understanding that not all knowledge will be directly provided by the lecturer or materials. Effective time management is also crucial, as successful time management is a key indicator of future professional competence. Students must develop metacognitive skills, taking control of their learning and discarding ineffective solutions independently. Additionally, they must embrace teamwork with peers who bring diverse perspectives, helping to avoid errors that may arise from working in isolation. Students should also be aware that the ability to source information independently, beyond what the lecturer provides, is vital. Furthermore, they must recognise the importance of clear communication, both publicly and privately, and learn to manage frustration when challenges arise. Achieving these goals requires proficiency in comprehensive reading, problem-solving, critical analysis, researching innovative solutions, and communicating results effectively.

As mentioned, the lecturer's role is essential, particularly in the planning and subsequent motivation needed to sustain learning. The instructor's first task is to prepare the teaching materials with clarity, combining written content with concise, direct audiovisual elements relevant to the student's context. It is evident that synchronous interaction is less valuable in online education, making careful scheduling and course design essential. Clear instructions regarding what tasks need to be completed and when should be provided. Periodic encouragement is necessary to maintain student engagement, while frustration or criticism should be avoided if participation is lacking. Group work should be encouraged, with individualised outcomes emphasised. In both synchronous and asynchronous sessions, only the most critical content should be highlighted, with synchronous sessions used to address doubts and concerns. The goal in these sessions is not merely knowledge acquisition but fostering an understanding of key concepts, encouraging student participation, and creating a positive learning environment. Providing individualised feedback is particularly important and should be done as much as possible. Feedback on students' work is critical for their learning progress (Dias-Trindade et al. 2020).

In summary, the four keys to successful online teaching are: 1) organising the content effectively, 2) fostering debate to facilitate learning, 3) encouraging reflection on what has been learned, and 4) providing both academic and emotional support throughout the learning process. Practically, this involves giving students clear and precise instructions, providing timely and concise responses, monitoring student progress, and creating a climate of trust. It is important to note that in this context, there are no gender differences in teaching performance, although differences may arise based on age (Hidalgo & Gisbert 2021).

4.1.3. Specific aspects of university students

We can clearly point that all university students align with the previously outlined profiles, and that lecturers who possess these competencies will be better equipped to address the challenges of their discipline. However, it is crucial to account for the necessary adaptations and specializations specific to the subject area, which are indispensable for effective instruction.

These students will require strong skills to prevent disengagement from the course content. Therefore, it is crucial to emphasise the need for basic digital literacy prior to the start of the course, especially given the uncertainty regarding students' proficiency levels. Providing brief introductory modules on prerequisite knowledge in key areas may be necessary. Additionally, we may need to offer guidance on performing basic tasks, supplemented by exercises aimed at bridging any knowledge gaps related to fundamental institutions that students may not be familiar with (Randolph & Tasto 2019).

To accomplish this, the initial activity plan focused on essential knowledge must be rich and diverse, providing substantial feedback before delving into the core content of the syllabus. It is important to consider that we may need to offer instruction on how to complete basic exercises to close the knowledge gap related to essential prior educational stages or institutions. Additionally, we can leverage third-party videos or those created by the students themselves (Ortiz Luzuriaga et al. 2016).

4.2. Strengths and weaknesses of online teaching and learning

We must set aside our previous perspectives on face-to-face teaching and approach online instruction with an understanding of the student profiles we are working with. We cannot expect direct visual engagement from all students in an online setting, even during

synchronous sessions. It is important not to become frustrated if students choose not to turn on their cameras or if, at certain moments, they may be multitasking. These behaviours are, to some extent, unavoidable. Rather than dwelling on the disadvantages we cannot control, we should focus on the opportunities and strengths of online education. Whether or not a student has their camera on, or even if they temporarily disconnect, our focus should remain on the active learners who are engaged with the course content.

As we have observed, students will require basic knowledge in our subject, as well as specific knowledge from other disciplines, which places us in a position to guide them in these areas. If this is done effectively, the complexity and richness of activities will increase as the course progresses. A proper initial feedback phase will be crucial in reinforcing what students are learning. At the start of the course, students will need more detailed and meaningful information, accompanied by high-quality feedback delivered to the entire class. This approach will enhance the overall learning experience. Providing public feedback—without identifying the source—can be especially beneficial, as it allows students to see common mistakes and doubts addressed by the instructor before they even engage with the material (Vinicio Lozano & Bastidas Romo 2019).

4.2.1. Strengths of online teaching

From a social standpoint, one of the key advantages of online teaching is the ability to reach a significantly larger number of students with the same instructional effort. This approach dramatically expands access to education for students who may otherwise be unable to attend in-person classes. Additionally, online teaching allows both instructors and learners to engage from any location in the world, broadening the scope of influence and enabling the dissemination of knowledge on a global scale. This democratization of education fosters more inclusive teaching, as it facilitates access for disadvantaged communities and individuals with limited resources. In turn, this improved access to knowledge supports economic planning and development in underserved regions, contributing to a more equitable economy and a balanced economic system. Online teaching thus enhances inclusivity, not only in terms of physical accessibility but also by reaching sectors of the population that might be excluded in traditional educational contexts.

From an academic perspective, online teaching offers a greater capacity to develop reusable and effective materials that simplify instructional tasks over the long term. We can create documented audiovisual resources based on both our own expertise and external

sources, which allow for more comprehensive and accessible explanations for students. This approach not only enhances the learning experience but also contributes to more efficient and sustainable teaching practices.

Explanations that may not be fully grasped in a specific moment during class—and which cannot be immediately revisited in a traditional face-to-face setting—can be prepared, refined, and delivered more effectively in online teaching. These explanations can remain accessible over the long term and be continuously updated, adapted, and aligned with current realities, something that is not easily achieved in real-time, in-person instruction. This flexibility allows us to tailor the materials to address the specific learning challenges we encounter within the student body (Albertos et al. 2016).

Furthermore, as previously mentioned, we can naturally integrate third-party resources that enhance learning, which are not as easily accessible in traditional face-to-face instruction. In online education, the ability to offer supplementary materials, such as freely accessible videos, explanations, commentaries, or perspectives from external sources without the need for copyright payments, is a distinct advantage. In contrast, incorporating such materials in face-to-face teaching can be perceived as less valuable or appealing. Lastly, online learning offers greater flexibility in adapting to current events, emerging trends, and contemporary issues, allowing for more meaningful reflections on societal changes.

4.2.2. Weaknesses of online teaching

One of the primary challenges faced by instructors transitioning from face-to-face to online teaching is the inability to see their students. However, this should not be regarded as a significant obstacle and must be dismissed as an issue immediately. The essence of online teaching does not lie in students visually observing their instructor during synchronous or asynchronous sessions, but rather in their ability to comprehend the material being presented. Students should be allowed to turn off their cameras without this posing any concern. In many cases, students may need to disable their cameras due to limited bandwidth or connectivity issues, and this should not be seen as problematic. What should truly drive us is their presence and willingness to engage, provided we offer them meaningful learning experiences.

One of the recurring challenges in teaching is the constraint of time, as educational programs often have limited content and scope. At the beginning of a course, considerable time is often lost on administrative tasks and technical issues related to connectivity. However, it is

essential to allocate time at the outset to address these problems. Once they are resolved, we can concentrate on the more specific and complex subject matter, which can be difficult to explain at times. For minor issues, we can provide supplementary materials, while for major challenges, a more detailed explanation is necessary. It is crucial to leverage the platform's supplementary resources to establish basic concepts, allowing us to later focus on the more difficult aspects of the content. One approach is to initially address students' prior questions, dedicating a portion of the class to resolving them, and then uploading written responses to the platform for future reference. Once these preliminary concerns are addressed, we can shift our attention to the more significant issues of the course. This strategy helps consolidate students' questions and prevents the volume of inquiries from becoming an obstacle to progressing through the core topics of the course (Trujillo García et al. 2019).

Lecturers often express frustration over the inability to provide individualised explanations to each student. However, one of the key advantages of online teaching is its capacity to deliver a large volume of information to a broader group of students simultaneously, ensuring that all receive it from the same source—the instructor—at the same time. This approach enhances the overall learning experience, making it more effective and accessible to a wider audience. In terms of student assessment, the development of standardised evaluation templates and formats can be a highly effective method, a topic that will be revisited in Chapter 0 of this book.

4.2.3. Methods to use strengths and limit weaknesses

The key strategies to overcome these challenges are effective planning, fostering a positive attitude in the classroom and toward teaching, informed monitoring of class participation, and providing constructive feedback. In terms of planning, a clear and well-informed teaching plan must be presented at the beginning of the course, detailing deadlines and student responsibilities. It is essential that all students understand the timelines for lectures, consultations, and evaluations. The schedule should be adhered to closely, and any modifications must be communicated clearly, along with their reasons and consequences. Using designated dates for both collective and individual feedback can help optimise the time spent with students.

Regarding classroom attitude and teaching approach, participation should be actively encouraged, even when contributions may not be particularly significant or knowledge-intensive. Offering time for participation and acknowledging it is important, as it allows instructors

to use students' opinions on pre-structured topics to further develop key aspects of the syllabus. It is also important to balance formal lectures with periods of open discussion, where students can express their doubts, concerns, and difficulties, even if these are fundamental. The goal is not to cover all course content during virtual sessions; rather, the focus should be on ensuring that students have access to comprehensive materials on the teaching platform.

An informed system for monitoring class participation should also be in place, even if it is primarily used for resolving potential uncertainties. While it may not always be entirely reliable or of high value, keeping a record of student interventions serves to encourage engagement. The purpose is not to quantify participation mathematically, but to foster a more interactive learning environment.

All feedback provided by the lecturer during the session should be positive and assertive, grounded in the context of the discussion and recognizing the student's potential. It is important to approach comments with the understanding that a student's lack of knowledge may reflect common gaps among their peers, and they may need additional guidance beyond what the online format offers. Feedback must be clear, honest, comprehensive, coherent, and transparent, with particular precision in addressing the specific questions raised. Similarly, evaluation criteria should reflect these same qualities, as online students require clarity and certainty regarding how they will be assessed.

The evaluation process should aim to motivate and empower students, encouraging meaningful learning where the emphasis shifts from numerical grades to the value of knowledge construction. While academic assessments must remain fair, grades should be viewed as one of the many tools to address the challenges of online education, not as an additional hurdle. Clear evaluation dates should be communicated well in advance.

To optimise time management, experienced instructors who have a strong grasp of both the subject matter and common student mistakes can provide individualised feedback. This feedback may be concise and targeted, with reflective or general corrections that, while stereotyped, can be highly significant. Such corrections can lead to more authentic learning experiences, contributing to the student's development and improving the overall quality of the instructor's work (Buenaño-Barreno et al. 2021).

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5. New methods in online teaching

Online teaching requires the implementation of teaching methods that actively promote and support student autonomy. Consequently, online instructional methods must evolve along two key dimensions. First, traditional written materials, such as manuals and discipline-specific content, remain essential, as do lecturers' explanations. However, these documents must be concise, highly pedagogical, and free from excessive information, while explanations should facilitate students' independent engagement with the material. All resources should be designed to support the student's self-directed study of the subject matter. Second, learning activities take on greater importance, both in their structure and format, as they play a crucial role in fostering meaningful learning and moving towards authentic assessment. Finally, audiovisual materials are indispensable in online education, as they can effectively compensate for the absence of in-person interaction with the lecturer.

Learning Goals

- ∞ To understand the specific characteristics of teaching methods in online teaching.
- ∞ To understand how written documents and the lecturer's explanation must evolve in online teaching.
- ∞ To know the importance of learning activities.
- ∞ To know how to develop good learning activities that lead us to meaningful knowledge.
- ∞ To be able to develop useful and effective audiovisual content in online teaching.
- ∞ To know the diverse types of audiovisual content of online teaching.

5.1. New pedagogical methods in online teaching

As we have explored thus far, different educational environments require distinct teaching methods and materials. In Chapter 0, we will focus on the appropriate format for instructional materials, while in this chapter, we will examine how teaching methods must evolve to meet the needs of online education. A key principle of online teaching is that the majority of student learning will occur independently, beyond the direct supervision or guidance of the instructor. Consequently, traditional in-person teaching methods are not directly transferable to the online environment. We cannot expect immediate feedback on student comprehension during synchronous online sessions, as we might in face-to-face instruction. Instead, this feedback will emerge later, after students have engaged with the material on their own.

For this reason, it is essential to provide students with a method that fosters autonomy and self-regulation, enabling them to study both individually at home and collaboratively with peers, even though the outcomes are assessed individually. Our goal should be to design learning activities that demonstrate students' meaningful mastery of the subject matter and their ability to apply this knowledge. It is important to critically evaluate which teaching methodologies enhance student autonomy and which do not. As educators, we cannot employ the same methods in online teaching as we do in face-to-face settings. Making this mistake would undermine the effectiveness of online education, and it is a pitfall we must consciously avoid.

For this transition, the first evolution must occur in our own approach to teaching. We must move beyond merely presenting content to linking content with appropriate formats and methodologies. The traditional role of the synchronous lecturer becomes less central, while the importance of clear instructions increases. Written materials must explicitly acknowledge that the student's work is independent and self-directed, with minimal direct intervention from the lecturer. These materials should be complemented by visual aids and meaningful, well-sequenced learning activities that contribute significantly to the final grade. In this model, the final exam carries less weight than the cumulative development of learning activities, where students demonstrate their mastery of the subject and their ability to solve real-world problems they may encounter in their future professional careers (Guevara Íñiguez et al. 2021).

5.1.1. General introduction and initial approach to the subject

Thus, our focus shifts from ensuring student's attention during online and distance sessions to providing students with the most suitable

materials for learning the subject effectively. Before moving on to specific activities, our primary consideration must be the careful planning of our teaching approach and course structure, as well as the quality and clarity of the written materials we provide to our students.

In terms of planning, the lecturer must, through prior preparation, facilitate the student's initial engagement with the discipline and the subsequent development of the course, fostering a genuine willingness to learn. It is essential for educators to be reflective, critical, and creative when designing the student learning process. We must present the content in a way that enables students to comprehend it independently. Our goal should be to ensure that students, by following our materials and methods, can autonomously attain the deep understanding of the discipline that we aim to teach. Additionally, students should acquire the skills necessary to 'learn how to learn,' and develop the ability to assess whether they are achieving meaningful learning. The lecturer's role is to construct the infrastructure, resources, and activities in a generalised manner, allowing each student to engage with and utilise them individually.

To achieve this, the lecturer must prepare several key elements before the beginning and development of the course: a general outline of the essential content required to successfully pass the subject; a comprehensive conceptual map that reflects the entire structure of the discipline's knowledge; a breakdown of the knowledge structure for each part of the syllabus to facilitate easier access; information on fundamental ideas and core concepts, which may later form a final glossary of terms; and annotations that help make the knowledge more meaningful (Cavero-Almenara et al. 2022).

In the evolving landscape of online education, several key factors contribute to effective teaching performance. The lecturer must provide clear and precise instructions for each learning process within the subject. A well-structured outline of the content, along with a clear understanding of both the student's obligations to pass the course and the lecturer's responsibilities, is essential. Timely and clear responses to student inquiries are highly desirable. If a common question arises, it is beneficial for the lecturer to address it in the course's general forum to benefit all students. If a response cannot be provided within a reasonable timeframe, it is crucial to communicate the delay to avoid uncertainty, which can be detrimental to the student's learning experience and the lecturer's credibility.

Regular monitoring of class activity is essential and should be conducted consistently—whether daily or several times a week—in a sequenced and predictable manner. While individual feedback is

preferable, collective feedback should be provided when individual responses are not feasible. Above all, it is important to foster an atmosphere of trust and comfort, encouraging students to ask questions, even when they are acknowledging gaps in their understanding. Valuing such inquiry helps create a positive and productive learning environment.

Regarding written materials, it is highly advisable to provide a general manual that covers all key aspects of the discipline. The manual should be written in a clear and direct manner, emphasizing essential concepts and avoiding content that is not directly relevant or does not add value to the subject. As a result, these manuals may be shorter than traditional ones, but should offer more concise and pedagogically focused writing. It is beneficial for the manual to include concept maps that outline both the overall content and each individual topic, along with clearly stated objectives for each section. Additionally, at the end of each topic, a glossary of terms, a set of test-style questions to assess comprehension, and activities to help students gauge their ability to apply the knowledge in practice should be provided. These resources will help students independently verify their understanding of the material they have studied.

In addition to the general manual for the subject, it is beneficial in online teaching to provide students with supplementary materials such as articles, news reports, economic analyses, and current economic situations. These materials serve a primarily descriptive purpose, offering real-world contexts in which students can apply the economic knowledge they are acquiring. This approach helps bridge the gap between theory and practice, providing students with practical examples that support their engagement in learning activities (Buenaño-Barreno et al. 2021).

5.1.2. Effective design of activities

The learning activities designed for online students should foster not only the construction of knowledge but also the application of active self-learning principles. It is insufficient for activities to merely serve as assessments of constructed knowledge, as this can already be accomplished through review questions or exams. Instead, these activities should be geared towards the development of both general and specific competencies within the subject, particularly those of a practical and professional nature. The activities should ensure that students demonstrate their theoretical understanding while also applying this knowledge to solve real-world problems relevant to their future professional roles.

When focused on this direction, the activities become integral to meaningful learning. They should challenge students to solve future problems, analyse the practical applications of theory, anticipate future events, or critically assess complex cases that have already been resolved. These are just a few examples of the types of activities that can be implemented. Educators involved in online teaching must exercise creativity in the development of new activities, and it is strongly encouraged that all lecturers explore innovative approaches in designing these tasks.

Therefore, it is not appropriate for learning activities in online teaching to consist solely of answering multiple-choice questionnaires or other simple memorization tasks. Nor should activities involve merely summarizing the content of the manual without expanding upon, relating, developing, or applying the concepts in practice. Additionally, activities should not require students to use resources that are not readily accessible to them, demand skills that cannot be realistically developed within the educational environment, or address issues unrelated to the student's future professional practice.

To achieve this objective, the activity must build on the student's existing knowledge and, from that foundation, provide clear requirements, a well-structured task, and an explanation of the diverse didactic strategies and resources that can be utilised in both developing and responding to the activity. The activity should encourage the use of external resources and foster creativity, stimulating meaningful thought. It should present a challenge, but one that is achievable with a solid understanding of the syllabus and the resources provided. Activities can be either individual or collaborative, although it is advisable that the final presentation contains some degree of individualization for assessment purposes.

In relation to content, the activity should focus on topics that are both relevant and central to the subject. It should also follow a progression of increasing complexity, which implies that our evaluation should be more lenient for the initial activities and become more rigorous as students advance. A carefully calculated and appropriate amount of time, as well as a reasonable workload, should be allocated to each task. While the evaluation of the activity will be discussed in more detail later, it should focus on multiple aspects, including knowledge construction, the problem-solving process, and the achievement of progressively challenging goals. The evaluation must be both authentic and meaningful, with significant weight placed on the rubric, which we will address in more detail subsequently.

To achieve this, the activity must begin with a concise but clear description outlining the nature of the learning task, providing a general understanding of its purpose. The description should explain the components of the activity, the processes involved, and the intended outcomes for the student. It must clearly state what needs to be done (procedure) and how it should be executed (method). If necessary, to enhance understanding, a worked example or clarification of potential student doubts should be provided. For instance, the task might involve creating a problem based on a given scenario, analysing a correct or incorrect solution conducting a study of a situation relevant to the domain of study, or evaluating a specific scenario. In each case, the activity should require the student to analyse the best resource to use and outline the steps that need to be followed.

The activity must clearly state its objectives, outlining the connection to the subject matter and the expected outcomes for the student. Both general and specific objectives should be articulated using definitive, clear, and measurable verbs that can be evaluated and verified. For example: ‘select sources of information to support the solution,’ ‘analyse potential scenarios,’ or ‘propose solutions to the given problems.’ The activity should also specify the resources and materials required for its completion. These resources may include necessary tools for problem-solving, such as formulas, theories, statistics, data, software, or analytical tools. Additionally, the materials to be used, such as the course manual, articles, dictionaries, or other relevant elements, should be clearly indicated (Sangrá 2020).

5.1.3. Effective development of activities

If the activities have been designed thoughtfully, the average student should be able to understand the instructions. After this, it is important to provide students with the opportunity to ask questions and seek clarification on any aspects of the activity that concern them. All queries should be addressed in a general and objective manner, ensuring that students are fully aware of what is expected of them and how they will be evaluated.

For the evaluation process, the key element is the rubric, which must clearly and accurately outline what will be assessed. Providing effective feedback and grading is essential. Students should be informed of both their strengths and areas for improvement, and should be given the opportunity to correct their errors with concise but clear guidance in an environment of trust. If students are permitted to revise their work after an initial correction, they should be provided with suggestions for improvement rather than the correct answer. In the final

evaluation, where no further revisions are allowed, the correct solution should be provided. A collective response to the entire class at the conclusion of the evaluation may also be offered.

The evaluation criteria must clearly define the knowledge and skills that students are expected to demonstrate. For example, whether the ability to identify relevant sources of information, present a well-structured text or solution, or clearly articulate a theory is being assessed. The grading criteria should explicitly state the score or percentage allocated to each task or achievement. It is essential to specify in detail how each piece of work will be evaluated and under what conditions this evaluation will take place.

In any type of evaluation criteria, there must be a clear statement regarding what the student is expected to produce, along with a reference to the quality of the work. These elements are essential in determining whether the student meets the success criteria for the task. It is highly beneficial to complement the numerical grading system with qualitative explanations of what will lead to the achievement or non-achievement of the objectives. A well-constructed rubric is particularly useful in this regard, as it outlines what constitutes deficient, average, satisfactory, and excellent performance (Centurión César et al. 2021).

5.1.4. Group activities

Group activities are also a viable option in this modality, as online teaching facilitates collaborative work, allowing students to rely on each other and resolve general queries collectively. The design of group activities should mirror that of individual tasks, with clear requirements and responsibilities outlined for each member. These activities can be either lecturer-assigned or student-chosen, with the latter option requiring prior notification to the instructor. Interaction between individual and group content should be integrated, enabling students to engage with both types of material. Groups may submit a unified result, a collective output, or related segments of the project, but evaluation must always align with the specified requirements and be capable of individual assessment. Students will receive both individual and, where possible, collective evaluations to assess each member's contribution to the activity (Sangrá 2020).

5.2. New pedagogical methods in audiovisual teaching

As previously discussed, written theoretical content remains particularly important in online teaching, although its structure and presentation must be adapted for this format. In addition to written material, it is both advantageous and necessary to provide high-quality visual content. In an

online environment, where written material can often be dense and challenging, visual aids offer students easier access to the core ideas. Videos, in particular, should serve as introductory tools, helping students familiarise themselves with key topics and gain preliminary knowledge of theoretical concepts. It is especially beneficial for the instructor to create these videos, as they not only introduce the content but also help establish an initial connection between the lecturer and students, fostering a sense of trust (López Díaz et al. 2021).

We must adapt our teaching methods to the current learning process, embracing flexibility and creativity. It is important to recognise that videos are more easily accessible and engaging for today's students, many of whom, despite the necessity of reading books, no longer engage with written material as thoroughly as they should. For these students, video is often the most practical and direct way to capture their attention and convey the essential information they need to learn. By doing so, we can spark their interest and motivate them to subsequently study the course manual in greater depth. To achieve this, videos must be meaningful, concise, and designed with incentives that encourage students to engage with the subject. Watching the video alone should never be sufficient to pass the course, but rather, it should serve as an effective starting point for deeper study and comprehension of the subject matter.

To achieve these objectives, several key aspects must be considered before creating the video. The first is to clearly define the pedagogical purpose of the video—whether it serves as an introduction to a topic, a focused explanation of a specific concept, or a resolution of a particular or general question. Next, evaluate the necessity of the video, taking into account whether it is essential or if some students may not have access to it. Its usefulness and relevance to the broader course content must also be carefully considered. Additionally, the instructor must assess the intended impact of the video: whether it is purely informative, motivational, relevant to the students' real-world context, or designed to serve multiple purposes. Once these factors are clearly understood, the process of creating the video can begin with purpose and direction.

5.2.1. Features of the videos

Videos possess multiple inherent values, and it is essential to recognise and leverage them effectively. The most evident value lies in the transmission of information. Videos provide accessible, precise, visual, and auditory content, requiring less cognitive effort from students compared to studying theoretical material, which enhances their value

significantly. Moreover, videos have long served as an iconic tool for student literacy and communication, as students are generally more inclined to passively receive information. This inherent receptivity can be effectively utilised to enhance learning. Beyond their informational function, videos are also powerful motivational tools. Often, they serve as the student's first point of contact with new content, and their experience with the video can either inspire a desire to delve deeper into the material or deter further engagement. As educators, we must be mindful of this impact and use videos to reinforce positive messages that link the subject matter to students' financial realities, as well as the broader societal and national context.

Secondly, videos can facilitate the final evaluation by clearly explaining to students what will be required and what will be assessed in the evaluation activities. They can also serve as a tool for lecturers to enhance their own understanding of the content within their subject area. Furthermore, videos can be used to motivate students to take an active role in explaining portions of the subject matter to their peers, thereby diversifying teaching strategies and making the learning experience more engaging and attractive for students.

Videos can be utilised for a variety of educational purposes. From the lecturer's perspective, they can include condensed lessons focused on essential content, specific reports on topics of interest, recordings of answers to common questions and doubts, or updates on current issues that students should be aware of. Additionally, videos may include recordings of simulations performed by students, documentation of real-world practices, or demonstrations of problem-solving procedures across various scenarios (Morales Salas 2021).

5.2.2. The video and its educational context

As we can see, the video itself does not teach; rather, it is the context, situation, motivation, and subsequent development in the study of the subject and content analysis that facilitates learning. A video must be accompanied by relevant content, as merely watching the speaker does not sufficiently enrich the learning experience. This accompanying content may include images, texts, graphics, or presentations, which are already familiar tools. Such elements give the presentation a more dynamic flow, helping students retain key concepts. The presentation should also be provided as complementary material, allowing students to reinforce the essential information conveyed in the video.

While enhanced visual and interactive elements can make the video more engaging, they are not strictly necessary. What is important is that the content enables students to connect with the material. Another key

advantage of video content is that it can be made permanently available to students. This significantly increases its value, particularly for those with significant family or professional commitments, as it allows them to engage with the material at times most convenient for them.

5.2.3. Video context

From a technical perspective, when preparing to record a video, it is crucial to first have a clear understanding of the content in order to effectively enhance students' knowledge and facilitate their study. It is also important to determine the medium through which the video will be recorded. Today, there are numerous video recording platforms available, many of which are widely used by organisations and are accessible for free to users. We will explore these options in detail in Chapter 0 of this book.

To create a successful video, a well-structured graphic and content outline, along with a script, must be prepared, accompanied by the complementary material previously discussed. Only with this preparation can the video be executed effectively. Further discussion on the development of audiovisual materials can be found in Chapters 0 and 0 (Núñez Gómez et al. 2015).

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6. The Technical Context of Online Teaching

Online teaching requires a technical context that needs to be studied and evaluated when preparing materials and content. One of the most important aspects of today's e-learning is the learning management system, which we will study in depth in this chapter.

Learning Goals

- ∞ To familiarise with Learning Management Systems (LMS)
- ∞ To understand the Organisation of LMS
- ∞ To know the Moodle LMS
- ∞ To be able to organise and place learning activities in the LMS

6.1. Technical basis of online teaching

The shift from blackboard-based teaching to computer-based teaching represents a new paradigm in education. In the past, lessons were dictated on the blackboard with chalk and books were used for reading. This method of teaching was sequential and step-by-step. However, with the advent of computers, almost all teaching is now based on them. This has brought about a new way of thinking about teaching and learning (see Figure 2).



Figure 2. Basics of teaching before XXI century

In a computer presentation, lessons must be prepared in a ladder way because computers can present all information at once, which can be overwhelming for students. This is a significant departure from the sequential approach of blackboard-based teaching. The new paradigm requires that lessons be prepared in a way that the student's knowledge construction is facilitated. This is essential for effective teaching and learning.

When the course was a correspondence course, it was based on books to study, mail for asking questions, and the figure of a tutor to follow the process of learning and teaching. This method of teaching was effective in its time, but it has been replaced by computer-based teaching. The new approach requires that teachers and students adapt to new technologies and methods of teaching. It is paramount for the continued success of education in the 21st century.

The shift from blackboard-based teaching to computer-based teaching represents a new paradigm in education. This new paradigm requires that lessons be prepared in a way that is easy to follow and understand. Academic staff and students must adapt to the new educational world where at least relatively advanced technologies and

methods are present. In the next sections we will introduce the tools to accomplish this, beginning with the Learning Management System.

6.2. Learning Management Systems

A Learning Management System (LMS) is a comprehensive software application designed to help educators create, manage, and deliver educational content and training programs across various settings, such as schools, universities, and professional workplaces. LMSs provide a centralized platform that enables educators to distribute educational materials, monitor student progress, facilitate communication between learners and instructors, and streamline administrative tasks. The LMS plays a pivotal role in modern education by offering an accessible and interactive learning environment that promotes flexibility and engagement.

Historically, the concept of an LMS evolved from correspondence courses, which were an early form of distance education. In correspondence courses, instructors acted as tutors, sending study materials to students by mail, assigning tasks, reviewing them, and then providing feedback. These courses relied heavily on written communication between instructors and learners, offering flexibility but with slower feedback and limited interaction. As depicted in Figure 3, the LMS builds on this foundation, bringing the principles of distance learning into the digital age. Through the internet, it enables educators to create, manage, and deliver courses and training programs efficiently.



Figure 3. Correspondence courses versus Online Education

Today, LMS platforms offer a wide array of features that enhance the teaching and learning experience. They include tools such as forums, wikis, blogs, messaging systems, quizzes, surveys, and more (Figure 4). These tools allow for real-time feedback, interactive assessments, collaborative learning, and the easy distribution of multimedia content.

Importantly, learners benefit from 24/7 access to course materials, enabling them to study at their own pace and from any location.

The flexibility and accessibility provided by LMSs distinguish them from traditional correspondence courses. While both systems offer self-paced learning, LMSs enhance the experience by integrating modern digital technologies. Learners can engage in collaborative activities, such as participating in discussion boards, working on group projects, or engaging with instructors through chat functions. These interactive features foster a richer, more dynamic educational environment.

Learning Management System

- Born in base of Correspondence Courses
- The teacher is the tutor
 - Send the study material
 - Send tasks
 - Tasks are reviewed
 - Loopback is closed by teacher feedback



Figure 4. Learning Management System (LMS)

Moreover, LMSs have adapted to the growing demand for personalized learning. Many platforms now incorporate adaptive learning algorithms that tailor content and assessments to individual learner needs, creating a more customized learning journey. Mobile accessibility has also become a hallmark of modern LMS platforms, allowing learners to access courses on-the-go, making education even more adaptable to diverse lifestyles and time constraints.

In conclusion, while LMSs and correspondence courses share a common goal of providing flexible learning options, LMSs offer significant advantages in terms of accessibility, interactivity, and engagement. LMS platforms have revolutionized teaching and learning by making education more dynamic, accessible, and collaborative, providing a powerful tool for both formal and informal educational settings. As technology continues to evolve, LMSs are expected to further integrate advanced features, continuing to transform the educational landscape for learners and educators alike.

6.2.1. Moodle

Moodle is one of the most popular LMSs available today. It is an open-source platform that is free to use and can be customised to meet the needs of individual users. Moodle provides a range of features that make it easy for educators to create and manage online courses, including forums, wikis, blogs, messaging, quizzes, surveys, and many more.

One of the key benefits of Moodle is its user-friendly interface. The platform is intuitive and easy to use, which makes it ideal for both lecturers and students. Moodle also provides unlimited access to eLearning materials, which means that learners can access the information they need at any time and from any part of the world with Internet access.

Another benefit of Moodle is its collaborative tools and activities. These tools help educators engage learners and keep them interested in the course material. Moodle provides a range of collaborative activities and tools, such as forums, blogs, wikis, chat, assignments, databases, and other resources. These tools provide learners with opportunities to practice skills, receive immediate feedback on their work, interact with peers and the instructor, and engage in meaningful communication.

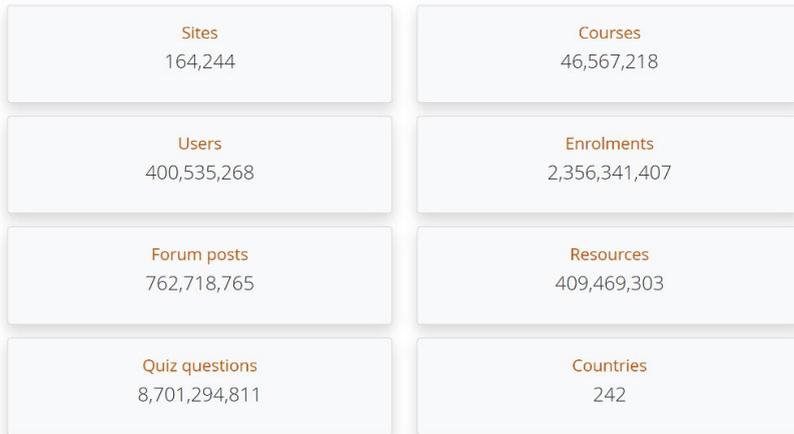
Moodle also provides a range of multimedia features that make it easy for educators to create engaging and interactive courses. These features include audio and video recording, screen sharing, and interactive whiteboards. Moodle also supports a range of file formats, including PDFs, Word documents, and PowerPoint presentations.

In addition to these features, Moodle provides a range of benefits for educators and learners alike. For educators, Moodle provides a centralised platform for managing course content and resources. This makes it easy to organise and deliver course material, track learner progress, and provide feedback and support. For learners, Moodle provides a flexible and accessible platform for learning, which means that they can access course material when and where they prefer.

In 2024 Moodle had more than 160,000 registered sites, more than 46 millions of courses, and more than 400 million users in 242 countries as stated in the statistics page as stated in Figure 5.

Hence, Moodle is a powerful and flexible LMS that provides educators with a range of tools and features for creating and managing online courses. Its user-friendly interface, collaborative tools and activities, multimedia features, and other benefits make it an ideal platform for educators and learners alike. Whether you are a lecturer, student, or professional, Moodle can help you achieve your educational goals.

Statistics



[Registered Moodle sites](https://stats.moodle.org)

*Figure 5. Statistics of registered Moodle sites
(source: <https://stats.moodle.org>)*

Sakai is another free, community-driven, open-source educational software platform designed to support teaching, research, and collaboration. It is one of the most popular LMS available today too. Sakai is known for its feature-rich and robust learning management system created by and for educators, with a focus on meaningful, participatory, and privacy-friendly learning experiences. Sakai LMS offers robust communication options, easy integration with third-party apps, and community-built tools for course creation and management.

In addition to Moodle and Sakai, there are several other popular Learning Management Systems (LMS) available in the market, such as Canvas LMS, Blackboard Learn LMS, D2L Brightspace LMS, Docebo, iSpring, MATRIX LMS, and TalentLMS. Each of these LMSs has its own unique features and benefits, so it is important to choose the one that best suits your specific needs. After all, the software should be tailored to meet your needs, not the other way around.

6.2.2. Learning Management System organisation

LMSs are organised around user profiles, which include administrators, lecturers, and students. Administrators have the highest level of access and are responsible for managing the LMS, including user accounts, security, and system settings. Lecturers are responsible for creating and managing courses, including course content, assignments, and

assessments. Students are the end-users of the LMS and are responsible for completing coursework and interacting with the course materials.

LMSs organise content into courses and categories. Courses are the primary unit of instruction and are typically organised around a specific topic or subject. Categories are used to group-related courses together and make it easier for learners to find the content they need (see Figure 6).

LMSs provide a range of features for managing course content. These features are connected through a communication system that allows learners to interact with each other and with the instructor. The communication system also provides a way for learners to ask questions, receive feedback, and collaborate on assignments.

LMSs also provide a gradebook that allows instructors to track student progress and provide feedback on assignments and assessments. The gradebook is an essential tool for monitoring student performance and identifying areas where additional support may be needed.

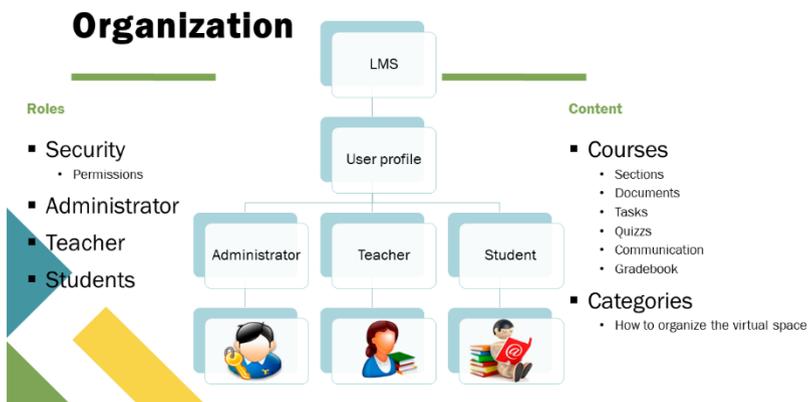


Figure 6. LMS organization

Security is an important consideration for any LMS. LMSs provide a range of security features, including user authentication, access controls, and data encryption. These features help ensure that only authorised users have access to the LMS and its content.

In conclusion, the LMS is organised around user profiles, courses, and categories. The roles of administrators, lecturers, and students are the mechanism of security within the LMS. Courses are included in categories to organise the virtual space, and each course is organised into sections to classify documents, tasks, quizzes, and other course materials. The communication system connects these features and allows learners to interact with each other and with the instructor. The

gradebook is an essential tool for monitoring student performance and providing feedback. Security features ensure that only authorised users have access to the LMS and its content.

6.2.3. Analysing Moodle in-depth

Due to its widespread use around the world and the benefits it provides, this section further analyses the use of Moodle as an interesting LMS. Moodle courses are organised around a specific topic or subject. Each course is divided into sections containing different types of content, as indicated below.

The organisation and layout of a Moodle course is very flexible and can be customised to meet the specific needs of the students and the instructor. This customisation is usually done by the administrator through what are called themes. Courses can be organised into categories for easy searching and access to content. Categories are a list of related courses that are grouped according to topic or subject. For example, in the Science category, you might have courses in Physics, Chemistry and Biology.

Within each course, sections are used to organise the course content into different topics or modules. Sections can be organised according to the length of the course or the complexity of the content. For example, a 10-week course may have 10 sections, one for each week of the course. Each section can contain different types of content, such as documents, assignments, quizzes, and other course materials.

Documents are a common way of providing information to students. Documents can be text files, presentations, videos, or any other type of file that contains information relevant to the course. These documents can be uploaded directly into Moodle or can be linked to an external resource.

Assignments are a way of assessing student learning. Assignments can be written assignments, projects, presentations, or any other assignment that the instructor deems relevant to the course. Assignments can be set up for students to submit directly through Moodle or to submit via email.

Quizzes are a way of assessing student knowledge; they can be based on multiple choice, true or false statements, or any other type of question that the instructor deems relevant to the course. Quizzes can be set up for students to complete online or to print out and hand in person or sent by email.

In addition to these types of content, Moodle also offers a variety of communication and collaboration tools. Forums are a common way to encourage discussion and collaboration among students. Wikis and

blogs are useful tools for students to collaborate on projects and share information. Chat rooms and video conferencing are useful tools for real-time communication between students and the instructor.

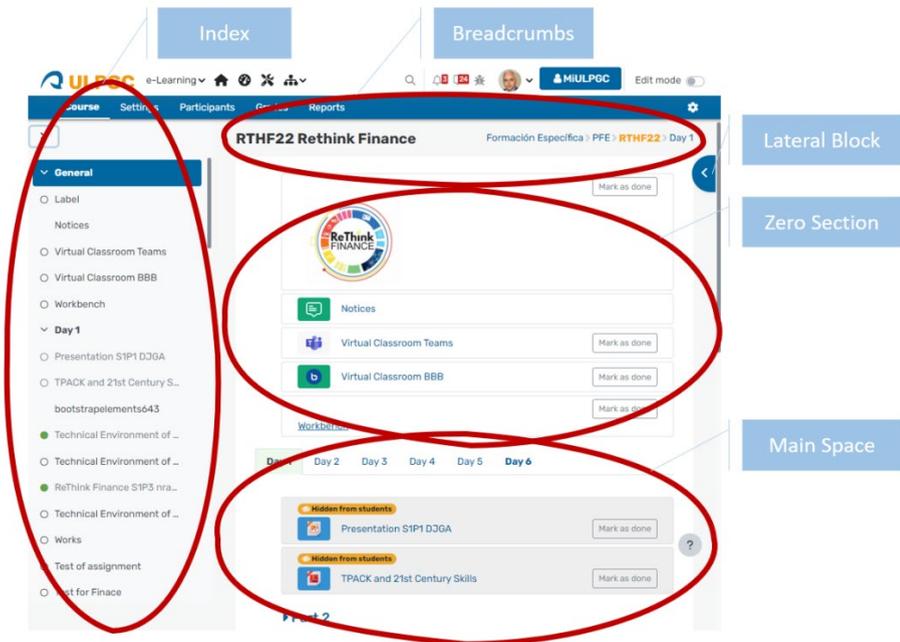


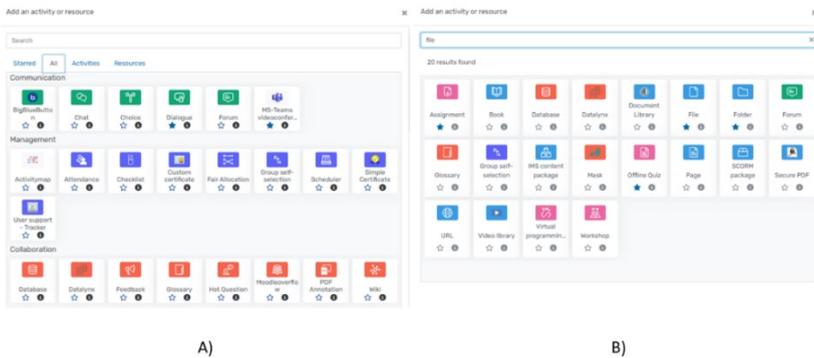
Figure 7. Workspace in moodle: index, breadcrumbs, zero section and main space.

The Moodle workspace is usually divided into areas with various information (Figure 7). At the top we have the main and sub menus. On the left we have a course index that allows us to quickly navigate to any section of the course and is retractable, to maximise the main area. The main area is placed below the zero section, which usually contains indispensable elements for the student, in order to facilitate the completion of the course. At the top, there is usually a space for breadcrumbs that allows the student to move between courses in a comfortable way, without having to resort to the main or secondary menus. There is a side block, on the right, with relevant information about the course or the current activity. It is also retractable so that it does not take up unnecessary space.

In conclusion, the organisation and layout of a Moodle course is very flexible and can be customised to meet the specific needs of the students and the instructor. Courses can be organised into categories for

easy searching and access to content. Sections are used to organise course content into different topics or modules. Papers, assignments, and quizzes are common ways of providing feedback and assessing student learning. Communication and collaboration tools, such as forums, wikis, and video conferencing, are useful to encourage discussion and collaboration among learners.

6.2.4. Teaching Activities



*Figure 8. Activities in moodle:
A) All activities, B) Filtered activities by "file" word.*

From the lecturer's point of view, editing a course consists of incorporating the activities needed to teach the course. These activities are based on modules chosen by the administrator. The lecturer chooses the module that suits the activity that s/he wants to include and fills in the necessary information to present it to the student in the most appropriate way (see Figure 8). There are hundreds of different types of activities available. But if an activity type does not exist, it is relatively easy for an expert programmer to make the module that implements it. Every month, dozens of modules are released that improve the functionality of the LMS. Users can mark any activity as commonly used with the star symbol (Figure 9).

All activities consist of a general component and a specific component that varies according to the type of activity. The general component encompasses elements such as the name, description, and other common settings of the module, primarily focused on managing availability. This includes access restrictions, which enable the selection of who can view or participate in the activity, thereby limiting access to specific groups or imposing various other restrictions as required. Additionally, it is possible to configure whether the student

can manually mark the activity as completed, or if the completion status is automatically triggered based on the student's actions.

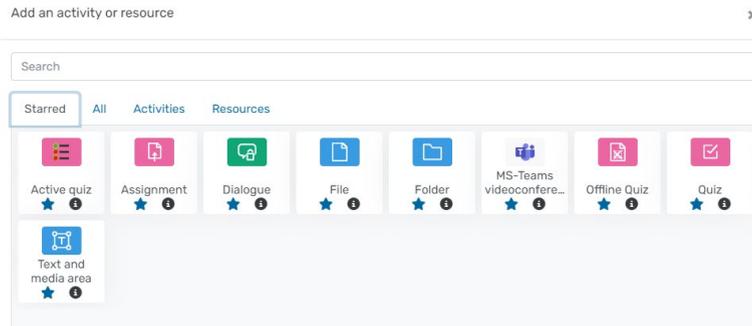


Figure 9. User can select useful activities with the star.

Activities can be assessable, which will appear in the grade book, or simply instructional, without assessment. Each student can see their own grade, while the lecturer sees all grades.

It is essential to organise courses in such a way that the student can climb the learning ladder step by step. To achieve this objective, the course must be organised clearly and in a progression of increasing difficulty, giving the basic concepts first, and then referring to these concepts in more complex units each time. To reinforce knowledge, self-assessment questionnaires are often inserted in the course to allow the student to know how thoroughly he/she has understood the lessons. The metacognition ladder (Figure 10) expresses what we need to accomplish for a good course planning or organisation.

The course can be organised by weeks or topics, or according to the organisation that the lecturer considers most appropriate to organise the knowledge it or she wants the students to acquire through long-term learning. At this point it is important to consider whether the course is entirely online or whether the LMS is a support to face-to-face teaching. The type of content is not the same and neither is the way it is presented. In the case of fully online training everything must be very well linked because the learner cannot question the lecturer in every class, but the answers to the questions he/she asks may take one or two days to be answered.

6.3. Course organisation

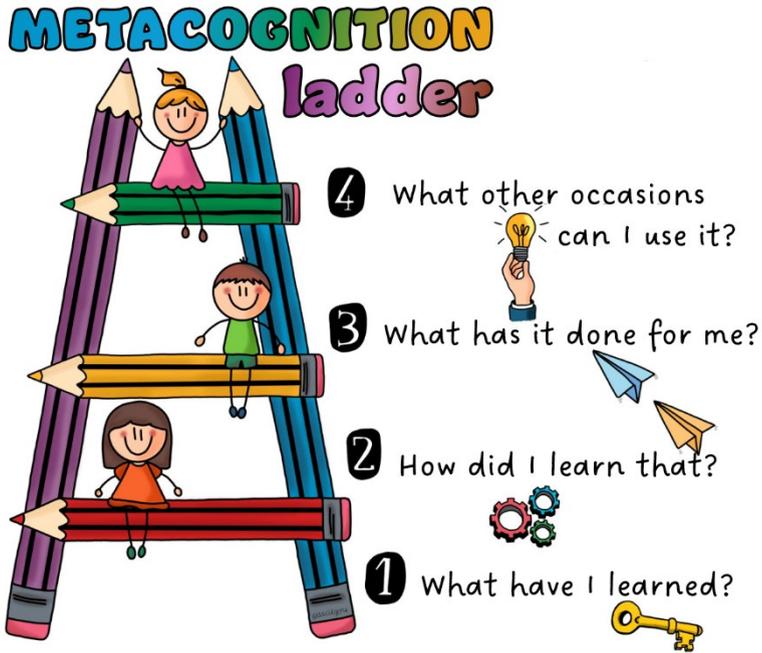


Figure 10. Metacognition ladder. After González (2024)

6.4. References

D. González, 2024, <https://www.orientacionandujar.es/2016/03/13/la-escalera-la-metacognicion-aprender-pensar-dacil-gonzalez> accessed on sept-24

7. New materials in online teaching

In online teaching, study materials are fundamental. Students may attend only a few online classes, whether synchronous or asynchronous, or perhaps none at all, and after doing so, they must focus on studying the subject through the materials provided by the instructor, whether written or audiovisual. This feature positions study materials as a critical, strategic element in online education. These materials must be clearly aligned with the objectives of online teaching and designed to facilitate optimal access to knowledge for students studying from home. Consequently, the preparation and configuration of these materials require a different approach than that used in face-to-face teaching. In this chapter, we will explore the specific preparation of these materials, divided into two main categories: written and audiovisual content, although other resources may also be employed in online teaching.

Learning Goals

- ∞ To know the diverse types of written material that can be used in online teaching.
- ∞ To know the characteristics that should be respected in written materials.
- ∞ To know how to get the most out of the written materials we use.
- ∞ To know the distinct types of audiovisual material that can be used in online teaching.
- ∞ To know the characteristics that should be respected in audiovisual materials.
- ∞ To know how to get the most out of the audiovisual materials we use.

7.1. Written materials for the innovation of online teaching

Written material will generally be the second resource students engage with, following their initial exposure to the video recording where the basic content of the subject is explained, although this sequence is not always fixed. What is certain, however, is that meaningful learning cannot be achieved solely through the video. The video serves as an introduction to the subject, familiarizing students with its foundational aspects. It is through written materials that students will engage in deeper study, exploring the subject's comprehensive content and its development. For this reason, written materials are essential and must be carefully adapted to suit the requirements of online learning.

7.1.1. General introduction

It is evident that the materials must be closely aligned with the content of the discipline, and it is the instructor who best understands how to approach this content. From a scientific perspective, the manual must contain all the essential components typically found in manuals for the discipline. However, the most significant adaptations for online teaching will occur in the methodological approach and structure of the manual. This material must be varied and incorporate different types of resources, ranging from a comprehensive general manual to more specific or partial documents, as well as supplementary content (Buenaño-Barreno et al. 2021).

Each of these materials should serve a distinct role in the teaching and learning process. The general manual must provide comprehensive content and explain the fundamental aspects of the subject. Once students have studied these foundational elements, the supplementary materials and development activities should focus on clarifying more complex or in-depth topics. The variety of materials offered should compensate for the absence of direct interaction with the teacher in the classroom. It is the teacher's responsibility to provide these resources, ensuring that they support the students' learning journey.

We must avoid the common academic tendency to cover every topic in excessive detail. In online teaching, this approach can be counterproductive, as the principle of 'less is more' often proves more effective. The more direct and focused the content, with less emphasis on unnecessary background and more on clear structure and prior explanation, the better students will understand what is required of them and what they need to achieve. Teaching materials should be prepared by the instructor but designed and organised with the student in mind. These materials must clearly outline the content and focus on the essential concepts of the discipline, avoiding digressions and excessive

detail. Ideally, the materials should be specifically tailored for online learning and structured in a way that allows students to engage with and understand them independently, without requiring constant guidance from the lecturer.

The content must be concise and direct, with clear writing that employs technical terminology only after it has been adequately explained. Solutions to processes should also be articulated clearly to facilitate a deeper understanding of the subject. Lengthy sentences and digressions into unrelated content should be avoided. The writing should be straightforward, engaging, and focused, ensuring that the reader does not need to consult external sources to comprehend the material.

Thus, the book must be effective, user-friendly, and comprehensive, covering all necessary aspects of the subject. To achieve this, it must be of high quality, easy to read, and appropriately tailored to the academic level of the students. All content should be thoroughly explained and include complementary material, which will be further elaborated based on the types of resources provided (Cavero-Almenara et al. 2022).

7.1.2. General manual

The general manual must, of course, maintain high standards with respect to the subject matter of the discipline and the accuracy of the content explained. In this regard, the higher education specialist who has developed the course is best suited to structure the material. However, the format and presentation of the manual for online teaching must differ, ensuring that it is clearly identifiable and easily navigable. Each topic should follow a consistent structure, incorporating not only the subject matter but also supplementary sections designed to help students engage more effectively with the material.

These sections are flexible, allowing each instructor to bring their own creativity, though we will suggest some that would be beneficial to include. At the outset, an introduction should be provided to familiarise students with the basic content that will be explained. Alongside this introduction, the objectives of the topic must be clearly outlined. A global outline of the subject should also be presented, ideally in the form of a conceptual map that correlates with the headings of the manual.

Following this, the core content of the subject should be presented. At the end of the manual, it would be advisable to provide students with various tools to assess whether they have adequately understood the material. These tools could include a glossary of essential technical terms with clear definitions related to the subject, a basic bibliography

for students wishing to further explore the content, and simple review questions to help students gauge their understanding of the material.

Additionally, it is recommended that the manual includes practical learning activities that allow students to assess, at an initial level, their ability to apply the individual concepts they have studied in practice.

With regard to its composition, the manual must be written in a direct manner, focusing on the essential aspects of the discipline while avoiding content that does not add value. As a result, online teaching manuals are often shorter than those used in traditional face-to-face instruction, but they feature more focused and pedagogically effective writing, where nothing is superfluous. The manual should be concise, straightforward, and user-friendly, enabling students to study the subject independently without needing to consult additional materials (Real Torres 2019).

7.1.3. Second written materials: short presentations

To enhance student learning, particularly for those aiming to improve their performance, online teaching presents opportunities that are not as readily available in traditional face-to-face instruction. In face-to-face settings, even with the manual and the lecturer's explanations, it can sometimes be challenging to provide additional materials. However, in online teaching, it is easier to offer specific resources that support and encourage autonomous study, which are highly valuable for students.

Conceptual outlines of the key aspects covered in the syllabus, concise summaries of the essential ideas, and complementary explanations—such as the practical applications of the subject matter—are highly beneficial for student learning. Additionally, supplementary documents, such as articles by prominent authors that explore specific topics relevant to the subject, can enhance theoretical content. It is also valuable to provide materials that highlight the relationship between the subject matter and current events, including articles, news reports, and analyses of contemporary social situations.

In online teaching, offering students these types of supplementary resources is particularly advantageous. These materials serve a descriptive function, helping students apply the knowledge they are acquiring to real-world contexts. This approach helps bridge the gap between theory and practice and supports the completion of learning activities. It is important to clearly explain the purpose of these resources, the rationale for their inclusion, and whether they are part of the evaluation requirements (Martínez Mediano 2000).

7.1.4. Other written materials

Finally, in online teaching, we can provide supplementary materials that, while not directly related to the core teaching content, can greatly assist students in studying and mastering the subject. These are optional resources, not mandatory, that allow students to deepen their understanding, resolve doubts, and cater to the diverse student profiles discussed in Chapter 0. Such materials can be more complex or comprehensive and often benefit from accompanying explanations.

These resources can take various forms, including lists of terms, lists of processes, prior explanations assumed to be known, a frequently asked questions document, interactions between theory and practice, and other materials of interest. These supplementary resources are highly appreciated by students who seek further enrichment or encounter specific questions during their studies, allowing them to resolve issues independently without needing to consult the instructor.

A key advantage of these materials is that, once developed, explained, and uploaded by the instructor to the teaching platform, they can be reused in subsequent years. This not only reduces the need for additional preparation but also effectively complements the core content of the discipline

7.2. Audiovisual materials for innovation in online teaching

As explained in Chapter 0, our society is increasingly characterised by audiovisual interaction, and this is especially true for our students, many of whom have only recently reached adulthood. Therefore, incorporating relevant audiovisual material into teaching resources can provide a competitive advantage, offering students an accessible entry point into the course content. Videos should primarily serve to introduce students to a topic and provide preliminary exposure to theoretical concepts. In today's society, however, video content has become an essential tool for facilitating knowledge acquisition. For students, video is often the most practical and direct medium to capture their attention and engage them with the subject matter, motivating them to subsequently delve deeper into the course manual (Sangrá et al. 2020).

To capture students' attention, the video must be meaningful, concise, and include incentives that spark their interest in studying the subject. Watching the video alone should never be sufficient to pass the course, but it should serve as an effective introduction, helping students begin their studies and gain a foundational understanding of the subject matter.

To achieve these objectives, several factors must be carefully considered before creating a video. First, it is essential to have a clear understanding of the pedagogical purpose of the video—whether it serves as an introductory overview, addresses a specific content area, or resolves a particular or general question. Next, evaluate the necessity of the video, taking into account whether it is essential, particularly as some students may have limited access to it. Additionally, assess the video's usefulness and relevance to the overall course content. It is also important to consider the impact you aim to achieve—whether the video is intended to be purely informative, motivational, relatable to students' real-life contexts, or a combination of these purposes. Once these aspects are clearly defined, the process of creating the video can begin with focused direction.

As discussed in Chapter 0, videos hold various inherent values, and it is important to leverage these effectively. The most obvious value is that of being a simple transmitter of information—delivering accessible, precise, visual, and auditory content that requires less effort from students compared to studying theoretical materials. This makes video an invaluable resource. Videos can be applied to different types of studies, which will be discussed below, and for each, the video may require different characteristics.

It is beneficial for the video to be accompanied by supplementary content that students can use for independent study outside of the video itself. This content can include images, texts, graphics, or even a presentation. The presentation should be provided as supplementary material alongside the other resources, enabling students to engage in independent study while utilizing their visual and auditory memory from the video. While enhanced visual elements may make the video more appealing, they are not essential. A straightforward video using commonly known methods that combine image, sound, and content is sufficient.

Additionally, the video should always be available to students, as this significantly increases its value, especially for those with significant family or professional commitments who may only engage with online teaching at specific times (Morales Salas 2021).

Before recording a video, it is essential to consider how it complements face-to-face teaching. Reflect on what aspects you aim to improve or enhance and identify the key points you want to emphasise. Focus on which fundamental aspects of the subject you wish to highlight and determine the two or three core ideas that you intend to convey. As we will discuss later, the video should not be lengthy, as longer videos tend to dilute attention and diminish the value of

immediacy. Given this, the student should not conclude the video with more than two or three essential takeaways.

The video should be guided by an outline or basic script, but it should not involve merely reading from that script. Rather, the lecturer should present the material with the same naturalness and fluidity as in a face-to-face class.

When recording a video, there are several technical aspects that must be considered. Ideally, if possible, the video should be recorded with the instructor standing, either full-body or half-body. This, however, typically requires access to recording studios, which may not always be available. In such cases, the limitation of not being able to use full body language must be compensated for through posture and engagement from a seated position.

If recording while seated, it is important to sit upright, using your body and hands to maintain an active and expressive demeanour. Under no circumstances should you rest your entire body on the chair in a passive position, as this can create a sense of detachment and disconnect with the audience. At this moment, eye contact becomes especially crucial. The focus should be directed primarily at the computer camera rather than the screen. While this may feel unnatural, it is essential to avoid constant screen-gazing, as this gives the impression that the instructor is not directly engaging with the viewer.

A key element of effective oral communication is the use of hand gestures. Hands play an essential role in reinforcing the message and should move freely—neither static along the body nor intertwined. The movement should feel natural, purposeful, and supportive of the message, without appearing forced. Hand gestures should align with the content being communicated, emphasizing key points and remaining more controlled when the message is less critical.

In particular, when listing items or enumerating points, using your fingers to count can be extremely helpful, visually signalling to the listener the number and importance of the aspects being discussed. All of this can be executed effectively from a seated position.

The final aspect to consider regarding the speaker's appearance is clothing. Attire should be appropriate for the target audience. When recording a video, it is advisable to wear solid-coloured garments without stripes or checks, as such patterns can create visual effects in the recording that may distract or confuse the viewer. In some cases, these effects can even cause discomfort or dizziness, prompting the audience to discontinue watching the video.

Finally, in both body language and speech, it is important to avoid repetitive gestures or verbal tics. Frequently repeated movements or

overused phrases can distract the audience, causing them to shift their attention away from the content of the message. This diminishes the effectiveness of the communication, as the audience may focus more on the speaker's habits than on the intended message, reducing the impact of the presentation.

The final aspect to consider is the tone of voice. The speaker must be thoroughly familiar with the message they are delivering, as discussed in the next section. Once this content is understood, the speaker should plan their delivery, recognizing that certain aspects of the speech are more important than others. The voice should be used strategically to emphasise these key points.

The tone should be strong and directed toward the recording microphone, avoiding a low, unprojected tone that remains confined to the speaker's throat. However, while maintaining a projected tone, the volume and intensity should vary, rising and falling depending on the significance of each phrase. This modulation helps the listener focus on the most important ideas of the message, while naturally de-emphasizing less critical parts.

7.2.1. First audiovisual materials: contents of explanation pills

The videos we create can take various forms. The first type might be a basic and general script for each topic in the subject. Before recording, it is essential to carefully plan the structure and key points, reflecting on the main ideas. It is recommended to complement the video with a presentation and relevant images to clarify the content. The videos should provide an overview of the topic, emphasizing the essential elements and focusing on the more challenging aspects. Videos are particularly useful for explaining complex concepts that may be difficult for students to grasp through text alone.

In terms of duration, videos can range from 5, 10, to 20 minutes, depending on the length and complexity of the topic. They should cover the core content and highlight key points but should be designed in a way that allows students to rewatch them as needed, independent of the written material. After watching the video, students should find it easier to engage with the written topic, having already gained an understanding of the foundational and, if possible, more complex concepts.

7.2.2. Second audiovisual materials: doubt clarification pills

A second type of audiovisual content can be short videos that clarify doubts, especially those that are more effectively addressed through audiovisual means than through written explanations. These video

'pills' should be concise and direct, created when we notice recurring questions that arise from student study and that could benefit a broader audience. These videos may or may not include extensive graphic or explanatory content, depending on the nature of the topic. Their purpose is to clarify doubts with a clear structure and targeted vocabulary, particularly focusing on the most complex areas of the subject.

These videos should last approximately 3 to 5 minutes and should be adaptable to include other relevant materials. One significant advantage of these videos is their reusability; if recorded without time-specific references, they can be used across multiple years without needing to be recreated. This allows for a more in-depth explanation than is typically feasible in videos covering the syllabus, and students can watch them repeatedly. If new questions arise, we can easily refer students to these pre-recorded videos.

7.2.3. Other audiovisual materials: expert's and students' videos

Another type of audiovisual material that is particularly advantageous in online teaching, compared to in-person instruction, is publicly available videos featuring experts in the field. These videos serve as a valuable complement to the core content of the discipline. Expert input provides an alternative perspective and, due to their academic prestige, enhances the professor's explanation. Such videos add depth to the learning experience, addressing the needs of more demanding and professional students. They also allow for the exploration of more advanced content and topics that cannot be covered in the general instructional videos.

Finally, with the students' consent, we can offer videos created by students as part of their group work when presented in video format. These videos can be particularly valuable because, although they may contain inaccuracies that need clarification, students often communicate with their peers using familiar vocabulary and cadence. This peer-to-peer communication can provide explanations that resonate more effectively with their classmates, facilitating a deeper understanding and supporting the students' process of constructing knowledge (Cillero Pino 2012).

7.3. References

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8. Creating innovative formats and pills in online teaching

Developing new and creative ways of delivering educational content through digital platforms involves structuring and organising content, using "pills" which refer to the small, easily digestible units of information that make up the content. Creating innovative formats and pills is essential to engage students and promote effective learning in e-learning. Innovative formats such as multimedia content, gamification and interactive simulations can help provide students with a more personalised and interactive learning experience. Pills can be used to break longer content into manageable chunks, making it easier for students to understand and retain information.

Learning Goals

- ∞ To understand the particularities of online teaching
- ∞ To know formats of pills
- ∞ To design pills for online teaching
- ∞ To use gamification in online teaching

8.1. Knowledge construction in e-learning

The creation of innovative formats in online teaching involves the development of new and creative ways of delivering educational content through digital platforms. By innovative formats we refer to the structure and organisation of the content, in the form of pills that divide the information into small, easily assimilated didactic units that together make up the total content.

In the context of online teaching, creating innovative formats and pills is essential for engaging students and promoting effective learning. With the rise of online education, students are increasingly looking for interactive and engaging content that can be accessed from anywhere at any time. Innovative formats and pills can help to meet these needs by providing students with a more personalised and interactive learning experience.

One example of an innovative format is the use of multimedia content such as videos, animations, and interactive simulations. These formats can help to break up the monotony of traditional text-based content and provide students with a more engaging and interactive learning experience. Another example is the use of gamification, which involves incorporating game-like elements into the learning process to make it more fun and engaging.

In addition to innovative formats, the use of pills can also be an effective way of delivering educational content online. Pills are small units of information that learners can easily consume. They can be used to break long content into more manageable chunks, making it easier for learners to assimilate and retain information. They can also be used to provide learners with quick summaries of key concepts or to reinforce important ideas.

8.2. Innovative formats

In the context of online teaching, creating innovative formats is essential for engaging students and promoting effective learning. With the rise of online education, students are increasingly looking for interactive and engaging content that can be accessed from anywhere at any time.

Innovative learning formats include multimedia content, gamification, virtual and augmented reality, project-based learning, and social learning. These formats are well suited to learners because they are naturally using them every day in their regular use of the internet.

8.2.1. Multimedia content

Multimedia content refers to the combination of various media elements, such as text, images, audio, video, and interactive elements, to deliver information or entertainment in a dynamic and engaging format. The use of multimedia content captivates and engages audiences more effectively than traditional text-based content. The use of visuals, audio, and interactive elements stimulates multiple senses, making the content more memorable and impactful ¹. Multimedia content can be used to simplify complex concepts through visualizations, animations, and interactive elements, making them more understandable and digestible for the audience. It also has the potential to drive higher conversion rates by capturing users' attention, increasing their interest in your products or services, and ultimately leading to higher conversion and sales. In short, multimedia content can help to break up the monotony of traditional text-based content and provide students with a more engaging and interactive learning experience.

8.2.2. Gamification

Incorporating game-like elements into the learning process can make it more fun and engaging. Gamification in learning is the process of using game elements in a non-game context to enhance learning. It has many advantages over traditional learning approaches, including increasing learner motivation levels, improving knowledge retention, and better learner engagement through social mechanisms like badges, points, or leader-boards. In our modern world, technology is naturally a driving force behind learning and the development of curricula. To achieve better results from students, today's educators must use cutting-edge digital tools and strategies in their teaching methods. Gamification for learning is one of these strategies used increasingly by teachers around the world. Using gamified elements can positively impact student engagement and collaboration, allowing them to learn more efficiently as a result. Gamification is about applying gaming strategies to improve learning and make it more engaging for individuals. Gamification for learning is beneficial because games instil lifelong skills such as problem-solving, critical thinking, social awareness, cooperation, and collaboration. Games also motivate people, increase interest in certain subjects, reduce drop-out rates among students, improve grades and enhance cognitive skills.

8.2.3. Virtual and augmented reality

Virtual and Augmented Reality (VR/AR) provides students with a more immersive and interactive learning experience, making it easier for

them to understand complex concepts and retain information. VR/AR can be used to create simulations that allow students to explore and interact with virtual environments, such as historical sites, scientific phenomena, or engineering designs, that would otherwise be difficult or impossible to access in real life. This can help make learning more engaging and memorable for students, as well as providing them with a more practical and hands-on learning experience. VR/AR can also be used to create personalised learning experiences that are tailored to the needs and interests of individual learners. For example, students can use VR/AR to explore different career paths or to learn about different cultures and languages.

VR/AR is an innovative and effective way of delivering educational content that is better adapted to the needs of today's learners and provides them with a more immersive and hands-on learning experience.

8.2.4. Project-based learning

Project-based learning (PBL) is a teaching method that involves students working on practical projects that allow them to apply what they have learned in real-world situations. PBL is an immersive, hands-on experience that ignites curiosity, nurtures creativity, teaches life and career skills, and prepares students for the challenges of the real world. According to research conducted by The Autodesk Foundation [<https://www.destinationimagination.org/blog/10-benefits-of-project-based-learning/> 2018], studies have shown that project-based learning is linked to significant improvements in student test scores, attendance, and classroom engagement. PBL also gives teachers the opportunity to build stronger relationships with their students by acting as their hands-on learning facilitator. In essence, PBL is an instructional method where students collaborate with others and “learn by doing”. The same skills learned through PBL are also many of the skills sought by employers.

Some benefits of project-based learning are Collaboration, Problem Solving, Creativity, In-Depth Understanding, Self-Confidence, Critical Thinking, Perseverance, Project Management, Curiosity, and Empowerment among others.

Collaboration: Relationships formed during collaboration is a huge part of PBL. Not only do students learn how to work better in groups - providing their own input, listening to others, and resolving conflicts when they arise- they build positive relationships with teachers, which reinforces how great learning is. Students also form relationships with community members when working on projects, gaining insight for careers and beyond.

Problem Solving: Students learn how to solve problems that are important to them, including real community issues, more effectively—even learning from failure and possibly starting over.

Creativity: Students apply creative thinking skills to innovate new product designs and possibilities for projects.

In-Depth Understanding: Students build on their research skills and deepen their learning of applied content beyond facts or memorization.

Self-Confidence: Students find their voice and learn to take pride in their work, boosting their agency and purpose.

Critical Thinking: Students learn to look at problems with a critical thinking lens, asking questions and coming up with possible solutions for their project.

Perseverance: When working on a project, students learn to manage obstacles more effectively, often learning from failure and making adjustments until they're satisfied with their work.

Project Management: Students learn how to manage projects and assignments more efficiently.

Curiosity: Students get to explore their curiosities, ask questions, and form a new love for learning.

Empowerment: Students take ownership over their projects, reflecting on and celebrating their progress and accomplishments.

In short, project-based learning is a powerful teaching method that has extensive benefits for students, ranging from critical thinking to project management to self-confidence. It can better prepare students with life skill that set them up for future success because they work on practical projects that allow them to apply what they have learned in real-world situations.

8.2.5. Social learning

Social learning is a teaching method that involves students working together in groups to learn and solve problems. This approach is beneficial because it allows students to learn from each other, which can lead to a deeper understanding of the material and better retention of information 1. Social learning also promotes collaboration and teamwork, which are important skills for students to develop in order to succeed in the workplace. Additionally, social learning can help to build a sense of community among students, which can lead to increased engagement and motivation 2. By working together, students can share their knowledge and expertise, which can lead to a more comprehensive understanding of the material 2. Social learning can also help to develop critical thinking and problem-solving skills, as students are encouraged to think creatively and work together to find solutions.

Overall, social learning is a valuable teaching method that can help to promote collaboration, critical thinking, and problem-solving skills among students.

8.3. Information pills in online learning

As already stated, an information pill is a short message or audio-visual format that seeks to capture our attention. It is a form of communication that has become increasingly popular in the digital age, as it allows for more frequent and faster access to information, news, and updates. News pills are known as "news breaks" or "news bulletins" and are consumed in small doses of information that we absorb very quickly. These communication formats are ideal for satisfying our information curiosity and communicating messages effectively. Information pills in online learning must be concise and engaging, flexible and accessible and effective and efficient.

8.3.1. Concise and engaging

Information Pills are designed to be short and engaging, making them ideal for learners who are looking for quick and easy access to information. They must be presented in a visually appealing format, such as an infographic or a short video, to capture the learner's attention and make the content more memorable.

Teaching briefings are usually between 2 and 15 minutes in length. It is important that they are concise and show a maximum of 2 or 3 key ideas to keep the focus on the important information with a clear introduction and a short summary that restates the key ideas.

8.3.2. Flexible and accessible

Information pills should be accessible from anywhere and at any time, making them ideal for learners seeking flexibility in their learning. They can be consumed on a wide variety of devices, including smartphones and tablets, making them accessible to learners who are always on the move.

Flexibility and accessibility mean that content should be adapted to different formats. They should include subtitles and transcripts and even offer language options for a wider audience.

Adapting content to different formats: Information pills can be presented in different formats, such as videos, infographics, podcasts, etc. This allows learners to access the content from different devices and platforms.

Provide subtitles and transcripts: Including subtitles and transcripts in the information pills can make the content more accessible to

students with hearing disabilities or those who prefer to read rather than watch a video.

Offer language options: If learners speak different languages, it is important to offer language options so that they can access content in their native language.

8.3.3. Effective and efficient

Information pills are an effective way to communicate important information to learners. They should be designed to be easy to digest, which means that learners can absorb information quickly and retain it for longer. This makes them an effective way to convey information to learners without overwhelming them with too much information at once.

To achieve this, you can follow these five steps as closely as possible:

1. Define your objective: Before you start to create your news pill, it is important that you are clear about the objective you want to achieve with it. Do you want to teach a specific concept? Do you want to introduce a new product or service? Do you want to share a relevant news story?
2. Gather your resources: Once you are clear about your objective, it's time to gather the resources you will need to create your briefing pill. These resources can include images, videos, graphics, text, etc.
3. Create your content: With your resources in hand, it's time to start creating the content of your info-pill. Remember to be concise and focus on the 2 or 3 key ideas you want to convey.
4. Design your briefing pill: Once you have your content ready, it's time to design your info-pill. You can use tools to create videos or tools to create infographics. The tool is not important, but some tools can help you get better results.
5. Share your info-pill: Finally, it's time to share your info-pill with your audience. You can post it on your LMS, on social media or send it by email to your recipients but remember to make clear any copyright that you wish to place on your work.

Pills are small, bite-sized units of information that can be easily consumed by students. They can be used to break up longer pieces of content into more manageable chunks, making it easier for students to digest and retain the information. Pills can also be used to provide students with quick summaries of key concepts or to reinforce important ideas. In the following section we will look at the development of an example of a teaching pill.

8.4. Basic pill example

We are going to design a basic pill to illustrate what we have learned in the previous sections. The title of the pill will be "Doing a sum using a spreadsheet like Excel" and it will be a script for a short video or audio podcast.

1. Objective
To explain how to do a sum in a spreadsheet: This is just one key idea but is extended to four related ideas: basic addition, addition of referenced cells, using the sum function and, finally, using the auto-sum button.
2. Gather your resources: You will need a spreadsheet to explain the solution at an appropriate speed and without making mistakes. We will use the bibliography to document the development well and, if we are going to make a video, we will need tools to capture the screen and our image and a microphone with its application for audio recording.
3. Create your content: Now it is time to write the script with the ideas that we want to transmit, taking as a reference the resources that we have available and that we selected in the previous section. Remember that we have a general idea that is specified in four key ideas, but we must be concise. I recommend creating a storyboard describing the scenes we are going to use and indications of what is going to happen in each scene.
4. Design your briefing pill: With all the material prepared, we proceed to the final design and realisation of the pill that we have developed. At this point it should be remembered that the duration should be between two and fifteen minutes. An average speaker reads about 180 words per minute aloud, so by counting the words of our script we will know how long it will be approximately. In our case we have 353 words —see section 0—, so the reading time would be about two minutes. To this we must add the pauses between sentences to fix the ideas, which in our case are 5 and do not add a significant length. Remember to follow as closely as possible the storyboard designed in the previous step. The actual length of the recording time can be 20 to 30 times the length of the final clip. This is due to the multiple takes and the editing, montage and rendering times of the sketch.
5. Share your info-pill: It is time to share our creation. In a teaching environment the most common is to upload it to the

LMS, but you can also use social networks such as YouTube or other similar ones that connect us with our followers.

8.4.1. Script example

This is an example of a script created with artificial intelligence to explain the addition of cells in a spreadsheet:

☞ Hi, in this video I am going to show you how to add cells and ranges in Excel in different ways.

☞ The first way is to add inside a cell. To do this, type an equal sign (=), the number you want to add with another number, a plus sign (+) and another number. For example: `=2+3`. Then press Enter and you will see the result of the addition in the cell.

☞ The second way is to add with cell references. This means that you can use the name of the cells where the numbers you want to add are, instead of typing the numbers directly. For example, if you have the number 2 in cell A1 and the number 3 in cell B1, you can type `=A1+B1` and press Enter to get the result of the addition.

☞ The third way is to use the SUM function, which allows you to add up a range of cells quickly and easily. To use this function, type an equal sign (=), the word SUM, and in brackets the range of cells you want to add. For example, if you want to add the cells from A1 to B5, you can type `=SUM(A1:B5)` and press Enter.

☞ The fourth way is to use the **AutoSum button**, which is a shortcut to apply the SUM function. To use this button, select the cell where you want to display the result of the sum, and then click the AutoSum button, which has a capital letter E symbol. Excel will automatically detect the range of cells you want to add and show you the formula. If you agree with the range, press Enter, and you will see the result of the sum.

☞ These are some of the most common ways to add in a spreadsheet, but there are many more you can explore. I encourage you to practice with different numbers and cells, and to consult your spreadsheet help or online resources to learn more about addition formulas. I hope you found this video useful and learned something new - see you next time!

We could then set out places where more information on addition can be found in spreadsheets or other links related to the topic, both in text and in videos from external sources. And that would be the end of our information pill.

9. Authentic evaluation in the digital context

The evaluation of distance learning is the final key moment in the teaching process. A proper evaluation should not focus solely on theoretical content, but should also assess the learning process and the practical skills the student has developed, even if they are not yet professionals in the field. Evaluation must include comprehensive feedback, allowing students to understand the reasons behind their grade and how they can improve both in their educational journey and future professional context. In this chapter, we will also explore emerging evaluation methods that aim to achieve these goals in a more automated and efficient manner than current practices allow.

Learning Goals

- ∞ To know the different evaluation methods of online learning
- ∞ To know the ways to evaluate knowledge of online teaching
- ∞ To reflect on how best to achieve authentic assessment in online teaching
- ∞ To know text matching tools
- ∞ To manage the use of AI in assessment

9.1. Types of evaluation in online teaching

The key to effective evaluation in online teaching lies in assessing not only the students' theoretical understanding of the core subject matter but also their progress in completing assignments and acquiring practical skills relevant to solving real-world problems in their future professional careers. Therefore, evaluation in online teaching should be multifaceted, employing diverse methods, and should not be limited to verifying the acquisition of basic theoretical knowledge. A balanced approach that integrates the assessment of both theoretical and practical competencies is essential, though this approach is not always fully implemented in online education (Marín et al. 2022).

In online teaching, the emphasis on professionalizing activities and their meaningful evaluation is crucial for enabling students to advance in their knowledge and build confidence as they prepare for professional life. Providing detailed feedback on practical exercises is key to translating theoretical knowledge into practical skills, leading to an authentic evaluation. The true value of this approach lies in its alignment with the learning process and the method by which knowledge is acquired. This alignment is essential for achieving an authentic and meaningful assessment.

Certainly, in distance teaching, we can evaluate any type of knowledge. The key lies in determining which knowledge we wish to assess and how we structure the evaluation to capture the student's achievements. Various types of activities and corresponding evaluations can be designed to analyse different forms of knowledge. These may include multiple-choice questions, teamwork, role-playing exercises, theoretical problem-solving, or practical problem formulation followed by an analysis conducted through specific questions. In each case, it is the method by which we approach both the activity and the evaluation that determines what type of knowledge the student has acquired.

9.1.1. General introduction

The general criteria for conducting an effective evaluation focus on the design of the teaching and assessment activities. Evaluation tasks must be closely aligned with the content of the teaching process and clearly related to the subject matter, ensuring that students understand what is being assessed, how it will be evaluated, and how their performance will be quantified. Additionally, to manage a large number of students and grades, it is important to design activities that are straightforward to assess.

As instructors, it is our responsibility to adapt the evaluation process to the online teaching environment, balancing various types of assessments to complete the process effectively. We must carefully analyse, adjust, and justify the choice of evaluation methods, ensuring that they align with the learning objectives and provide meaningful insights into the knowledge being taught and assessed, while maintaining efficiency.

Throughout the evaluation process, we must maintain a clear understanding of what we intend to assess. Initially, the focus may be on evaluating students' knowledge of economic and financial analysis procedures, along with the theoretical content. As the process evolves, the evaluation should shift toward assessing students' ability to approach problems, their progression toward a solution, and their practical handling of potential final scenarios.

It is important to remember that evaluation is not merely measurement. Measurement involves assigning a numerical value to a specific human activity, while evaluation involves making a value judgment about both the substance of the process and its outcome. Evaluation should be comprehensive, continuous, and systematic, allowing the student to participate, provide feedback, and revise their solutions after understanding the information provided by the evaluator.

In online teaching, it is even more critical to assess the final result in the context of the entire learning process, as this approach enables a deeper understanding of the student's overall performance. Key aspects to consider include the time dedicated to the activity, the progress made, and the flexibility needed to account for the difficulty of the tasks the student has undertaken. The evaluation process may also evolve over time, with different criteria applied in the early stages of the course compared to the later, more decisive moments, depending on the knowledge the student has already acquired (García Cabrero et al. 2011).

9.1.2. Evaluation of multiple-choice questions

A considerable number of online courses opt for multiple-choice questions to evaluate students, as these are relatively easy to standardise, implement in real-time, and automate in terms of grading. This makes them particularly advantageous for managing large student cohorts. While this evaluation method has received some criticism within the realm of online education, it is not inherently flawed. When designed thoughtfully and with experience, multiple-choice assessments can effectively evaluate a variety of knowledge domains.

Depending on the type of question asked, multiple-choice assessments can evaluate both simple and advanced knowledge, encompassing theoretical as well as practical content. While practical scenarios can be presented, it is generally challenging to create complex practical cases within this format. The effectiveness of multiple-choice questions largely depends on adhering to specific guidelines, which can be categorised into rules affecting either content or structure.

Regarding content, the questions must align with the objectives of the course and be directly related to the core concepts of the syllabus. Each question should assess knowledge of a key concept rather than focusing on trivial or insignificant details. The questions should direct attention to the concept being evaluated, rather than requiring students to interpret prior knowledge not included in the question itself. The phrasing of the questions must provide all necessary information for the student to correctly identify the answer. Additionally, exams should include a variety of question types, assessing different levels of knowledge such as basic recall, recognition, comprehension, analysis, and practical application.

In terms of question structure, it is essential to write clear, grammatically and syntactically correct statements, free of typos and formatted with appropriate spacing. Each question should be phrased in language that is accessible and understandable for the student level being assessed. It is also important to distribute the correct answers evenly across the exam, as individuals tend to follow patterns, often placing the correct answer in the same option repeatedly.

Avoid making all the options too similar or easily discardable due to their irrelevance to the subject. None of the four options should stand out, whether in terms of content, length, or appearance. Distractors—the incorrect options—should be homogenous and fall within the same category as the correct answer (Lezcano & Vilanova 2017).

Moreover, multiple-choice questions should avoid statements involving value judgments or opinions, as well as those with negative or double-negative phrasing. If a negative statement is necessary, it should not be emphasised in a way that misleads students. Ensure that all answer choices grammatically correspond with the question stem, so each option can be seamlessly read after the statement.

Avoid using obvious or mutually exclusive answers, as well as vague responses such as "None of/All of the above" or "Only options a) and b) are valid," as these introduce bias unrelated to the subject matter. Additionally, refrain from using imprecise or absolute terms like 'possibly,' 'it is important,' 'frequently,' 'never,' 'always,' etc. In many higher education subjects, numerical data should be expressed

consistently and accurately, listed in increasing or decreasing order, with uniform levels of detail, and stating units when necessary. Numerical options should not overlap, especially when answers are framed as "greater than" or "less than."

Multiple-choice questions offer a wide range of possibilities. The most common format includes four options, with one correct answer. Other variations include questions designed to create concept maps, fill-in-the-blank statements where students select the correct option, and true/false questions. The flexibility of multiple-choice questions allows for diverse assessment formats (Pales-Argullós 2010).

9.1.3. Teamwork evaluation

When assessing how students interact with each other, teamwork evaluation is a valuable approach. The objectives—both collective and individual—must be clearly communicated to the students. It can be beneficial to set individual objectives for each group member, as this ensures that students understand the value of effective teamwork while also recognizing that the poor performance of one member will not negatively impact others. Each student has both an individual and a collective responsibility. The evaluation questions should be designed to assess both factors, and the final grade for each group member may differ based on their contributions. This approach helps foster a sense of fairness in the grading process. In such cases, peer evaluation, where students assess their group members, can be particularly insightful. Students often find themselves in a new evaluative role and, in many instances, they may be more rigorous in their assessments than the instructors themselves (Marín et al. 2022).

9.1.4. Role plays evaluation

In the later stages of the course, when students are familiar with the basic concepts, role-playing exercises can be applied as an authentic evaluation method to simulate situations they are likely to encounter in their professional lives. This type of activity allows students to engage with practical financial scenarios, placing them in realistic decision-making contexts. Through this process, students are not only involved in the analysis but can also participate in evaluating themselves and their peers.

In such evaluations, the questions should focus on both the process and the outcome, identifying correct and incorrect solutions within the role-playing scenario. Peer evaluation is also highly effective in this context, offering valuable insights into the students' understanding and performance (Luchena Mozo et al. 2014).

9.1.5. Evaluation through problem solving

In this type of evaluation, the student is presented with either an unresolved real-world problem or an already solved case, and is tasked with providing a guided analysis based on specific questions prepared by the instructor. The evaluation should measure two key aspects: the process and the results. These measurements do not necessarily need to be summative. The evaluation should follow a progression from simpler tasks to more complex ones, allowing the student to gradually grasp the nature of problem-solving in real-life scenarios.

The goal is to gather the most individualised information possible, but once the practical case is understood, the instructor can prepare a range of standard solutions to expedite the authentic assessment process (Scriven 2013).

9.2. Anti-plagiarism Assessment Tools



Figure 11. Antiplagiarism tools. IA generated image, bing.com (2024)

Plagiarism is the act of copying or imitating someone else's artistic or intellectual work and presenting it as one's own, without giving credit to the original author. It includes taking part or the entire work and violates intellectual property rights. Plagiarism can be considered a crime and has legal consequences, such as penalties or compensation. In the academic field, plagiarism is a serious offense and can result in severe punishments, such as expulsion from the educational institution.

However, the definition of plagiarism and its consequences in educational institutions, at the beginning students' work is plagiarism. When students are young their parents help them with homework, as they get older the sources of plagiarism or let's call it, textual coincidences, expand. This is part of learning. We learn by imitation and, naturally, we copy what we like just as we forget what we don't like. It is obvious that the student must gain autonomy through his learning, and at the end of his university stage, the autonomy must be complete. It is in these final works where the originality of the essays is strongly applied.

The consideration of plagiarism is quite subjective. The textual coincidence tools do not even indicate whether or not there is plagiarism. They indicate how similar fragments of the text are to fragments of texts by other authors, including the author of the text. Copying oneself is called self-plagiarism and may or may not be appropriate. There are situations where not copying oneself is an indication that the work is poorly done and in others it is fraud. It is up to the evaluator to decide this, not the absolute value of the textual match indicator.

In a thesis by compendium, which must include the articles that compile it, it must indicate a very high level of textual coincidence, in the order of 65% to 80%. This indicates that the work is well done. The original part will be the part that explains how the compendium has been compiled. In legal documents or documents containing legislation, between 30% and 60% could be considered legitimate, as the author cannot or should not invent the laws on which the document is based. In technical texts, between 20% and 30% is considered to be reasonable and supportive of the technical underpinning of the work. When the text has been developed entirely by a generative artificial intelligence system, the textual match rate is less than 8%, depending somewhat on the length of the paper.

It is dangerous to say that a paper is 50% plagiarised when the textual match indicates a 50% match value. In certain environments only the numbers are looked at and not the interpretation that the expert must give. This happens a lot in the tabloid press in some countries.

9.2.1. Textual Matching Tools

As we have been discussing, there are no anti-plagiarism tools, there are tools that allow us to know what proportion of the text matches other documents. There can be plagiarism without textual coincidence. The idea, the concept, the method is plagiarised; and it

is written in other words. There is blatant plagiarism, but the textual match tools do not reveal it.

It is painted white - It is decorated with the colour of cream

If we are analysing the form, the texts are radically different. There is no textual match. But if what is relevant is the colour that was applied, there is blatant plagiarism because in both cases reference is made to the colour white. This is a very simple example that I hope everyone can apply to their own field. This is very clear in the case of patents. Textual matching systems are of no use at all because what is patented is the idea, not the text, as would be the case with the registration of a song, where what is plagiarised is the text itself.

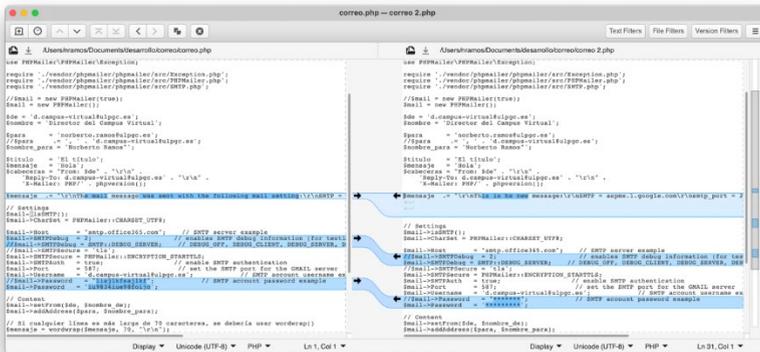


Figure 12. Example of textual comparison of two documents.

There are numerous text-matching analysis tools on the market (Figure 12). In all of them, the document to be analysed is sent to the company's data servers for analysis. This means that we are taking information that may be confidential out of our university. We need to have a confidentiality agreement with the company providing the text-matching service and ensure that it complies with European or regional data protection regulations. In addition, it is important that, if we are based in the European Union, the data never leaves the European Union. If the data leaves, even if the regulation is complied with, in the event of litigation, and even if we are right, we can have serious problems to be recognised and incur large costs.

9.3. The future of evaluation in the digital Context

The future of university assessment in the digital context is heading towards a more holistic and student-centred approach, where technology not only facilitates assessment but also enriches it, making it more relevant and effective in preparing students for the challenges of the 21st century.

9.3.1. Towards the future

The future of university assessment in the digital context is shaping up to be an ever-evolving field, where adaptability and innovation are key. The transition towards more digital methods of assessment has been accelerated by the need to adapt to unforeseen circumstances, such as the global pandemic, which has led to a profound reflection on existing evaluative practices and their relevance in the digital world. Digital assessment aims not only to measure theoretical knowledge but also to evaluate practical competencies and soft skills, such as analytical ability, creativity, and collaboration. This entails a significant shift in how assessments are designed and implemented, moving from standardised tests to tasks that are more integrated with real-life and the professional challenges that students will face in the future.

With the aid of technology, educational institutions are exploring new ways to conduct assessments that are fairer and more equitable. This includes the use of artificial intelligence tools to tailor assessments to the needs and learning pace of each student, as well as advanced systems to ensure academic integrity and prevent plagiarism.

Moreover, online assessment offers the possibility of providing instant and detailed feedback, which can be a key factor for continuous learning and student performance improvement. The active involvement of students in the evaluative process is also an important aspect, as it encourages self-assessment and critical reflection on their own learning.

9.3.2. AI in future online evaluation

While Artificial Intelligence (AI) presents a promising future for online education assessments, it is crucial that we approach its integration with careful consideration. By striking a balance between technological innovation and ethical standards, we can harness the full potential of AI to create an assessment landscape that is not only efficient and effective but also fair and conducive to the holistic development of learners.

AI is poised to play a transformative role in the realm of online education, particularly in the domain of assessment. As we navigate through the digital age, the integration of AI in educational practices is

becoming increasingly prevalent, offering a myriad of possibilities for enhancing the learning experience. One of the most significant contributions of AI to online assessment is its ability to provide personalised evaluations. By harnessing the power of data analytics, AI can tailor assessments to the individual learning styles and proficiency levels of students, ensuring that each assessment is both challenging and achievable. This customisation extends beyond mere question difficulty, encompassing the types of questions posed, the subjects covered, and even the feedback provided.

AI-driven assessments can also facilitate real-time feedback, a feature that traditional assessment methods struggle to offer. This immediacy not only aids in reinforcing learning concepts but also empowers students to take immediate corrective actions, thereby fostering a more dynamic and responsive learning environment. Moreover, the use of AI in assessments can significantly reduce the administrative burden on educators. Automated grading systems can swiftly evaluate student submissions, freeing up valuable time for instructors to engage in more meaningful interactions with their students and to focus on the nuances of teaching that AI cannot replicate.

However, the integration of AI into online assessments is not without its challenges. Concerns regarding data privacy, the potential for bias in AI algorithms, and the need for robust security measures to prevent academic dishonesty are all pertinent issues that must be addressed. Ensuring that AI systems are transparent, equitable, and secure is paramount to their successful implementation in educational settings.

To expand on the ideas raised, we need to know that AI can, and indeed does, have biases marked by the training system of the neural networks that make it up. They have the bias introduced by the company that trains them, all the types of biases introduced by internet-based learning with all its phobias and lack of rigour together with the lack of judgement and coherence of knowledge that makes up Generative Artificial Intelligence systems. We must not lose sight of the fact that the purpose of assessment is to have an objective rating of student achievement. Therefore, the key to ensuring that students learn effectively when using these resources is to integrate AI in a way that complements and reinforces learning skills, rather than replacing personal effort.

AI can serve as an invaluable support tool for students, helping them to improve the structure, grammar and coherence of their essays and papers. Advanced programmes can suggest improvements in writing style

and help students cite sources appropriately, which contributes to the academic quality of their papers. However, it is crucial that students understand that these tools are designed to assist, not to do the work for them. Education on how to use AI ethically and effectively should be a priority for educational institutions. In addition, fostering the development of critical thinking and analytical skills is essential.



Figure 13. Real world model for AI. AI generated image.

Students should be encouraged to use AI to gain ideas and perspectives that can enrich their work, but always with a critical and reflective approach. This ensures that technology serves as a catalyst for learning, rather than a shortcut to avoid deep thinking and understanding.

Academic integrity is also a key issue. Universities must implement robust plagiarism detection systems and other measures to ensure that students' submissions are the result of their own intellectual effort. This not only protects academic standards, but also teaches students the value of originality and hard work. However, personalised, and constructive feedback is vital. AI can analyse essays and provide comments that guide students towards areas of improvement, which can be a key factor in continuous learning and improved student performance. Ongoing training on new technologies and their application in education is equally important, ensuring that both students and lecturers are up to date with best practice and can use AI effectively and responsibly.

As a corollary, we can conclude that there is a need for continuous training of lecturers and students in the field of information and communication technologies, especially in teaching and learning using the tools provided by AI. It is necessary to learn how to ask questions so that the “mixture of experts¹” selects the most appropriate answers to what we intend to study, but it is almost more important to know that at present, AI systems do not know how to think. They just put one word after another in a way that makes apparent sense to humans, but the system is not aware of what the human being is understanding when reading the generated sequence of words.

One can readily discern the limitations of AI’s understanding of the real world by posing scientific or engineering questions. Often, the AI may present contradictory responses or fail to make connections between concepts that are well-understood by humans. Take, for instance, the relationship between a circle’s diameter and its radius; they are intrinsically linked. However, if a current AI system is provided with a formula that requires the diameter, and instead, it is given the radius, the system may insist on receiving the diameter. It may not autonomously employ the known relationship between the two ones to compute the solution.

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¹ Mixture of Experts (MoE) is a machine learning technique where multiple expert networks (learners) are used to divide a problem space into homogeneous regions to reduce the search space. Wikipedia: https://en.wikipedia.org/wiki/Mixture_of_experts

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10. Current Trends and Artificial Intelligence in Online Teaching

We discuss the transformative potential of Artificial Intelligence (AI) in education, highlighting its ability to revolutionize teaching, enhance learning, and bridge global knowledge gaps. AI could play a crucial role in achieving Sustainable Development Goal 4 (SDG 4), which focuses on inclusive and equitable education. However, the rapid pace of AI development presents challenges, particularly around policy, regulation, and potential technological divides between countries. UNESCO is committed to supporting countries in harnessing AI for education while adhering to principles of inclusion and equity. A human-centered approach ensures that AI tools are used with a deep understanding of diverse learners' values and needs. The text also emphasizes the importance of nuanced conversations about AI's impact on inequality, access to knowledge, and cultural diversity, warning against the risks of deepening technological divides. Finally, the chapter acknowledges the potential for AI-generated content to contain errors, encouraging critical thinking and media literacy as essential skills in navigating the digital world.

Learning Goals

- ∞ To know the different evaluation methods of online learning
- ∞ How to use AI in online learning
- ∞ To know the opportunities and risks associated with AI
- ∞ To understand the considerations of using AI

10.1. Artificial intelligence in online teaching

The concept of Artificial Intelligence (AI) refers to the ability of computers or robots to perform tasks typically associated with intelligent beings, such as learning, reasoning, problem-solving, and using language (Copeland, 2024). In the field of education, AI has been an area of interest for some time, offering immense potential to address significant challenges, innovate teaching and learning practices, and accelerate progress towards Sustainable Development Goal 4 (SDG 4).

AI is applied across various domains and tasks, including medical diagnosis, search engines, voice recognition, and chatbots. The different types of AI, such as machine learning, deep learning, natural language processing, and artificial general intelligence (AGI), possess distinct characteristics and applications. Notably, AI has been in existence since McCullough and Pitts' groundbreaking paper "A Logical Calculus of Ideas Immanent in Nervous Activity" was published in 1943, introducing a mathematical model for neural networks.

AI's transformative potential extends to teaching and learning practices, research, and assessment. Advances in AI could revolutionise education systems, making them more equitable and freeing up lecturers' time to focus on social-emotional learning. However, the rapid pace of technological developments often outpaces policy debates and regulatory frameworks, posing multiple risks and challenges.

The theory and development of computer systems capable of performing tasks that historically required human intelligence – such as recognizing speech, making decisions, or solving problems – has traditionally been assessed using the Turing test. AI's potential to revolutionise education is undeniable. Crucially, its application in educational contexts must be guided by the core principles of inclusion and equity to ensure that AI enhances human capacities while protecting human rights.

To achieve effective human-machine collaboration for sustainable development, policy debates and regulatory frameworks must keep pace with rapid technological developments, leveraging AI's potential to enhance learning outcomes and promote social justice.

10.2. The potential of artificial intelligence in addressing education challenges

The potential of Artificial Intelligence (AI) in addressing education challenges is a topic that has garnered significant attention in recent years. According to the U.S. Department of Education, AI has the capacity to transform teaching and learning practices, research, and

assessment. While there are opportunities and risks associated with AI in education, advances in this technology could potentially make education systems more equitable by freeing up lecturers' time to focus on social emotional learning.

In 2024, we tend to view intelligence through the lens of chatbots such as ChatGPT-type systems, which utilise Natural Language Processing to understand our input and generate responses. However, it is essential to note that these systems are based on information available until 2021 and can often produce false content that asserts itself as true. In contrast, AI has the potential to personalise learning, improve student engagement, and provide real-time feedback to students and lecturers. It is not trivial to retrain systems with more recent information because of the danger of overtraining. A system becomes contaminated with information generated by itself.

One of the significant challenges in education today is the lack of access to quality education, particularly in developing countries. However, AI can help address this challenge by providing high-quality educational resources and personalised learning experiences to students who cannot access traditional educational institutions. Additionally, AI can bridge the digital divide by facilitating access to educational resources for students in remote or underserved areas.

AI has the potential to improve the quality of education by providing real-time feedback to students and lecturers. It can analyse student data to identify areas where students are struggling and provide targeted interventions to help them improve their learning outcomes. AI can also assist lecturers in identifying areas where they need to improve their teaching practices and provide personalised feedback to enhance their skills.

However, rapid technological developments inevitably bring multiple risks and challenges that have so far outpaced policy debates and regulatory frameworks. There are concerns about the ethical implications of using AI in education, including privacy, security, and bias. Furthermore, there is a risk that AI could impact employment in the education sector, particularly for lecturers.

Despite these challenges, AI has the potential to revolutionise the field of education by addressing some of the biggest challenges in education today, such as access to quality education, personalised learning experiences, improving student engagement and learning outcomes, and reducing the workload of lecturers. It is essential that the application of AI in educational contexts is guided by the core principles of inclusion and equity.

The potential of Artificial Intelligence in addressing education challenges presents both opportunities and risks. Policy debates and regulatory frameworks must keep pace with rapid technological developments to ensure that AI is used to enhance human capacities and protect human rights for effective human-machine collaboration in life, learning, and work, as well as sustainable development. This scenario creates new opportunities and risks associated with AI in education in general and higher education in particular.

10.3. Opportunities and risks associated with AI in education

The advent of Artificial Intelligence (AI) in education has the potential to revolutionise the way we learn, but it also raises concerns about its impact on student outcomes, equity, and the role of educators. One of the most significant opportunities lies in AI's ability to personalise learning experiences by analysing student data and providing targeted interventions. This technology can help improve student engagement through real-time feedback and reduce the workload of lecturers by automating administrative tasks. Another significant advantage is the potential for AI to bridge the digital divide by providing access to high-quality educational resources, particularly in remote or underserved areas. This could lead to a more equitable distribution of educational opportunities. Additionally, AI can provide students with real-time information and lecturers with valuable insights into student performance.

However, there are also several risks and challenges associated with AI in education. One of the primary concerns is the potential for AI to perpetuate and amplify existing biases and inequalities. As AI systems are only as good as the data they are trained on, if this data is biased, the system will be biased as well. Therefore, it is crucial that we develop more sophisticated training models that incorporate diverse perspectives and reduce bias.

Furthermore, there are concerns about the ethical implications of using AI in education, including privacy and security issues. The impact of AI on employment in the education sector also raises important questions about the future role of lecturers. On the other hand, the use of intelligent systems by students to solve their tasks necessitates a rethinking of teaching approaches. Another ethical consideration arises from the construction of mathematical models that underlie AI. These models are often created by private companies, which may intentionally or unintentionally introduce bias. This raises concerns about the potential for AI to exacerbate existing social and economic inequalities.

To address these risks and challenges, it is essential that we ensure that the application of AI in educational contexts is guided by core principles of inclusion and equity. Policy debates and regulatory frameworks must keep pace with rapid technological developments to guarantee that AI enhances human capacities and protects human rights for effective human-machine collaboration in life, learning, and work.

The European Union's adoption of a world-first law on artificial intelligence, approved in May 2024, serves as an example of the importance of regulating AI development. This regulation aims to ensure that AI systems used in the EU are safe and respect fundamental rights and European values.

10.4. Advances in AI and their impact on teaching and learning practices

The advent of Artificial Intelligence (AI) in education presents a significant opportunity for transformation. As educators and policymakers, we have the chance to re-evaluate the purpose of education and reimagine what it means to be a student in the 21st century.

According to the World Economic Forum, AI has the potential to free up time in the classroom, accelerate students' holistic development, and make teaching more fulfilling (World Economic Forum, 2023). By embracing this technology, educators can provide students with tailored feedback and recommendations, identify struggling students and offer additional support, and reduce the achievement gap between students from different backgrounds.

AI can also help create more inclusive learning environments by providing students with disabilities with additional support. For example, AI can create closed captions for videos and provide text-to-speech software, ensuring that all students have equal access to learning opportunities.

The latest advances in generative AI and Natural Language Processing (NLP) allow us to interact with AI systems using our own language. This technology enables users to ask questions aloud and receive coherent responses based on the system's knowledge base. The ability to transform spoken speech into text and vice versa means that students can engage with AI systems without needing to use keyboards.

This revolutionises the way we interact with AI, making it feel more human-like. We can ask questions aloud and receive answers aloud, as if a human were responding. This technology has the potential to greatly enhance the learning experience for students of all abilities.

The integration of AI in education also presents an opportunity for lecturers to improve their teaching practice and professional experience. By leveraging these technologies, educators can focus on more important tasks such as lesson planning and student engagement, while AI automates routine tasks like grading and administrative work.

Ultimately, the incorporation of AI in education has the potential to accelerate our progress towards inclusive learning that prepares young people to thrive and shape a better future. As we navigate this rapidly changing landscape, it is crucial that we prioritise collaboration between educators, students, parents, and policymakers to ensure that our education systems are equipped to provide students with the skills they need to succeed in an ever-evolving world.

10.5. Policy debates and regulatory frameworks for AI in education

The European Union has recently (May 2024) adopted a groundbreaking law on artificial intelligence, known as the Artificial Intelligence Act (AI Act). This pioneering legislation aims to ensure that AI systems used in the EU are safe and respect fundamental rights and European values. The regulation also seeks to protect democracy, the rule of law, and the environment by governing high-risk AI systems. The AI Act is a significant EU initiative designed to promote safe AI use in the single market. It adopts a risk-based approach, with stricter rules applying to higher-risk AI systems. As the world's first-of-its-kind regulation, it has the potential to set a global standard for AI governance, similar to the General Data Protection Regulation (GDPR), thereby promoting the European tech regulatory approach globally.

The Act aims to guarantee that AI systems placed on the European market and used in the EU are safe and respect fundamental rights and EU values. It also seeks to stimulate investment and innovation in AI across Europe by providing a clear framework for companies to operate within. A key aspect of the provisional agreement is the inclusion of rules on high-impact general-purpose AI models that can cause systemic risk in the future, as well as high-risk AI systems. The compromise also aligns with the definition proposed by the Organisation for Economic Co-operation and Development (OECD) to provide clear criteria for distinguishing AI from simpler software systems. The regulation does not apply to areas outside the scope of EU law and should not affect member states' competences in national security or any entity entrusted with tasks in this area. To alleviate the administrative burden for smaller companies, the provisional agreement

includes a list of actions to support such operators and provides for some limited derogations.

In higher education, AI has the potential to transform learning by enabling more personalised and practical learning. However, the rapid evolution of AI and the slow pace of adaptation of official educational projects present significant challenges that cannot be ignored. Recent European legislation on AI also has important implications for higher education, both in terms of opportunities and restrictions.

AI is transforming university education in many fields significantly, enabling personalised learning and tailoring learning material to individual needs. This can help students learn at their own pace, analyse large data sets in real-time, and make informed decisions based on data. AI simulations can also be used to create interactive and engaging learning experiences, such as managing investment portfolios or learning about financial markets, for example.

The recent approval of the AI Act by the EU Council and European Parliament has important implications for university education. The law regulates AI systems based on their ability to cause harm to society, which means that AI systems used in university-level education must be safe and respect fundamental rights and EU values. This law also seeks to stimulate investment and innovation in AI across Europe, which could lead to an increase in the quantity and quality of AI tools available for higher education. However, the law also imposes certain restrictions and requirements on AI systems, which could limit their use in some cases.

The direct consequence of this European law is that certain companies may limit the use of AI in the territory of the European Union. Some authors believe that this will slow down the development of AI products in Europe, while others argue that clear guidelines for training large language models (LLMs) and respecting rules and restrictions are necessary. The issue of liability in AI usage also remains open, with questions surrounding who bears responsibility for the consequences of an AI act – the developer or the user.

Overall, the European Union's AI Act represents a significant milestone in regulating AI, setting a global standard for AI governance, and promoting investment and innovation in AI across Europe.

10.6. Ensuring inclusion and equity in AI-enabled education

The incorporation of artificial intelligence (AI) into education has the potential to revolutionise the way we learn by providing personalised learning experiences tailored to individual students' needs. This can

help ensure that every student, regardless of their skill level or prior knowledge, has equal opportunities to learn and succeed.

Furthermore, AI can help remove barriers to learning faced by certain students, such as those with disabilities or learning difficulties, by providing additional support and ensuring they have access to the same quality of education as their peers. However, it is crucial to acknowledge that AI can exacerbate existing inequalities if not implemented equitably. For instance, if only students from specific socio-economic backgrounds have access to AI technology, this could widen the education gap.

Moreover, it is vital to recognise that AI systems used in education must be free from bias and ensure that special effort is devoted to eradicating any kind of bias. The inclusiveness and fairness of AI in education can only be guaranteed if we work towards eliminating bias.

In terms of European legislation, the Council of the EU and the European Parliament are well aware of the implications of AI-enabled education on inclusion and equity. The law regulates AI systems based on their potential to cause harm to society, which means that AI systems used in education must be safe and respect fundamental rights and EU values. While the law aims to stimulate investment and innovation in AI across Europe, it also imposes certain restrictions and requirements on AI systems, which could limit their use in some cases.

AI has the potential to improve inclusion and equity in education, but it also presents significant challenges. It is essential that educators, policymakers, and AI developers collaborate to ensure that AI is used in a way that benefits all learners. The recent European legislation on AI is an important step in this direction, and we must work together to harness its potential while addressing the challenges it poses.

10.7. AI-based learning management systems

AI-powered LMSs can help automate administrative tasks, personalise learning experiences, and provide real-time feedback to students. As LMSs enable lecturers to organise and distribute learning materials, assess student performance, and facilitate communication between students and lecturers, in an AI-enabled learning environment they can play an even more crucial role. By collecting and analysing data on student behaviour and performance, they provide valuable information that can be used to personalise learning. For example, an LMS can identify areas where a student is struggling and automatically adjust learning material to address these areas.

Building on this, LMSs can facilitate collaborative learning, an important aspect of modern education. Students can work together on

projects, discuss ideas, and learn from each other, all facilitated by the LMS. AI can further enhance these interactions, for example, by using sentiment analysis to moderate discussions and ensure a positive learning environment.

To achieve this goal, it helps that LMSs are dynamic modular systems that can integrate various AI tools and resources, such as virtual tutors and learning assistants. These can provide additional support to learners, answering questions and providing additional explanations as needed.

LMSs are essential tools in AI-based education, facilitating personalisation of learning, collaborative learning and the integration of various AI tools and resources. As AI technology continues to advance, we are likely to see even more ways in which LMSs can enhance education. For now, we will focus on chatbots, virtual and augmented reality, adaptive learning, gamification, and data analytics.

10.7.1. Chatbots

A chatbot is a computer program that simulates human conversation with an end user. It can provide instant responses to user queries, making it easy for users to find information. Modern chatbots increasingly use artificial intelligence techniques like natural language processing (NLP) and machine learning to understand the user's questions and automate responses. They can understand free-flowing conversation through the use of sophisticated language models. In this way, chatbots can be used to provide 24/7 support to students, answer frequently asked questions, and provide personalised guidance.

Chatbots, powered by artificial intelligence, are revolutionising higher education. These virtual assistants can provide invaluable support in higher education learning, for example, offering a personalised and accessible learning experience. Firstly, chatbots can provide instant responses to student queries. This is especially useful in the university courses, where concepts can be complex, and students may have many questions. Chatbots can quickly search their knowledge base and provide accurate answers. This not only saves time, but also allows students to learn at their own pace. In addition, chatbots can adapt to each learner's level of knowledge. They can assess the learner's level of understanding through quizzes and interactive tests, and then adjust the learning content accordingly. This ensures that each learner receives the right level of challenge, which can improve motivation and engagement.

Chatbots can also provide contextualised learning. In some academic fields, this could involve presenting real-life scenarios to help students understand how relevant concepts apply in the real world.

Chatbots can automatically generate these scenarios based on real-world data, providing students with a relevant and engaging learning experience. In addition, chatbots can facilitate collaborative learning. They can connect students with peers who have similar interests or learning needs, encouraging discussion and the exchange of ideas. This can help students develop critical thinking and problem-solving skills, which are essential in academic fields, but is not only applicable to this particular field but is adaptable to any field of knowledge.

Finally, chatbots can constantly monitor students' progress. They can track students' performance over time, identify areas of weakness and provide constructive feedback. This allows students to reflect on their learning and make adjustments as needed.

10.7.2. Virtual reality and augmented reality

Virtual Reality (VR) and Augmented Reality (AR) are two distinct but related technologies that are changing the way we interact with digital content.

Virtual Reality (VR) is a technology that immerses you in a computer-generated world. When you put on a VR headset, your vision is completely taken over by the digital environment that the headset displays. This could be a game, a 360-degree video, or even the virtual space of the platform's interface. VR headsets also use a technology called head tracking, which allows you to look around the environment by physically moving your head. The display will follow whichever direction you move, giving you a 360-degree view of the virtual environment.

Augmented Reality (AR), on the other hand, adds digital images to your real-world view. AR devices, such as the Microsoft HoloLens or various enterprise-level “smart glasses”, are transparent, letting you see everything in front of you as if you are wearing a pair of clear glasses. Instead of transporting you to a virtual world like VR, AR takes digital images and layers them on the real world around you through the use of either a clear visor or smartphone. This means you could see digital content, like directions or game characters, overlaid on your actual surroundings.

While VR and AR are different, they are not mutually exclusive. As these technologies continue to develop, they are starting to blend into each other in some ways. This has led to the term Mixed Reality (MR), which is a blend of VR and AR, where digital and physical objects co-exist and interact in real time.

VR and AR are emerging as powerful tools in higher education. These immersive technologies provide students with hands-on,

engaging learning experiences that can be difficult to achieve through more traditional teaching methods. VR and AR can be used to simulate real-world financial situations. For example, students can use VR to explore a virtual stock market, where they can practice buying and selling stocks in a safe environment. This can help students better understand how financial markets work and develop practical skills in financial decision-making.

In addition, VR and AR can be used to visualise financial data in a more intuitive way. Students can “walk” through a three-dimensional graph of financial data, which can help them better understand trends and patterns. This can be especially useful in many academic fields that rely heavily on data analysis.

VR and AR can also facilitate collaborative learning. Students can work together in a virtual environment, discussing ideas and solving problems together. This can help students learn from each other and develop teamwork skills.

10.7.3. Adaptive learning

Adaptive learning is a method of education that uses Artificial Intelligence (AI) algorithms to personalise learning experiences. It tailors educational content and the pace of learning to meet the unique needs of each student, based on their performance, preferences, and goals.

At the heart of adaptive learning systems are AI algorithms that continuously collect and analyse data about a student’s interactions with the learning material. These algorithms monitor a student’s performance on assessments, the time they spend on different topics, the resources they use, and even their navigation patterns within the learning platform. Based on this data, the AI algorithms identify patterns and make inferences about the student’s learning style, strengths, weaknesses, and progress. For instance, if a student consistently struggles with a particular concept, the system might provide additional resources or exercises on that topic. If a student excels in a certain area, the system might present more advanced material to keep them challenged and engaged.

In addition to performance data, adaptive learning systems can also consider a student’s stated preferences and goals. For example, if a student indicates a preference for visual learning, the system might prioritise video content or infographics. If a student’s goal is to master a specific skill or topic, the system can recommend a personalised learning path to help them achieve that goal. By continuously adapting to each student’s needs, adaptive learning systems aim to provide a

more personalised, efficient, and effective learning experience. They can help students to learn at their own pace, focus on areas where they need improvement, and achieve their learning goals. However, it's important to note that while adaptive learning can be a powerful tool, it's most effective when used in conjunction with traditional lecturing methods and human guidance.

10.7.4. Gamification

Gamification in learning involves the application of game design elements in non-game contexts to make learning more engaging and enjoyable. It's a powerful tool that can increase student engagement, motivation, and retention.

In the context of higher education, gamification can take many forms. For instance, students could earn points or badges for completing assignments, participating in class discussions, or achieving high scores on assessments. These rewards provide immediate feedback and recognition, which can motivate students to stay engaged and strive for excellence. Another common gamification strategy is the use of leaderboards, which rank students based on their performance or participation. Leaderboards can foster a healthy sense of competition among students, encouraging them to put forth their best effort.

Moreover, concepts can be taught through interactive games. For example, a game could simulate a stock market, where students make investment decisions and see the impact of those decisions in real-time. This not only makes learning fun but also provides a safe environment for students to apply what they've learned and gain practical experience. Challenges or quests can also be incorporated into the curriculum. These could involve complex problems that require critical thinking and collaboration to solve. Completing these challenges can give students a sense of accomplishment and mastery. It's important to note, however, that while gamification can make learning more engaging, it should be used thoughtfully and in conjunction with other teaching methods. The goal of gamification is not just to make learning fun, but to enhance students' understanding and retention of the material.

All areas of knowledge can be gamified. This gives AI great versatility to adapt to them and generate content in the form of games.

10.7.5. Data analytics

Data analytics is increasingly being used in higher education to monitor student performance, identify areas for improvement, and provide personalised feedback. This approach leverages the power of data to enhance the learning experience and outcomes.

Monitoring student performance involves collecting and analysing data on various aspects of a student's engagement with the course material. This could include metrics such as test scores, assignment completion rates, and time spent on different topics. Advanced analytics can reveal patterns and trends in this data, providing insights into each student's strengths and weaknesses. For instance, if a student consistently performs poorly on questions related to a specific concept, this could indicate a misunderstanding or lack of knowledge in that area. Data analytics can pinpoint such issues, allowing educators to provide targeted support and additional resources to help the student improve.

Data analytics can also be used to deliver customised feedback. Instead of generic comments, educators can provide feedback that is tailored to each student's performance and learning style. For example, if a student learns best through visual aids, an educator might recommend video resources or infographics to help them understand a complex concept. Furthermore, data analytics can inform the design of adaptive learning pathways. These are personalised learning plans that adapt to a student's progress and performance. If a student is excelling in one area but struggling in another, an adaptive learning pathway could adjust the sequence and focus of topics to address this.

In the realm of higher education, where the material can be complex and abstract, data analytics offers a powerful tool for enhancing student learning. By providing a more nuanced understanding of student performance, it allows for more effective teaching strategies and a more personalised, engaging learning experience. Data analytics can be used to track student performance, identify areas of improvement, and provide personalised feedback.

10.8. Considerations on the veracity of information provided by Generative IA systems

We will demonstrate, in a few lines and in a practical way, how AI fails and why we cannot trust completely what it tells us. To do this we will use a commonly used electronic circuit, the LC resonant circuit (Figure 14). The example is very technical, but it is necessary to demonstrate when AI fails.

An LC circuit, also called a resonant circuit or LC oscillator, is an electrical circuit consisting of a coil, represented by the letter L, and a capacitor, represented by the letter C, which are connected to each other, as shown in Figure 16. It is used in all electronic systems,

including computers, televisions, and mobile phones, to name but a few, and is a fundamental component of modern technological life.

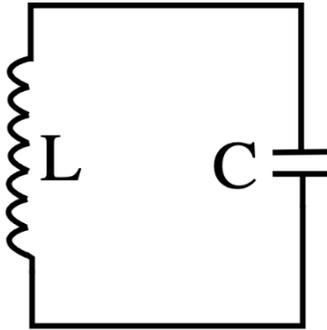


Figure 14. Simplified resonant LC circuit. From Wolfmankurd, CC BY-SA 3.0, <https://commons.wikimedia.org/w/index.php?curid=3433450>

In the following sections we will see how AI systems are incapable of solving elementary systems for any human being with minimal knowledge of mathematics and the necessary formulas. We will start with Microsoft Copilot in creative mode, then we will use the precise mode and finally chatGPT. All these systems use the same inference engine in version 3.5, as of the date we studied them, April 2024.

10.8.1. Calculation of an LC resonant circuit with Microsoft Copilot in Creative mode

Microsoft Copilot is an artificial intelligence assistant that can help you get information, answer your questions, and engage in conversations. It uses advanced technology, such as GPT-4 and Bing Search, to provide relevant and useful answers, although the version we are using here is version 3.5, as stated in the introduction. It can understand and communicate fluently in your preferred language and can generate imaginative and innovative content, such as poems, stories, code, essays, songs, celebrity parodies and more, using its own words and knowledge.

Copilot is supposed to help you write, rewrite, improve or optimise your content by identifying errors in the conversation, even without explicit user feedback, and rectifying them by providing accurate information. But while Copilot is a powerful tool, it has some limitations. For example, its internal knowledge and information was only up to date to some extent in 2021 and could be inaccurate or incomplete. However, it has some predefined internal tools that help it

to keep its knowledge up to date, although it still has some shortcomings that we should be aware of before using it.

We define “prompt” as the question we ask the chat in order to find an answer to our problem.

10.8.2. Initial calculation

Prompt: *What is the most suitable value and type for a capacitor to operate at 77KHz?*

Copilot:

To select the most suitable value and type of capacitor to operate at 77KHz, it is important to consider several factors such as capacitance, voltage rating, tolerance, temperature and frequency characteristics. Here is a general guide to help you make your choice:

Capacitance: The capacitor capacitance, measured in farads (F), should be adequate for your circuit's needs. For high frequency applications such as 77KHz, you may need a capacitor with a lower capacitance to avoid unwanted effects such as resonance.

Rated Voltage: The rated voltage should be higher than the maximum voltage the capacitor will experience in the circuit to ensure a safety margin.

Tolerance: The tolerance indicates the allowable variation in capacitor capacitance. For precision applications, it is preferable to choose a tighter tolerance.

Temperature: The capacitance of some capacitors may vary with temperature. It is

important to select a capacitor with good thermal stability, especially if the operating environment has significant temperature changes.

Capacitor Type: For a frequency of 77KHz, **ceramic** or **film** capacitors might be suitable due to their high stability and accuracy. **Tantalum** capacitors are also a good choice for high frequency applications due to their accuracy and stability.

In summary, for a 77KHz application, you might consider a ceramic or film capacitor with a capacitance suitable for your circuit, a voltage rating that exceeds the maximum circuit voltage, a tight tolerance and good thermal stability. Always remember to check the manufacturer's data sheets for exact specifications and usage recommendations.

Analysis: So far so good. This is general information. Let's make the question concrete.

Prompt: *We are going to work with voltages below 12V and a temperature no higher than 40 degrees Celsius.*

Copilot:

With those specifications, you can look for a capacitor that has a **voltage rating** of at least **16V** to

have an adequate safety margin. Since the maximum operating temperature is 40 degrees Celsius, you don't need a capacitor with high temperature specifications, which simplifies the selection.

For an operating frequency of 77KHz and an operating voltage of less than 12V, a **multilayer ceramic capacitor (MLCC)** would be an excellent choice. Ceramic capacitors are known for their stability and reliability over a wide range of temperatures and frequencies. In addition, they have low equivalent series resistance (ESR) and low equivalent series inductance (ESL), making them ideal for high-frequency applications.

Here is a general recommendation:

Capacitance: It will depend on the specific application, but for filters or couplings at a frequency of 77KHz, you might consider values in the **nanofarad (nF)** to **microfarad (μ F)** range.

Nominal Voltage: At least 16V.

Type: Multilayer ceramic capacitor (MLCC).

Tolerance: $\pm 5\%$ or better if accuracy is required.

Temperature: With an operating temperature of up to 40

degrees Celsius, most standard ceramic capacitors will perform well.

Remember to always check the data sheets for exact specifications and make sure that the capacitor you choose meets your circuit requirements. I hope this helps you.

Remember to always check the data sheets for exact specifications and make sure the capacitor you choose meets the requirements of your circuit - I hope this helps you find the right capacitor for your project! 😊

Analysis: The answer is correct, but it is still general information. Let's go into the calculations.

Prompt: *Calculate the capacitor, with these data, needed to make a resonant circuit if we use a coil with 30 turns in the air with a radius of 1cm. Give a concise answer without too much explanation.*

Copilot:

The capacitor required for your resonant circuit with a 30 turn coil and a radius of 1cm at a frequency of 77kHz is **240.48nF**.

10.8.3. Check calculation to verify that you know what you are doing.

Prompt: *Don't be so frugal.*

Copilot:

Got it! Let's calculate the capacitor value for a resonant circuit with a coil of 30 turns and

a radius of 1 cm at a frequency of 77 kHz. First, we need to calculate the inductance (L) of the coil and then use the resonance formula to find the capacitance (C).

The inductance (L) of an air coil can be calculated with the formula:

$$L = \frac{(N^2 \cdot \mu_0 \cdot A)}{l}$$

Where:

- ∞ N is the coil number,
- ∞ μ_0 is the permeability of the vacuum ($(4\pi \times 10^{-7})$ H/m),
- ∞ A is the cross-sectional area of the coil (in square metres),
- ∞ l is the length of the coil (in metres).

For a coil with 30 turns ($(N = 30)$) and a radius of 1 cm ($(r = 0.01)$ m), the area (A) is (πr^2) , and assuming that the length (l) is approximately equal to the diameter, we have:

$$A = \pi \cdot (0.01m)^2 = 3.14 \cdot 10^{-4}m^2$$

$$l \approx 2 \cdot r = 0.02m$$

Then, the inductance (L) is:

$$L = \frac{(30^2 \cdot 4\pi \times 10^{-7} \cdot 3.14 \cdot 10^{-4})}{0.02} \approx 1.77\mu H$$

Now, using the formula for the resonant frequency (f_0):

We clear (C):

$$C = \frac{1}{(2\pi f_0)^2 L}$$

Substitute $f_0 = 77\text{kHz}$ and $L = 1.77\mu\text{H}$:

$$C = \frac{1}{(2\pi \cdot 77 \cdot 10^3)^2 \cdot 1.77 \cdot 10^{-6}} \approx 1.47\text{nF}$$

Therefore, you would need a capacitor of approximately **1.47nF** for your resonant circuit. Remember that this calculation is an approximation, and you should adjust the value according to the actual conditions of your circuit. I hope this explanation is more helpful.

Analysis: Perfect, copilot has already explained the solution but wait! In the first calculation it told us that the capacitor was **240.48nF** and now it turns out to be **1.47nF**? We didn't ask copilot to change the data, just to explain what it did, and the results are different!

It is clear that something is wrong when copilot do calculations. It works very well when it gives us data from memory, it knows a lot, but when it has to apply that memorised information, it gets it completely wrong and his lack of knowledge of the world does not allow him to detect these mistakes. A human being, even if it makes mistakes when using a calculator, realises that something is wrong when it sees results that are disjointed or out of range, according to his experience. It always performs the calculations two or more times and makes sure that his data does not contain any misconceptions.

10.8.4. Calculating a resonant circuit with copilot in precise mode

We will now use Microsoft's copilot (Copilot, 2024), in a precise way, to avoid making too much up and to be more faithful to reality.

10.8.5. Initial calculation

Prompt: *What is the most suitable value and type for a capacitor to be operated at 77KHz?*

Copilot

The value and type of capacitor suitable for a frequency of 77KHz depends on several factors, including the specific application, the circuit in which it is to be used, and the desired characteristics of the capacitor.

There are several types of capacitors, each with their own characteristics and uses:

⊗ **Ceramic capacitors:**

These are small, lightweight, inexpensive and are generally used for low-power applications, such as general filtering or bypassing.

⊗ **Electrolytic capacitors:**

These are larger and heavier but offer the highest energy storage capacity for their size. They are used in circuits that consume a lot of power, such as motor control, power supplies or audio amplification.

⊗ **Tantalum capacitors:**

These are smaller and lighter than electrolytic capacitors but offer lower energy storage capacity for their size. They are

used in circuits that consume a lot of energy, such as motor control, power supplies or audio amplification.

To determine the value of capacitor C , the inversely proportional relationship between the charge (q) and the voltage (V) applied in the circuit is used, so the formula corresponds to

$$C=q/V$$

It is important to remember that the value and type of capacitor must be carefully selected to ensure that it meets the requirements of the specific application. If in doubt, I would recommend consulting an electrical engineer or electronics expert.

Analysis: So far so good, although it introduces a major misconception, but it is not what we are evaluating at this point, although in creative mode it was totally correct. It is generalist information. Let's make the question concrete:

Prompt: *We are going to work with voltages below 12V and a temperature no higher than 40 degrees Celsius.*

Copilot

Since you are working with voltages below 12V and a temperature no higher than 40

degrees Celsius, you might consider the following types of capacitors:

- ⊗ Ceramic capacitors: These are a good choice for this application because of their small size, light weight and economical cost. They are suitable for low power applications and can handle voltages up to 50V.
- ⊗ Film capacitors: These are another viable option. They are known for their thermal stability and high temperature tolerance.

The value of the capacitor will depend on the specific application. To calculate it, you can use the capacitance formula: $C=q/V$, where q is the charge and V is the voltage.

Analysis: To make the response comparable for non-experts, its response is **12 μ F** or **12000nF**, as opposed to the **240.48nF** it gave in its first creative response. It is clear that the calculations are totally incorrect, without us going into what is the correct result. The important point here is that we cannot rely on anything it says.

10.8.6. Check calculation to verify that you know what you are doing.

Prompt: *Don't be so sparing.*

Copilot

Apologies if I sounded too concise. For a resonant circuit with a 30 turn air coil and a radius of 1cm at a frequency of 77KHz, the capacitor value required would be approximately 1.20×10^{-5} Farads. This value ensures

Please note that these are only general tips. I would recommend that you consult an electrical engineer or electronics expert for more specific advice appropriate to your application.

Analysis: The answer is correct, but it is still general information and in the creative mode it gave better explanations so that the expert can make his own decisions. Let's get into the calculations:

Prompt: *Calculate the capacitor, with these data, needed to make a resonant circuit if we use a coil with 30 turns in the air with a radius of 1cm. Give a concise answer without too much explanation.*

Copilot

The capacitor needed for resonance is about **1.20 x 10⁻⁵ Farads.**

that the circuit resonates at the desired frequency. If you have more questions or need more details, feel free to ask - I'm here to help! 😊

Analysis: Now the extended response is not so extended, but it still keeps the same value. Let's

force it to tell us what the calculations were.

Prompt: *Explain the calculations*

Sure, here is the explanation of the calculations:

The resonant frequency (f) of an LC circuit (inductor and capacitor) is calculated with the formula:

$$f = \frac{1}{2\pi\sqrt{LC}}$$

Where:

- ⊗ L is the inductance of the coil in henries (H).
- ⊗ C is the capacitance of the capacitor in farads (F)

If we know the resonant frequency (f) and the inductance (L), we can clear the capacitance (C) from the above formula to obtain:

$$C = \frac{1}{(2\pi f)^2 \cdot L}$$

The inductance of a coil can be calculated with the formula:

$$L = \mu \cdot N^2 \cdot A / 2l$$

Where:

- ⊗ μ is the permeability of the material (in this case, air).

⊗ N is the number of turns of the coil

⊗ A is the cross-sectional area of the coil in square metres (m²)

⊗ l is the length of the coil in metres (m)

For an air coil ($\mu \approx 4\pi \times 10^{-7}$ H/m), with 30 turns (N = 30), a radius of 1 cm (r = 0.01 m), and assuming that the length of the coil is approximately equal to the diameter (l \approx 2r = 0.02 m), the inductance would be:

$$L = 4\pi \cdot 10^{-7} \cdot 0.02302 \cdot \pi \cdot (0.01)^2 \approx 1.41 \cdot 10^{-6} \text{H} = 1.41 \mu\text{H}$$

Substituting these values into the capacitance formula we obtain:

$$C = \frac{1}{(2\pi \cdot 77 \cdot 10^3)^2 \cdot 1.41 \cdot 10^{-6}} \approx 1.20 \cdot 10^{-5} \text{F} = 12 \mu\text{F} = 12000 \text{nF}$$

Therefore, the value of the capacitor required for the circuit to resonate at 77KHz would be approximately 1.20 x 10⁻⁵ Farads. I hope this clears up your doubts. If you have any more questions, feel free to ask - I'm here to help!



Analysis: In the answer it explains the calculations and comes back with the same results, which was not the case in creative mode. Now we have the need to know if the results are correct and match those of an expert.

10.8.7. Expert verification of the results

Assuming the calculated inductance is correct, with the data provided by copilot, the frequency f=39KHz, far from the 77KHz we asked for. This leads us to think that it did not calculate the inductance of the requested coil correctly. Recalculating the inductance, the real result is 12.6uH, far from the calculations made by the copilot AI, which should have given us a result of approximately 340nF.

The normalised value is 330nF and the coil would be 12.95uH. With this data and the same coil, the frequency would be 78KHz, which with the tolerance of the electronic components is perfectly acceptable.

10.8.8. Calculating a resonant circuit with ChatGPT 3.5

We will use ChatGPT (ChatGPT, 2024), as of April 2024.

10.8.9. Initial calculation

Prompt: *What is the most suitable value and type for a capacitor to be operated at 77KHz?*

ChatGPT

To determine the most suitable type and value of a capacitor that will operate at a frequency of 77 kHz, several factors must be considered, including the specific application of the capacitor, the operating voltage, and desired characteristics such as stability, tolerance, and temperature coefficient. Here's how to go about making a proper selection:

Application

First, you need to define the application of the capacitor:

- **Filtering:** If the capacitor is used to filter signals at 77 kHz, it may need a high capacitance to store more charge.
- **Coupling:** If it is used for signal coupling, you may need a more moderate value to allow the desired frequencies to pass through without affecting the signal too much.
- **Oscillators or resonant circuits:** In these cases,

accuracy and stability are critical.

Capacitor Type

Several types of capacitors may be suitable, but here are some common ones for RF or high frequency applications:

1. **Ceramic:** They are very popular for high frequency applications due to their low dielectric loss and good frequency response. Class 1 ceramic capacitors, such as NP0 or C0G, offer excellent stability and low loss.
2. **Film:** Film capacitors are good for high frequency applications and have higher tolerance and stability than electrolytic capacitors. They are suitable for high frequency signals and are often used in audio and RF applications.
3. **Tantalum Electrolytics:** Generally not preferred for frequencies as high as 77 kHz due to their higher dielectric losses and higher ESR (equivalent series resistance).

Capacitor Value

The capacitor value will depend on the specific application:

- For ****filtering**** applications, higher values (microfarads) may be necessary.
- For ****coupling or decoupling****, values in the nanofarad to microfarad range may be appropriate, depending on the input and output impedances of the connected circuits.

Additional Considerations

- **Resonant Frequency:** Make sure the capacitor's own resonant frequency is higher than the operating frequency (77 kHz) to avoid interference in normal operation.
- **Working Voltage:** Make sure that the rated voltage of the capacitor is suitable for the voltage to be handled in the circuit.

Example of Selection

If you need a capacitor for a filter in a 77 kHz application, you might choose a 1 μ F ceramic capacitor, with a voltage rating that is at least 25% higher than the maximum voltage expected in the circuit. Make sure it is of NP0/C0G type if stability and low loss are critical.

In summary, selecting the right capacitor involves

understanding the application, the most suitable capacitor type, and the value needed to meet the circuit specifications. These details will help you choose the right component for your 77 kHz application.

Analysis: So far so good. It is general information, but it is well explained and gives the designer options to choose the most suitable capacitor. Let's make the question concrete:

Prompt: *We are going to work with voltages below 12V and a temperature no higher than 40 degrees Celsius.*

ChatGPT

With those additional details of operating voltage and temperature, we can further refine the selection of the capacitor for your 77 kHz application. Here are some specific considerations:

Capacitor Type

Since the operating voltage is relatively low (below 12V) and the operating temperature is standard (not higher than 40 degrees Celsius), the options for capacitor types become more flexible:

1. ****Ceramic:**** For high frequency applications, ceramic capacitors are ideal. The NP0 or C0G type is still excellent because it offers thermal stability and low dielectric loss. You don't need to worry about high temperatures or extreme

voltages, so these capacitors are more than sufficient.

2. **Film:** Film capacitors are also a good choice here, especially if the application requires higher tolerance and stability in capacitance value. They present no problems with electrical characteristics at 40 degrees Celsius and are excellent for maintaining capacitance consistency with changes in voltage and temperature.

Capacitor Value

Depending on your specific application (filtering, coupling, resonance, etc.), you might consider:

- **Nanofarads** to **Microfarads:** For coupling or decoupling, a range of values from several nanofarads to a few microfarads would be typical. For example, common values might be 100nF or 1 μ F.
- **Microfarads:** For filtering applications, especially if lower signals need to be handled, you might choose higher values such as 1 μ F or even 10 μ F if a more robust filter is required.

Rated Voltage

Although the maximum operating voltage is 12V, it is

prudent to select a capacitor with a voltage rating of at least 16V to provide an adequate safety margin and to ensure that the capacitor is not near its maximum voltage limit during normal operation.

Example of Selection

- For a **filter** in a 77 kHz RF application, a 1 μ F NP0/C0G type ceramic capacitor with a voltage rating of 16V or 25V would be a safe choice.
- For **coupling**, a 100 nF film or ceramic capacitor with a voltage rating of 16V would also be suitable.

With these considerations, you can select a capacitor that not only handles the electrical needs of your circuit, but also offers reliability and stability throughout its operation.

Analysis: The answer is correct, but it is still general information. Let's get into the calculations:

Prompt: *Calculate the capacitor, with these data, needed to make a resonant circuit if we use a coil with 30 turns in air with a radius of 1cm. Give a concise answer without too much explanation.*

ChatGPT

To calculate the value of the capacitor needed for a resonant circuit at 77 kHz using a 30 turn coil with a radius of 1 cm, we first need to calculate the inductance of the coil and then use the

formula for the resonant frequency.

1. Coil inductance calculation
 Radius $r=1\text{cm}=0.01\text{m}$
 Number of turns $N=30$

*The approximate formula for a circular coil is $(L \approx \frac{\mu_0 N^2 \pi r^2}{2r})$, where (μ_0) is the permeability of the vacuum $4\pi \cdot 10^{-7} \text{H/m}$.

$$L \approx \frac{4\pi \cdot 10^{-7} \cdot 30^2 \cdot \pi \cdot 0.01^2}{2 \cdot 0.01} = 4.24 \cdot 10^{-6} \text{H} = 4.24 \mu\text{H}$$

2. Resonance frequency

The formula for the resonant frequency f , of an LC circuit is

$$f = \frac{1}{2\pi\sqrt{LC}}$$

10.8.10. Calculation checks to verify that it knows what it is doing.

Prompt: *Explain the calculations better.*

ChatGPT

Sure, I'll explain in more detail how I came to the conclusion that you need a capacitor of approximately 88.7pF for your resonant circuit.

1. Coil inductance calculation

The coil in question has 30 turns and a radius of 1 cm. to calculate the inductance of a circular air coil, we use an approximation of the general formula for a solenoid coil:

$$L \approx \frac{\mu_0 N^2 \pi r^2}{2r}$$

Where:

μ_0 is the permeability of the vacuum: $4\pi \cdot 10^{-7} \text{H/m}$. Or Henries per meter.

Clearing C and substituting $f=77\text{KHz}=77 \cdot 10^3\text{Hz}$ & $L=4.24\mu\text{H}$

$$C = \frac{1}{(2\pi f)^2 L} = \frac{1}{(2\pi \cdot 77 \cdot 10^3)^2 \cdot 4.24 \cdot 10^{-6}}$$

By calculating:

$$C = \frac{1}{(2\pi \cdot 77 \cdot 10^3)^2 \cdot 4.24 \cdot 10^{-6}} \approx 8.87 \cdot 10^{-11} \text{F} = 88.7 \text{pF}$$

Therefore, you need a capacitor of approximately 88.7 pF to form a resonant circuit at 77 kHz with a coil of 30 turns and a radius of 1 cm.

N is the number of turns of the coil

R is the radius coil in meters

By substituting the values:

*The approximate formula for a circular coil is $(L \approx \frac{\mu_0 N^2 \pi r^2}{2r})$, where (μ_0) is the permeability of the vacuum $4\pi \cdot 10^{-7} \text{H/m}$.

$$L \approx \frac{4\pi \cdot 10^{-7} \cdot 30^2 \cdot \pi \cdot 0.01^2}{2 \cdot 0.01} = \frac{4\pi \cdot 10^{-7} \cdot 900 \cdot \pi \cdot 0.0001}{2 \cdot 0.01} = \frac{0.0001131}{0.02}$$

$$L \approx 5.65 \cdot 10^{-6} \text{H} = 5.65 \mu\text{H}$$

2. Capacitor calculation for resonant frequency

With the calculated inductance, we can find the capacitor value needed to reach a

resonant frequency of 77kHz using the formula for the resonant LC circuit:

$$f = \frac{1}{2\pi\sqrt{LC}}$$

$$C = \frac{1}{(2\pi f)^2 L}$$

$$= \frac{1}{(2\pi \cdot 77 \cdot 10^3)^2 \cdot 5.65 \cdot 10^{-6}}$$

$$C \approx \frac{1}{(483.138)^2 \cdot 5.65 \cdot 10^{-6}}$$

$$C \approx \frac{1}{1.336 \cdot 10^{14} \cdot 5.65 \cdot 10^{-6}}$$

$$C \approx \frac{1}{7.55 \cdot 10^8} \approx 1.32 \cdot 10^{-9} F$$

$$\approx 1320 pF$$

I apologise for the error in the previous calculation. The correct

result indicates that you need a capacitor of approximately 1320pF to reach a resonant frequency of 77 kHz with a 5.65μH coil.

Analysis

Great, it has already explained the solution but wait! In the first calculation it told us that the capacitor was **88.7pF=0.0887nF** and now it turns out to be **1.32nF**? We didn't ask it to change the data, just to explain what it did, and the results are different! However, it seems to realise that something is wrong and apologises, thinking that the data is now correct.

It is clear that something is wrong when you do calculations. It works very well when it gives you data from memory, it knows a lot, but when it must apply that memorised information, it gets it completely wrong and its lack of knowledge of the world does not allow it to detect these mistakes. It is clear that, when it solves the calculations, it does not do it correctly. Moreover, it uses theoretical formulas, when there are dozens of articles that provide more approximate formulas using empirical data to calculate the necessary approximations.

10.8.11. Conclusion

The system could be forced further to show other inconsistencies in the results, but that would complicate the explanations with concepts that are not directly applicable to many academic fields. Generative AI is fine for generating essays and texts, but when we must deal with calculations and the real world, the results are bad and worse the less tabulated the data and the way it is used. This is the case in electronics, where the designer has many degrees of freedom and the results cannot be obtained by concatenating one word after the other but requires knowledge of the real-world model and making inferences and decisions, being aware of the implications. In short, AI lacks awareness, but it also needs to be fed by more scientific and reliable sources.

From an academic point of view, it must be stressed to students that generative AI infers things that do not correspond to reality and that its answers are too superficial for what is required at university, research, or professional environment.

The new challenge is to turn the intelligence system from a language parser (Large Language model, LLM) into a knowledge model (Artificial General Intelligence, AGI). As of September 2024, some AI players (Price 2024) have published new models capable of achieving results in physics, mathematics and science at the level of a PhD student. We will see what the future holds for reasoning models.

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