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# Bridging Pedagogy, Curriculum, and Assessment in Digital Education: Ensuring a Constructive Alignment

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## Abstract

An individual has the right to a quality and inclusive education and to training throughout their life. This is described in the European Pillar of Social Rights' principles of Education, training, and lifelong learning, and Equal opportunities. Given that digitalization processes are leading to pedagogical change, how this education and training are designed and delivered may be impacted. This article explores the important interplay between pedagogy, curriculum, and assessment in digital education. We begin by discussing the acquisition of digital skills—an important indicator of an individual's capacity to manage transitions—particularly focusing on the Portuguese context. Next, we reflect on how different learning theories and models can be applied in digital environments. In particular, we address the evolving roles of teachers and students, and the relevant pedagogical strategies, and propose the need for an alignment between pedagogy, curriculum, and assessment in digital education. By reflecting on how these aspects can be effectively integrated into the digital learning landscape, this overview provides valuable insights for both practice and policymaking, fostering meaningful and enriching educational experiences in the digital realm.

## Keywords

digital education; educational curriculum; learning assessment; pedagogy

## 1. Introduction

Digital technology has revolutionized our society, and the education field is no exception (European Education and Culture Executive Agency, 2019). Digital education, generally referred to as the innovative application of digital tools to teaching and learning, has come to prominence over recent decades. Nowadays, teachers, educators, trainers, and students have a great variety of innovative learning approaches and active methodologies at their disposal (e.g., blended or fully online courses; Moreira & Schlemmer, 2020). Consequently, software and digital educational resources have progressively been recognized, not merely as digital tools, but as purposefully designed entities to support teaching and learning processes. Didactic games, digital programs, educational podcasts, videos, tutorials, blogs, wikis, web pages, and other resources encompassing pedagogical materials, stored or made available online, constitute but a few examples (Alexandre et al., 2023; Kukulska-Hulme et al., 2023; Tchounikine, 2011).

When thinking about digital education, related concepts such as digitization, digitalization, and digital transformation must be considered. Digitization refers to the conversion of analogue data and processes into a digital format (e.g., storing educational information and making it digital and accessible), whereas digitalization refers to the use of digital technologies and data that results in something new or that modifies existing activities, processes, or services (e.g., adapting educational processes or services to make them digital). Digital transformation refers to the economic and societal effects of digitization and digitalization (e.g., realignment of educational institutions and organizations to adapt to the growing use of technology and becoming digital; Bloomberg, 2018; OECD, 2014). Thus, the pedagogical use of digital technologies requires a reconceptualization of traditional didactics towards e-didactics. Such a reconceptualization involves effective design and an alignment between learning objectives, content, and assessment, and has the potential to support, enhance, and effectively transform teaching and learning (Kearns, 2012; UNESCO, 2024).

Nonetheless, despite the growing recognition and use of technology in the field of education, curricular reforms related to digital competence are still not a reality for many European countries. Furthermore, teacher-specific digital competencies are absent from many top-level regulations or recommendations (European Education and Culture Executive Agency, 2019). In addition, there are still too few regulations that ensure the quality and diversity of methods employed and little evidence on how digital technology impacts and adds value to learning processes and to education in general (UNESCO, 2024). Therefore, several investments are needed at European and national levels and in both policy and educational domains (Mexhuani, 2025).

Such investments should focus on the development of structured teacher training programs and initiatives that enhance digital competencies. They should also address the integration of digital competence frameworks into initial and continuous teacher education and the implementation of policies that ensure an effective and equitable use of digital tools (Joya et al., 2025). Identifying specific training needs is also essential to the development of tailored initiatives. Such initiatives will equip teachers with the knowledge and competencies needed to critically assess and integrate digital resources, fostering students' digital literacy and critical thinking and ensuring institutional support through guidelines and best practices (Makda, 2025). These measures would help bridge gaps between policy and practice, ensuring a more effective and inclusive digital transformation in education while simultaneously contributing to the increased confidence of educators to teach in digital environments.

Within the European Pillar of Social Rights, paramount for assessing the social and economic conditions of European citizens, one major headline target, consistent with the UN Sustainable Development Goals, refers to the acquisition of skills, namely digital skills (European Commission, 2018). Two principles of the European Pillar are particularly relevant within the context of digital education: Education, training, and lifelong learning; and Equal opportunities. Through quality and inclusive education, training, and lifelong learning, individuals must be able to engage in up- and re-skilling. In doing so they will unlock new opportunities, successfully manage transitions, and fully participate in society. Furthermore, equal treatment and opportunities regarding access to goods and services, namely education and training services, is key to the efficacy and effectiveness of digital education. With equitable access to infrastructure, devices, and digital skills, digital education can serve as a powerful means to bridge educational gaps, by providing remote learning opportunities and quality educational content. This can be particularly relevant in certain geographical areas (e.g., rural) or to individuals from diverse socioeconomic, cultural, or linguistic backgrounds.

In relation to this, the development of digital skills is described as a precondition for inclusion and participation in a digitally transformed society and ultimately for high-performing digital (education) ecosystems (European Commission, 2021). In Portugal, a southwestern European country, 56% of the population aged from 16 to 74 had basic or above basic overall digital skills in 2023 (Eurostat, 2024). This constitutes an example of a headline indicator within the Equal opportunities principle of the European Pillar of Social Rights. For the same indicator and during the same time period, northern European countries tended to score higher (Eurostat, 2024).

Importantly, in recent years, a growing number of initiatives and frameworks have emerged at the European level (Cravinho et al., 2022; European Commission, 2018), such as the Digital Competence Framework for Educators (Punie, 2017). Directed towards educators at all levels of education (e.g., early childhood education, higher education, adult education, non-formal education), this framework describes a broad set of digital competencies. When applied to areas such as professional assessment, or in facilitating students' digital competencies, this framework seeks to help professionals in assessing and reflecting on their competencies, and to identify their training needs.

In Portugal, other national initiatives have been developed over recent years such as the Dynamic Digital Competence Reference Framework, launched within the scope of the INCoDe.2030 program (INCoDe, 2019). This framework proposes an instrument for assessing the population's digital skills, based on the European Digital Competence Framework (Punie, 2017), and on the definition of policies, strategies, and education programs.

The Digital Transition Action Plan (Conselho de Ministros, 2021) includes three main pillars of performance. The first pillar refers to the training and digital inclusion of people; the other two pillars refer to the digital transformation of businesses and to the digitalization of the State. More recently, the Portuguese Council of Education issued a set of recommendations providing a systemic overview of digital systems and technologies with the aim of promoting quality learning, safety, equity, and inclusion (Conselho Nacional de Educação, 2022). Also, the recently established National Council for Pedagogical Innovation in Higher Education, composed of national and international experts, aims to foster innovative pedagogical practices, recognizing them as fundamental to the development and excellence of higher education in Portugal and thus contributing to the success and well-being of academic communities (Conselho de Ministros, 2024).

Alongside key European and national initiatives, reflecting ambitions associated with sustainability and digitalization, the theoretical and conceptual levels are relevant to the shaping of digital education and training systems—equipping students with new skills and creating new opportunities. The sociocultural perspective is particularly relevant as it accounts for the students' sociocultural context (where learning occurs) as well as their interactions with the digital environment. Furthermore, it helps to frame how digital education environments can provide opportunities for collaboration, interaction, and peer learning (e.g., Picciano, 2017). Nonetheless, in this article we integrate other theories and perspectives—such as socio-constructivism—considering students' active participation in the construction of their learning processes, and reflecting on how technology can support teaching in a move towards meaningful and transformational learning (e.g., Batiibwe, 2019; UNESCO, 2024). Through these lenses, and considering the challenges imposed by digitalization, our main goal is to provide an integrative overview of how pedagogy, curriculum, and assessment can be integrated in digital education. In addition to this integrative overview, this article also situates digital education within European policy goals and within the Portuguese context. Furthermore, it examines the evolving roles of teachers and students in digital environments through multiple theoretical lenses. By providing these insights, this article provides a unique contribution with the potential to inform educators, policymakers, and researchers, and seeks to optimize digital education for more effective and inclusive learning experiences.

## 2. Pedagogy in Digital Environments: Insights From Learning Theories

Active pedagogies are those that focus on students' autonomy, their character, and their needs, and that involve them in the learning process. Such pedagogies that also make intelligent use of technology to increase learning experiences pave the way to new practices in digital environments (e.g., Freire, 2021; Siemens, 2004). Learning theories are crucial to reflect on pedagogical approaches and the use of technology in education, ultimately having the potential to shape education, training, and lifelong learning (Harasim, 2012; Koukopoulos & Koukopoulos, 2019).

Behaviourism, with its focus on observable behaviour, emerged from a positivist epistemology that emphasizes cause–effect relationships and the study of phenomena in terms of stimulus–response mechanisms. Behaviourism thus highlights how students behave while learning, namely how they respond to certain stimuli that, when repeated, can be evaluated, quantified, and controlled (Gewirtz, 2001; Skinner, 1968). Transposed to digital environments, it can translate into more operative, repetitive tasks, or programmed instructions that do not require individual assessment or judgment but instead imply a focus on the task, on the observation of behaviours, and on the measuring and monitoring of results (Picciano, 2017). Behaviourist principles, such as the implementation of learning sequences in a repetitive way or the provision of immediate and contingent feedback, can be useful to promote positive and effective learning activities in digital environments—for example using quizzes to assess students' knowledge and, based on the provision of automatic feedback, allowing them to proceed to the next section/level (e.g., if answering correctly a certain number of questions), or encouraging them to retry (e.g., if not scoring satisfactorily). Behaviourist principles can be appropriate, for example, within the teaching or training of students with learning difficulties in digital environments (e.g., Bock et al., 2008; Skinner, 1968).

In reaction to the behaviourist emphasis on stimuli and predictive responses, cognitivism highlighted the role of mental schemas and cognitive processes in learning, with a focus on what happens between the

occurrence of the environmental stimulus and the response of the learner. As such, motivation, memory, and the ability to relate newly learned information to previous existing knowledge emerge as key processes, particularly within the digital context (Harasim, 2012). Mayer's cognitive theory of multimedia learning (2008 is an example of how different types of memory are relevant for interpreting and making sense of digitally presented information. Within this perspective, the interdisciplinary nature of learning (e.g., interconnected fields of education, psychology, neuroscience, computing sciences) is promoted in order to further understand (for instance) brain mechanisms and the stages of cognitive development that underlie learning and knowledge acquisition (Harasim, 2012). Applied to digital environments, cognitivism can involve the creation of opportunities for reflection and metacognition through online discussion forums or reflective journals (as examples). Also, it can be particularly interesting as more advanced online software evolves into adaptive, personalized learning applications (e.g., integrating learning analytics; Picciano, 2017). Cognitive taxonomies also reflect how cognitive processes can be used to develop learning objectives, to inform instructional design, or to help students in coding, retaining, and applying information in digital environments. This is achieved while gradually increasing complexity and supporting students as they acquire new knowledge and skills (Bloom, 1984; Gagné et al., 2005; Krathwohl, 2002). From a constructivist standpoint, knowledge is constructed by the individual (Harasim, 2012). Knowledge and learning are seen as complex and occurring through cognitive development and are a mental representation of the external world that arises from individual actions performed towards objects, (e.g., Piaget & Inhelder, 1958). In the digital environment, an example can be the creation of interactive social communities where students, under the guidance of a teacher, solve problems while examining questions, mathematical equations, or case studies that integrate technology. This can be particularly useful for students to co-construct solutions based on critical thinking, in building teamwork experiences, and in developing new skills.

Importantly, social interactions between teachers and students are linked with cultural and cognitive development. When socially and culturally contextualized, learning is described as a major developmental factor itself (e.g., Vygotsky, 1978). As such, and from a socio-constructivist perspective, learning in digital environments may involve problem-solving based on shared experiences and mediated by a facilitator—the construction of solutions to such problems is considered the basis of the learning process. This is closely linked with the notion of challenge-based learning, which aims to stimulate students into active participation—towards an educational outcome (Kukulska-Hulme et al., 2023).

Creating situations of cognitive challenge in digital environments is thus crucial and involves the establishment of a zone of proximal development where the learner, the teacher, and the problem to be solved coexist (e.g., Lantolf & Xi, 2023; Vygotsky, 1978). Scaffolding (i.e., support) activities are a means to functionalize the concept of the "zone of proximal development" and can be effectively implemented in digital contexts (e.g., prompting questions, using demonstrations, providing examples), reinforcing reflection and interactive discussions towards the co-construction of solutions (Glassman et al., 2023).

Despite the valuable insights from classical learning theories, major changes in the way knowledge and information flow, grow, and evolve have been imposed by digitalization and have led to the emergence of new insights and perspectives (Harasim, 2012; Picciano, 2017). This shift from learning focused on internal, individual activities to learning within groups and communities, particularly those placed online, was accompanied by large-scale networks with the potential to support educators and students. In turn, these networks have reshaped relational dynamics and highlighted the need to design meaningful learning

situations suited to digital environments (i.e., situations where students can engage, collaborate, and navigate constantly evolving contexts). This was a catalyst for the emergence of connectivism, which emphasises the importance of fostering and maintaining connections to facilitate continuous learning (Bell, 2011; Coelho & Dutra, 2018; Downes, 2008; Siemens, 2004). In fact, the increasing presence of online learning communities and open educational resources has reinforced the role of connectivity in knowledge acquisition, emphasising how digital environments can foster knowledge exchange, co-construction, and adaptability to new information (e.g., Siemens, 2004). Importantly, the ability to see connections between ideas, concepts, and areas of knowledge is thus seen as an essential competency. These are key principles in digital education, applying, for instance, to courses or training initiatives involving multiple students where learning objectives encompass the development and creation of knowledge (e.g., through forums or online collaborative platforms), rather than its dissemination.

Furthermore, Anderson (2008) proposed an integrated theory of online education highlighting three elements that foster successful online learning experiences: social presence; cognitive presence; and teaching presence. Social presence refers to the possibility of having participants in an online learning environment expressing their individuality and establishing personal connections through effective communication and collaboration. Cognitive presence refers mostly to the development of critical thinking and reflection, encouraging students to engage in the exploration of ideas, concepts, and meaningful learning experiences through discussions and problem-solving in the digital environment. Teaching presence involves the crucial role of the teacher in designing, guiding, and supporting the online learning experience through meaningful interactions while providing clear instructions, planned learning activities/discussions, and timely feedback. This integrated perspective implies recognizing teachers and students as two important actors, but also the importance of the interactions between them and of the content, especially when considering the multiple learning tools, formats, and models available in digital environments.

More recently, the Covid-19 pandemic significantly reshaped theory, research, and practice related to educational technology and prompted widespread redefinition across and within countries (Siddiq et al., 2024). While building on past insights, the emergence of new information and perspectives has profoundly influenced how digital education is conceptualized and its future directions. In this context, recent literature reviews have highlighted: (a) the growing recognition of digital agency, emphasizing the need for transformative approaches in technology-enhanced teaching and learning (Siddiq et al., 2024); (b) the increasing adoption of e-assessments in digital education (Ortiz-López et al., 2022); and (c) the expanding diversity of online, hybrid, and blended learning models designed to foster student-centred learning environments (Otto et al., 2024). These practices play a key role in facilitating interactions between students, teachers, and content, while also requiring the development of new cross-curricular competencies (Otto et al., 2024). Therefore, in addition to considering the wide range of learning theories and the knowledge and evidence gained during and after the pandemic, it is essential to examine the role of different learning models and curriculum features in shaping digital education.

## 3. Learning Models and Curriculum Features in Digital Environments

Besides learning theories, several learning models can be applied to digital education to enhance educators' and students' experiences (Mayes & de Freitas, 2004; Picciano, 2017). In particular, we highlight the potentialities of implementing experiential learning (Kolb, 1984; Pimentel, 2007), project-based learning

(Dochy et al., 2003), communities of practice (Wenger, 2000), and individual learning paths (De Smet et al., 2016) in digital education.

In line with the assumption that simple exposure and memorization of a given subject does not necessarily translate into learning, digital environments provide ample opportunities for experiential learning allowing knowledge acquisition in an empirical way through interactive exercises, virtual simulations, or immersive learning experiences that provide students with hands-on experiences. In effect, by engaging in practical and problem-solving activities in digital environments, students can develop their competencies and understanding of specific topics and areas of knowledge in more meaningful and complete ways (Kolb, 1984; Pimentel, 2007).

Similarly, using project-based learning offers students the possibility of working on real-world projects, applying their knowledge and competencies towards solving real-world problems (Jonassen & Hung, 2008; Onyon, 2012). Collaboration tools, online resources, and multimedia content can be used to support students in researching, planning, and executing their projects. At the same time, they are also fostering critical thinking, creativity, and teamwork in digital environments (Dochy et al., 2003).

Communities of practice have the potential to allow students to connect and share their interests and goals, as well as their challenges and reflections, all while collaborating and learning from each other (e.g., Wenger, 2000). In digital environments, this allows the establishment of networks in a natural way. Such networks are anchored in trust, they sustain students' collaboration and involvement, and cultivate creative pedagogies (Cochrane & Narayan, 2016; U.S. Department of Education, 2014). Discussion forums and virtual classrooms are examples of ways to foster students' sense of belonging, providing opportunities for sharing information while promoting peer-to-peer learning and collective problem-solving.

Individualized learning paths can be adjusted to students' (ranging from individuals to entire organisations) needs, interests, and learning styles. These tailored paths clearly and efficiently guide students from learning goals to outcomes through a plan or a program consisting of different stages such as understanding content in an accessible way, or progressing in certain learning competencies. In digital environments, it can be particularly relevant to provide personalized recommendations, resources, and activities (e.g., based on the analysis of students' data). This allows for adapting learning activities and formats and enables students to progress at their own pace while accessing content that suits their interests and personalities before advancing to more challenging content or activities (De Smet et al., 2016). Artificial intelligence (AI) has played an important role in this field, enabling the development of sophisticated tools, such as intelligent tutoring systems. These systems have the potential to leverage large-scale data analysis to create personalized learning experiences that dynamically adapt to a student's difficulties and progress (UNESCO, 2021).

Relatedly, AI and generative AI are having a significant impact on people's engagement with information, digital technology, and media. This raises concerns about control, human agency, and autonomy over information, decision-making, gender equality, and freedoms in general. As such, user empowerment through media and information literacy as a response to generative AI, which is still in its infancy, needs to be fully deployed and public policymakers should ensure that it is developed properly from the outset (UNESCO, 2024).

The diverse learning models and approaches discussed throughout this article share the underlying assumption that learning is a continuous, bottom-up process driven by experience, which focuses on practical learning and posits the student at the centre of the learning process. In other words, digital environments provide extensive opportunities for students to expand their knowledge and develop their competencies—through involvement in real-world problem-solving and developing projects in which they mobilize information and reach their own conclusions. In addition, they receive immediate feedback, they have the opportunity to share insights with others in a collaborative context, and they are able to focus on a path that leads to solutions and outcomes—which is fundamental to their future learning and work experiences (Jonassen & Hung, 2008; Onyon, 2012).

Importantly, the diversity of pedagogical methods and approaches is relevant to inform and shape curriculum design in digital environments with a view to creating meaningful learning experiences. More and more, students are demanding that their education reflects their own contexts, experiences, and cultures (Kukulska-Hulme et al., 2023). The content and the activities included within a curriculum can therefore be adapted and designed to take advantage of the unique features and capabilities offered by technology. This in turn fosters extended collaborations and continuous innovation in pedagogy and information delivery while simultaneously enabling dynamic and interactive learning experiences and personalized pathways (Picciano, 2017).

In effect, the strategies and curriculum features that can be used in digital environments reflect the transactional (i.e., non-linear) nature of learning (Pimentel, 2007). Ensuring that these features are considered when navigating within digital education and incorporating them into formal (e.g., integrating digital pedagogies into school, university, and vocational curricula) and non-formal education initiatives (e.g., promoting lifelong learning, and community-based digital literacy initiatives, in more flexible learning pathways) is key to fostering digital literacy. This has the advantage of allowing an easy adaptation to students' specific needs, personalities, histories, and backgrounds (Kukulska-Hulme et al., 2023). Online resources can be integrated into the curriculum or learning activities to provide diverse perspectives, up-to-date information, and multimedia content. Teachers can therefore modify and update the curriculum or their strategies in real-time, addressing emerging topics, incorporating recent events, and responding to students' needs.

Furthermore, flexibility and interactivity are paramount to quality teaching in digital education. Flexibility can be ensured in terms of time, location, and pace of learning, but flexibility is also important to ensure students' autonomy—enabling them to take ownership of their own education process, setting goals and making choices that align with their interests and character (Cope & Kalantzis, 2009). In addition, offering a range of interactive features (e.g., timely, personalized feedback and assessment), digital tools and platforms allow students to actively engage in the learning process. Flexible and interactive activities, multimedia resources, and collaborative tasks are key to fostering deeper engagement, critical thinking, problem-solving, and creativity (Bates, 2015; Lindquist & Long, 2011).

Considering these features when navigating within digital education and incorporating them into formal curricula, lifelong learning, and modern training programs is key to fostering digital literacy and skills development. Importantly, it equips individuals with the knowledge and competencies needed to navigate an increasingly digitalized world in both critical and responsible ways, while also strengthening employability and resilience in the face of technological advancements (Alexandre et al., 2023; European Commission,

2021). In this sense, frameworks such as that proposed by the European Commission (i.e., focusing on critical thinking, ethical participation, and digital safety) are needed to inform the design of both formal and non-formal educational programs, equipping students with the skills necessary to interact meaningfully and ethically in digital environments (Punie, 2017).

Remarkably, digital education does not merely serve the purpose of promoting students' knowledge and skills. It also fosters social-emotional development and cultural awareness and involves ethical considerations (Buchanan, 2019). Therefore, within a holistic approach, pedagogical and curriculum strategies should address the cognitive, emotional, sociocultural, and ethical dimensions of learning in digital environments (e.g., Pimentel, 2007). As such, careful planning, teacher support, and inclusive design are vital to ensure that the curriculum in digital environments effectively supports meaningful and engaging learning experiences for all. This is particularly important when considering the evolving roles and relationships that shape digital environments (Brey, 2006; Olcott et al., 2015).

## 4. Teachers and Students: Evolving Roles and Relationships

Digital education facilitates communication, collaboration, and the exchange of ideas, and in doing so enables students to connect, engage, and learn from each other across geographic, cultural, and disciplinary boundaries (Kukulska-Hulme et al., 2023). Building horizontal relationships in these environments is crucial to creating inclusive and collaborative learning communities—where teachers and students interact as equal participants. For instance, the Digital Competence Framework for Educators foresees a set of competencies focusing both on educators and students and emphasizing a learner-centred approach to digital education. Here, teachers are pivotal in facilitating and supporting students' digital literacy and the development of competencies within collaborative and empowering learning environments (Otto et al., 2024; Punie, 2017). This, in turn, fosters a sense of shared responsibility, respect, and mutual support and ensures a co-construction of knowledge (Downes, 2008). Moreover, it highlights how both teachers' and students' roles have progressively evolved in digital environments (e.g., Sharma, 2017). As a recent example: Research has suggested the pandemic has impacted teachers' knowledge and beliefs about their teaching practices and roles, with professionals maintaining positive beliefs with regards to digital technology and being able to foresee benefits associated with its use (Brianza et al., 2024).

Within digital environments, teachers are responsible for aligning learning experiences with educational goals and standards but also with students' needs, learning styles, and interests—ensuring coherence and progression in the curriculum (Pelz, 2010). Nowadays, teachers are seen as facilitators, mentors, mediators, and gatekeepers of learning experiences and not simply as sources of knowledge. For instance, teachers design learning activities, promote problem-solving skills, facilitate discussions, and provide feedback to support students' journeys. When leveraging technology effectively, teachers help students to navigate the vast digital resources and information available, promoting the development of information literary skills, which encompasses the reflective discovery of information, an understanding of how information is produced and valued, as well as the use of information in creating new knowledge and participating ethically in communities of learning (Association of College and Research Libraries, 2015). Moreover, they encourage and guide students to set learning goals, to analyse and evaluate their progress, and to make informed choices regarding tools, platforms, and the effective use of digital content. As such, teachers enhance the educational experience, supporting active and individualized learning and promoting critical thinking while

also fostering students' autonomy and empowering them to take ownership of their learning process (e.g., Bates, 2015; Sharma, 2017).

Based on a sociocultural perspective, and consistent with socio-constructivism, students' roles have shifted from passive recipients to active participants and co-constructors of knowledge, with their identities and agency playing a crucial role in the learning process (Kumpulainen et al., 2018). Accordingly, students can set goals, seek resources, engage in shared activities and projects, monitor their progress, reflect on their learning experiences, and make connections between concepts and real-world experiences, all while expanding their knowledge in student-centred learning environments (Anderson, 2008; Otto et al., 2024).

Moreover, digital education environments constitute privileged arenas that allow students to connect their cultural identities to their learning experiences, thus fostering a sense of belonging and empowering students from diverse cultural backgrounds (Lindquist & Long, 2011; Roth et al., 2004). Digital environments contribute to more inclusive learning environments by helping students to develop self-regulation, communication, and interpersonal skills. With the integration of digital technologies in education, students also take on the role of digital citizens, developing literacy skills and being able to critically evaluate digital content—responsibly using online resources and engaging in ethical online behaviour (e.g., Buchanan, 2019; Olcott et al., 2015).

Besides teachers' and students' evolving roles, pedagogical relationships have also undergone several changes over time and the use of technology has introduced some unique features (Dias & Rodrigues, 2019). For instance, in digital education, communication through digital platforms, emails, video conferencing, discussion boards, and other emerging platforms or apps influences the nature and frequency of interactions along with their tone, immediacy, and richness (Cole et al., 2019; Wallace, 2003). When analysing communication, particularly during and after the pandemic, some authors noted the importance of recognizing how the material conditions (e.g., connectivity, digital devices) of online interactions influence the students (e.g., body-sensory dimensions). Such conditions shape the didactic environment and how meaningful interactions and relationships are established and maintained in digital environments (Brianza et al., 2024).

Importantly, teacher–student relationships still revolve around a positive environment and around sensitivity, guidance, and support—even if the context and forms of such interactions differ from traditional classroom settings (Cole et al., 2019). A recent report referred to relational pedagogies and to pedagogies of care as prioritising empathy and the development of students in a nurturing, supportive, and equitable environment. Although care has not always been central to teaching, relational pedagogy and pedagogy of care have been progressively recognised as vital within the educational process. They are particularly important in digital environments where they contribute to professional work collaborations and to students' self-esteem and well-being (Kukulska-Hulme et al., 2023). Specifically, ensuring a hospitable environment, empathising with students, and responding to their needs can be achieved through teachers' sensitive behaviour, by having open conversations, by applying concepts in practical, real-world situations, and through the provision of personalized feedback. In a related point: Students with a higher perception of a respectful, cooperative, and comfortable environment, and of active learning practices online, may be more engaged in an online course (Cole et al., 2019). These aspects are relevant for reflections on pedagogy and curriculum but are also relevant when considering the specificities of assessment in digital environments, which must be guided by positive interactions and constant communication between teachers and students, towards a culture of success (Cole et al., 2019; Fernandes, 2008).

## 5. Assessment in Digital Environments: Specificities, Strategies, Principles

Assessment refers to a pedagogical process whose main purpose is to simultaneously help students acquire more knowledge, with greater understanding, and to help teachers improve their teaching strategies and practices (O'Reilly et al., 2005). As such, assessment constitutes an intentional, formally organized, and systematized pedagogical practice with the aim of contributing to positive social transformations (Chuieire, 2008).

Instead of a unified theory of assessment, diverse conceptions of assessment (e.g., more traditional, focused on examining; more technicist, focused on measuring; or more quantitative, focused on classifying or regulating) and distinct traditions (e.g., greater focus on the regulation of learning processes, or on the sociocultural interactions that shape them) have emerged over time (Fernandes, 2008). Establishing a clear pedagogical rationale is an important step towards ensuring quality assessments in digital environments.

Therefore, several pedagogical principles must also be applied in these contexts. Such principles include the clarity of objectives (e.g., following a taxonomy) and evaluation criteria (e.g., rubrics outlining expected standards, for different levels of achievement). Also relevant are the creation of learning experiences offering multiple perspectives (i.e., reflecting students' contexts), the creation of opportunities for interaction and collaboration between students within authentic learning situations (e.g., real-world applications), and the provision of timely and appropriate feedback mechanisms (i.e., embedded within learning activities; O'Reilly et al., 2005).

Feedback, self-assessment, and co-assessment are fundamental strategies for optimizing digital learning processes and assessment and improving teacher practices whilst simultaneously optimizing student learning and growth, reflection, and metacognition (Nicola & Macfarlane-Dick, 2006; Panadero et al., 2019; Price et al., 2010). Specifically, feedback must be provided when students, individually or in a group, are aware of learning objectives and have time to act on them (i.e., contingent, timely). Enough time should be provided to ensure students understand what they can do to improve, and feedback can be provided either in written format (e.g., in a shared document), orally, or by demonstrating (e.g., in an online class). Importantly, feedback must focus on the task, activity, or process, rather than on the learner, and favour comparison with objective assessment criteria. Assessment criteria must be shared and known by all, enabling use in a positive and constructive way. As such, in digital environments, as in traditional classrooms, it is crucial to ensure an integrated mechanism of feed up, feedback, and feed forward—developing positive relationships based on trust and establishing clear objectives. These mechanisms can focus on tasks, on the process itself, or on self-regulation, and should allow for adjustment, reorganization, and improvement after feedback has been provided (Koumachi, 2021).

Quality feedback practices are those that offer information, opportunities for scaffolding and development of positive beliefs in assessment, but that also facilitate self- and co-assessment (e.g., peer-assessment; Nicola & Macfarlane-Dick, 2006). Self-assessment allows students to reflect on and evaluate their own work and learning path (for instance, through reflective journals, e-portfolios, or self-assessment questionnaires) with a focus on their development and with the aim of improving their actions and learning processes. Co-assessment, in turn, gives students the opportunity to give and receive feedback and evaluate each other—for example through peer review assignments, discussion forums, and through intervening in a cooperative way in each other's work and providing additional value (Panadero et al., 2019).

These practices, when fairly and adequately implemented in digital environments, through the provision of moments for feedback, discussion, and revision/implementation, reinforce students' autonomy, responsibility, and active roles. Such practices have the potential to contribute to students' increased motivation and to more comprehensive assessments. Importantly, this cannot be done without clear communication about assessment goals and criteria. This should be accompanied by a transparent negotiation of assessment goals, timelines, and conditions or types of activities. This all requires effective mediation with the teacher who acts as a mentor and facilitator of consensus, for instance during peer assessment (e.g., Ferrarini et al., 2019).

Several challenges are typically mentioned when considering assessment in digital education: the need to adapt to new technologies; greater time investment by teachers; physical distance between teachers and students; difficulties in accompanying and assisting students; and/or difficulties in ensuring fairness and security of online assessments (e.g., Kearns, 2012). Frequently, these and other challenges encountered in digital environments require multiskilled or multidisciplinary teams to come up with solutions (Kukulska-Hulme et al., 2023). To address these challenges, several strategies and mechanisms have been proposed in the literature—for example, an Academic Dishonesty Mitigation Plan integrating preventive and detection-based strategies has been proposed to enhance the security and integrity of online assessments (Garg & Goel, 2022). Importantly, mitigation strategies require the active involvement of key stakeholders (e.g., platform providers, institutions, educators, and students) and institutional support, towards the development of integrated and secure assessment frameworks (Garg & Goel, 2022). Such strategies may encompass the use of proctoring technologies, plagiarism detection tools, and randomized question banks (Jiang & Huang, 2022).

Relatedly, and beyond extant digital assessment strategies, generative AI is transforming how learning progress is evaluated. AI-generated simulations and scenario-based assessments allow students to engage in interactive problem-solving exercises tailored to specific levels of competence. Also, natural language processing models can generate personalized case studies, discussion prompts, and assessment tasks. All of this can be dynamically adapted to students' responses. In the realm of academic integrity, generative AI is driving the development of AI-assisted verification systems to analyse originality, posing a number of relevant ethical and pedagogical concerns. Although generative AI allows for self-directed learning assessments and for the close interaction of students with educators (e.g., through real-time questioning, argumentation, and reflection), it also requires educators to critically address its implications for fairness, transparency, and meaningful learning outcomes (e.g., Memarian & Doleck, 2023; Zawacki-Richter et al., 2019).

Additionally, alternative assessment approaches such as open-book exams and competency-based assessments have been suggested to reduce concerns about academic dishonesty while fostering deeper learning (Hobbins, 2022). Automated and adaptive feedback systems, peer assessment strategies, and learning analytics tools that allow teachers to monitor student progress in real-time, accompanied by structured communication channels (e.g., scheduled check-ins, discussion forums, synchronous feedback sessions), can help bridge the physical distance between teachers and students, while also contributing to enhance effectiveness and equity of assessment in digital education (Kulal et al., 2024).

On a more positive note, there are also a number of advantages that are raised when discussing assessment in digital education. These include the possibility of obtaining automatic classifications and feedback, of implementing adapted tasks and activities, of ensuring greater accessibility, of easier access to learner's data,

or even the inclusion of integrated security measures. Additionally, key formative assessment strategies (e.g., sharing learning intentions and success criteria, using questioning and discussion) and functionalities of technology (e.g., sending and displaying, processing, analysing, or ensuring interactivity) are described as contributing to more effective teaching and learning processes in digital environments (Kaya-Capocci et al., 2022).

Importantly, several key assessment principles must guide the assessment methods and strategies in digital education. Principles of equity (e.g., equal opportunities for the progression of each learner), positivity (e.g., emphasis on the process and on opportunities to practice the knowledge that was built, valuing students' capacities and competencies), improvement (e.g., involving constant readjustment of teachers, students, and of pedagogical strategies), diversity of procedures (e.g., various sources of information and forms of assessment) and stakeholders (e.g., participation of multiple stakeholders, reducing subjectivity), and transparency (e.g., all students aware of the assessment process and its specificities) are a few examples. In addition, a recent model of assessment in digital environments proposes the principles of transparency, authenticity, consistency, and practicability (see Ferrarini et al., 2019). The principle of coherence (e.g., of assumptions and assessment methods) becomes more important in digital education given the need to ensure that teaching and assessment in digital environments are carried out in a continuum (Cruz et al., 2010).

## 6. Pedagogy, Curriculum, and Assessment: Constructive Alignment in Digital Education

Enhancing teaching through constructive alignment, a concept originally proposed by Biggs (1996), emerged from the combination of constructivist learning theories and instructional design literature. This idea, which can be applied to diverse courses or programs, is particularly relevant within the context of digital education. Constructive alignment refers, for instance, to ensuring coherence between the objectives of a course/program and the expected outcomes (e.g., in terms of students' performance or competencies), to defining curriculum goals that represent a certain cognitive level (e.g., based on learning taxonomies), or to deciding on which teaching and learning activities can better elicit certain performances or competencies.

Constructive alignment also means ensuring consistency between learning objectives, teaching methods, and assessment activities, in line with a learning theory or a combination of learning theories. In effect, assessment is strictly linked to the nature of knowledge and should be adjusted to ensure epistemological coherence (Chuieire, 2008). Given so, from a behaviourist perspective, it can be important to provide assessment activities that ensure immediate feedback and reinforcement as students complete tasks on a digital platform (such as multiple-choice activities). Based on a cognitivist perspective, it can be relevant to assess students' understanding and ability to apply knowledge (for instance through online open-ended questionnaires). From a socio-constructivist standpoint, it will be important to ensure hands-on, interactive online assessment experiences allowing the student to build and regulate their understanding of contents (for example, through self-assessments). According to connectivism, it is appropriate to provide assessment opportunities that allow students to form connections among themselves, but also to form connections with the information and resources available online and to establish networks (for instance, to conduct the assessment of projects developed within communities of learning).

Applying behaviourist and cognitivist approaches to assessments in digital environments can ensure assessment processes that are much more focused on the cognitive aspects and that neglect the more

interactive and relational aspects of learning. By doing so, these assessments can lead to retroactive regulation of learning, where difficulties can only be detected after the teaching-learning process. In turn, socio-constructivist or connectivist perspectives can lead to assessments anchored in communication processes and in the interactions and networks established within the online learning contexts. At the same time, these approaches may neglect more individual (e.g., cognitive) aspects that also influence learning (Fernandes, 2008). Such specificities are important to consider when conducting digital assessments, adjusting to the goals and students' personalities.

Importantly, both socio-constructivism and connectivism share a foundational view of learning as an active, social, and context-dependent process. While socio-constructivism emphasizes the co-construction of knowledge through interaction, scaffolding, and cultural mediation (Kukulska-Hulme et al., 2023; Vygotsky, 1978), connectivism extends these ideas into the digital age, highlighting the role of networked learning, where knowledge is distributed across digital connections and social interactions (Coelho & Dutra, 2018; Downes, 2008; Siemens, 2004). As such, both perspectives conceive learning not as an isolated cognitive process, but as emerging through interactions and engagement with others, whether in traditional social settings (as in socio-constructivism) or in technology-mediated environments (as in connectivism). While socio-constructivism focuses on dialogue and peer collaboration, connectivism focuses on digital tools, online communities, and information flowing across networks. The fact that both approaches recognize the learner's active role in knowledge construction and adaptation makes them highly relevant to teaching and learning in digital environments.

Close alignment also needs to be ensured between learning formats, models, and assessment in digital environments. For example, in an online course that combines online and face-to-face formats, assessment can involve a combination of online tests and quizzes and individual or group presentations to promote reflection. Importantly, to assess learning in a meaningful and authentic way in these environments, effective learning models are those that focus more on applying knowledge and competencies to real-world situations through problem-based activities, with the provision of timely, regular, and constructive feedback (Nicola & Macfarlane-Dick, 2006; Panadero et al., 2019; Price et al., 2010).

Effective approaches to learning and assessment in digital environments are those that are anchored in quality interactions and that meet the specific needs and characteristics of students. As such, it is crucial to implement differentiated learning strategies and assessments, offering a range of options that meet different learning styles and preferences. Adaptive learning activities and assessment tools that adjust the difficulty of exercises and questions are also fundamental. Culturally responsive activities and assessment exercises that consider students' cultural backgrounds and experiences also reinforce the constructive alignment in digital education and contribute to more effective, cohesive, and engaging learning experiences, in line with a sociocultural approach.

Figure 1 provides a summary of the different learning theories discussed, focussing on pedagogy, curriculum, and assessment in digital education. An emphasis is given to the constructive alignment of these theories.

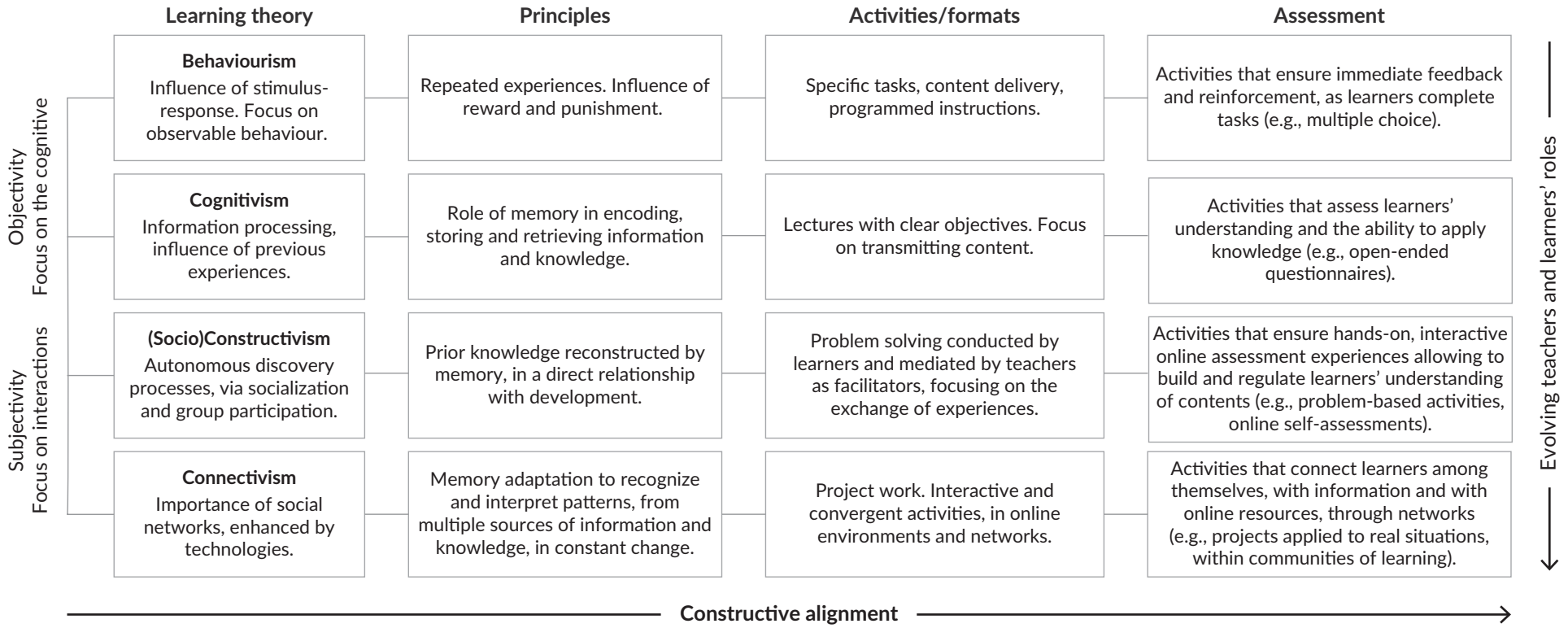


**Figure 1.** Integrating pedagogy, curriculum, and assessment in digital education.

## 7. Conclusions and Implications for Practice

The European Pillar of Social Rights, through its principles of Education, training, and lifelong learning, and Equal opportunities, is relevant when reflecting on pedagogical changes imposed by the emergence of digitalization processes. With this in mind, we initially discussed the importance of digital skills and the emergence of different initiatives, both in Portugal and at the European level. Next, we outlined the specificities of pedagogy, curriculum, and assessment in digital education and the significance of integrating them in a continuum to create more cohesive and effective learning experiences. Within this framework, constructive alignment emerges as crucial to guide teachers and institutions towards maximizing the potential of digital education, fostering its effectiveness and meaningful learning outcomes. It is therefore essential for institutions to develop guidelines for designing courses in digital environments, with constructive alignment as a central framework. This approach ensures consistency across the institution's academic programs, aligns technological development with the institution's pedagogical model, and supports the strategic planning of faculty training within a coherent institutional framework. Beyond being a pedagogical tool, constructive alignment can be viewed as a strategic indicator of institutional quality, crucial for ensuring the effectiveness of courses designed in digital environments.

This overview draws attention to several implications. Specifically, we note the importance of adopting learner-centred approaches—approaches that are aimed at meeting students' needs, interests, and learning styles. Furthermore, there is a need to select pedagogical strategies, curriculum content, and assessment methods that resonate with students' interests and needs, thus promoting engagement and motivation (Wenger, 2000). This work also highlights the importance of (a) designing flexible learning experiences that integrate real-world, authentic experiences within the curriculum and assessment; (b) facilitating collaboration beyond physical or disciplinary boundaries; (c) promoting inclusivity and accessibility; and (d) fostering the development of new knowledge and competencies (O'Reilly et al., 2005). To enhance the impact of these initiatives, it is important to ensure their integration into educational programs and alignment with institutional strategies (e.g., internationalization), advancing digital pedagogy at an institutional level and translating this into actionable policymaking initiatives. Taken together, these aspects are crucial for individuals' learning, but also for the acquisition of work-related competencies and for optimizing future work experiences and transitions (Pastore et al., 2021).

As technology continues to advance, embracing these implications at the practice and policymaking levels will pave the way for a future of digital education that is engaging, inclusive, and purposeful—empowering students to thrive in an ever-changing world. Education and training institutions will play an important role here through the creation of courses and programs integrating these features and therefore aligned with the jobs of the future (Alexandre et al., 2023). Guided by an ethically responsible conduct, education in digital environments can ultimately foster global citizenship and the promotion of equal opportunities, thus responding to the changes and challenges imposed by economic and social transformations (European Commission, 2021). To advance the principles outlined in the European Pillar of Social Rights, European countries can harness the potential of digital education by strategically investing in digital resources, by prioritizing the development of digital literacy and skills, and by promoting initiatives that seamlessly integrate digital goals into comprehensive social and educational policies. This concerted effort will contribute to the creation of more inclusive societies across Europe.

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## Conflict of Interests

The authors declare no conflict of interests.

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