The Pedagogical Ecology of Learning Technologies: A Learning Design Framework for Meaningful Online Learning

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Abstract This chapter introduces the concept of pedagogical ecology and its role in shaping the design of digital learning environments with specific emphasis on online and e-learning. The chapter analyzes the pedagogical ecology of learning technologies starting with pre-internet technologies and advancing to Web 1.0, Web 2.0, and Web 3.0 technologies. This analysis is premised on the theory of affordances and the non-neutrality of the learning space. The chapter presents a learning design framework that can be used to reinvent online and e-learning programs in higher education contexts locally and globally, by moving away from models that ask learners to memorize information and take recall tests, to a model in which technology enables the design of learning experiences that feel relevant, meaningful, and useful to learners. The Meaningful Online Learning Design (MOLD) framework can serve as a starting point for educational reform in the Arab world by moving the needle from "schooling to learning" in order to "serve the needs of pluralistic societies and foster the development of active, responsible citizens who are empowered to deal with complexity and advance constructive change".

Keywords e-Learning · Learning technologies · Learning design · Pedagogical ecology · Higher education · Web 3.0

1 Introduction

The "media versus method" debate regarding the linkage between technology (media) and instruction (method) has been going on for decades. It started in the early 1980s when Richard Clark [1] stated that media "are mere vehicles that deliver instruction but do not influence student achievement any more than the truck that delivers our groceries causes changes in nutrition". In other words, Clark was arguing

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that there are no learning benefits to the use of technology in instruction. Clark's statement triggered an uproar in the "educational technology" (EdTech) academic community with Robert Kozma taking the lead on addressing Clark's viewpoint. Kozma suggested reframing the question from "does technology (media) influence learning" to "*will* technology influence learning" given the lack of research evidence to make a judgment as to whether technology influences learning, and the premise that educational technology is not a natural science; rather, it is a design science; hence, new research paradigms are needed to examine the relationship between technology, learning, and instruction [2]. Kozma went on to argue that learning is not a static activity or the receptive response to instruction; rather, learning "is an active, constructive, cognitive, and social process by which the learner strategically manages available cognitive, physical, and social resources to create new knowledge by interacting with information in the environment and integrating it with information already stored in memory" [3]. Kozma and others [4–8] were essentially saying there is a reciprocal interaction or interplay between the learner's cognitive resources and aspects of the external environment that include both technology and pedagogy (instructional method).

Circling forward to the twenty-first century where many things have changed in education since this debate started, particularly technological advances that can be considered monumental with the explosion of social media and mobile devices enabling anytime-anywhere learning, online learning, and e-learning, the "media versus method" debate shifted to one that centers on erasing the technology–pedagogy dichotomy instead of determining which has more autonomy. For example, Fawns [9] views the relationship between technology and pedagogy as the mutual shaping of purpose, content, values, methods, and technology (see Fig. 1).

Fawns advocates an *entangled pedagogy* approach in which agency is negotiated between the elements of a learning environment to include teachers, technology, students, infrastructure, policy, outcomes, etc. Fawns suggests that we no longer think about the relationship between technology and pedagogy in terms of whether technology is the driver of educational activity (technological determinism) or pedagogy is the driver of educational activity (pedagogical determinism). Rather, Fawns suggests we transcend this technology–pedagogy dichotomy and perceive the relationship between technology and pedagogy as a complex entanglement of factors iteratively and mutually shaping each other in the learning space.

Dabbagh and Castaneda [10] also advocate that we perceive the relationship between technology and pedagogy or technology and learning through the lens of what some scholars call *sociomaterial entanglement,* i.e., the intersection of the technical (material) and the social (human) through thought and action, also known as multiagent socio-technical systems [11–13]. This suggests that humans and things are "ontologically inseparable from the start" and are observable through the intra-action and the relationships with the other elements of the learning environment. In other words, the components or elements of the learning environment, which include the instructor and the learner, mutually condition and transform each other while they interact, continuously shaping the learning process. Tietjen et al. also advocate for a sociomaterial approach when analyzing learning environments [14] and argue that a

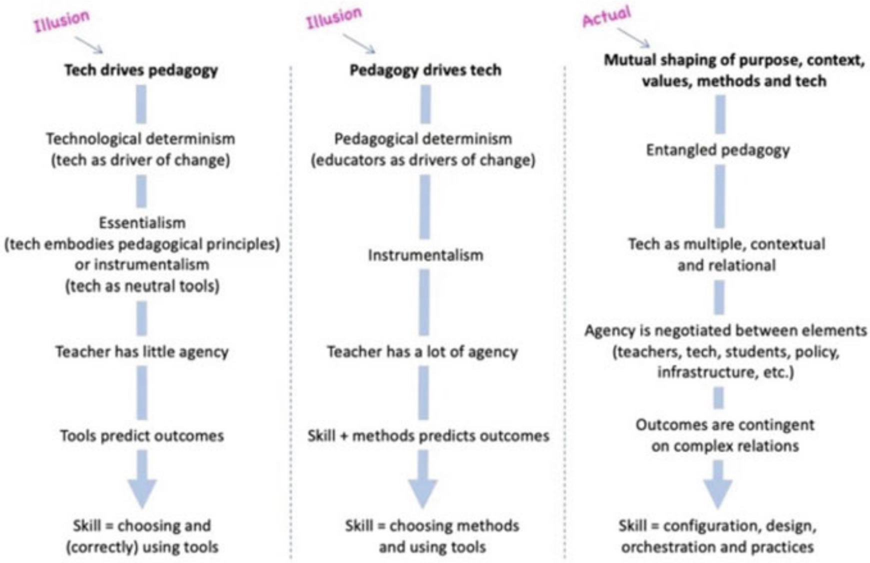

Fig. 1 Technology–pedagogy dichotomy

sociomaterial perspective resists viewing things (physical or material) and humans as separate or dichotomous entities. Instead, they advocate perceiving all elements in a learning environment, whether human or material, as equivalent or symmetrical in terms of their ability to exert force on one another. For example, technology is conceptualized as capable of shaping human activity in the same way that a human can direct or shape the use of technology. Thus, in sociomateriality, agency is not positioned as a human characteristic above the material; instead, both the human and the material elements have agency in relation to the other; they are enmeshed and entangled.

2 Pedagogical Ecology

The roots of sociomaterial entanglement or entangled pedagogy can be traced to the construct of pedagogical ecology. Pedagogical ecology emphasizes the non-neutrality of the learning space and consideration of the expectations and interaction potentials that each learning medium or resource brings forth to the teaching and learning process [15, 16]. Supporters of this view argue that each medium has a unique set of characteristics and that understanding the ways in which teachers and students use the capabilities of the medium is essential to understanding the influence of the medium on learning and on building media theory [3, 17]. Frielick suggests that the learning setting, whether the classroom, the lecture hall, the e-learning environment, the department, or even the institution itself, can be viewed as an ecosystem that transforms, influences, and shapes the quality of learning outcomes.

Pedagogical ecology has challenged traditional teaching practices, faculty and student roles, institutional roles, and academic infrastructures, prompting a reconceptualization of distance learning and a rethinking of the broader practice of education and training. The concept of pedagogical ecology is grounded in Gibson's theory of affordances, which is an ecological approach to psychology that emphasizes perception and action rather than memory and retrieval. Gibson proposed that objects, materials, and artifacts (e.g., technologies) have certain affordances (possibilities for action) that lead organisms (e.g., people) to act based on their perceptions of these affordances [18]. In other words, action and perception are linked through the affordances present in each situation and the abilities or capabilities of an agent to act upon these affordances.

> Affordances and abilities are relative to each other: a situation can afford an activity for an agent who has appropriate abilities, and an agent can have an ability for an activity in a situation that has appropriate affordances [19].

Affordances provide strong clues to the operation of things. For example, chairs "afford" sitting, glass "affords" seeing through or breaking, knobs "afford" turning, balls "afford" throwing or bouncing, etc. [20, 21]. The theory of affordances has direct implications on how we may understand the evolution or ecology of online learning and the technology-based design of learning activities and interactions [15, 22]. As we trace the affordances of learning technologies (a) from pencils and paper pads where writing was the primary functional affordance, to surface tablets and smart phones where touch typing and gesture-based computing is the primary affordance; (b) from correspondence courses where individual learning triumphed, to broadcast technologies such as film, slides, radio, and educational television where audiovisual learning became the primary affordance; (c) from pre-internet technologies to Web 1.0 technologies that paved the way to asynchronous and synchronous forms of online education in the late 1990s and early 2000s; to Web 2.0 technologies of the twenty-first century where 73% of students in the United States claimed they would not be able to study without digital devices such as laptops, smartphones, tablets, and e-readers [23]; to Web 3.0 technologies that are permeating the learning space with artificial intelligence (AI) and machine learning (ML) interventions (e.g., chatbots); and immersive learning technologies that are providing semantic, spatial, and 3D instruction using augmented reality, virtual reality, and mixed reality (AR/VR/MR) interventions; one thing remains consistent across this evolutionary path:

> As technology evolves our pedagogical practices also evolve.

To illustrate the role of technology affordances in shaping the pedagogical ecology of online learning and e-learning, we trace the pedagogical ecology of pre-internet technologies, Web 1.0 technologies, Web 2.0 technologies, and Web 3.0 technologies in the next sections. See Fig. 2.

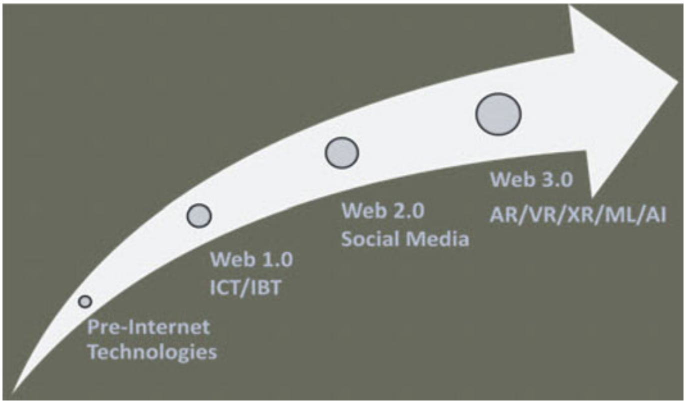

Fig. 2 Technology evolves

2.1 The Pedagogical Ecology of Pre-Internet Technologies

Pre-internet technologies can be characterized as print media or broadcast technologies such as film, educational television, video (compressed video) lectures, and PowerPoint (PPT) presentations. Broadcast technologies are effective in transmitting information (i.e., one-way provision of content) addressing assimilation rather than construction of knowledge and are largely utilized by the instructor, teacher, expert, or are system driven. In terms of pedagogical affordances, broadcast technologies characteristically enable teacher-centered instruction such as direct instruction, self-contained curricular units, and drill and practice activities resulting in predetermined technology-based adaptive systems such as programmed instruction (PI), stimulus response reinforcement (SRR), computer-assisted instruction (CAI), enabling cognitive information processing (CIP). These instructional practices are grounded largely in behaviorist and cognitivist learning theories and principles. The learning setting is usually that of an authoritative and knowledgeable figure who has been entrusted with the task of imparting reliable knowledge to the student and assessing student mastery of knowledge through tests and other observable and measurable behaviors. Learning interactions designed with pre-internet technologies were largely confined to learner-instructor and learner-content interactions. Distance learning was limited to correspondence courses, individual learning, and self-contained isolated curricular units, and learning was bound by time, space, and media constraints. Figure 3 illustrates the pedagogical ecology of pre-internet technologies showing the interactions among three components: technology type (top vertex), teaching and learning activities or learning interactions (right vertex), and pedagogical or instructional models and theories (left vertex).

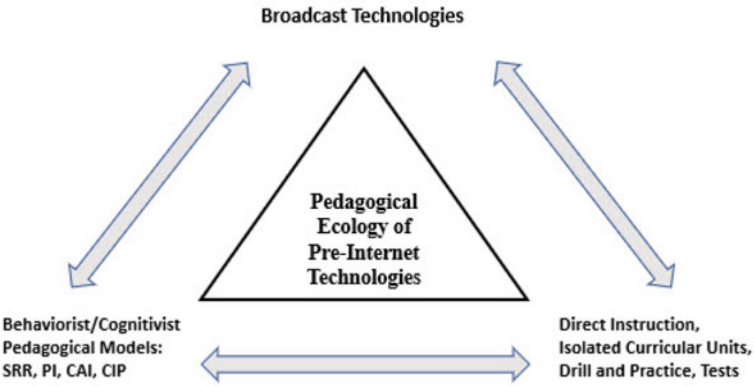

Fig. 3 Pedagogical ecology of pre-internet technologies

2.2 The Pedagogical Ecology of Web 1.0 Technologies

With the onset of information and communication technologies (ICT), the internet, and the World Wide Web (WWW), technology evolved from static and unidirectional to dynamic, networked, communicative, and collaborative. This class of technologies has come to be known as Web 1.0 technologies. Web 1.0 technologies characterized the first stage of the WWW, which consisted of an information portal made up of web pages connected through hyperlinks that users can access without being given the opportunity to post reviews, comments, or contribute content. The internet and the WWW prompted learning interactions and pedagogical models to evolve, enabling more open and flexible learning spaces and affording multiple forms of interaction.

For example, learning spaces and interactions became unbounded and distributed so that learning could happen anytime, anywhere synchronously or asynchronously using a variety of media; the "physical" distance between the learner and the instructor or the learner and other learners became blurred or relatively unimportant; learning resources proliferated prompting a reconsideration of what is an acceptable academic source; and the concept of learning in groups or collaborative learning flourished.

As shown in Fig. 4, the pedagogical ecology of Web 1.0 technologies resulted in teaching and learning activities that are more constructivist in nature, such as collaboration, articulation, social negotiation, exploration, and reflection. Web 1.0 technologies also supported pedagogical models that are grounded in theories of constructivism and situated cognition such as communities of practice (COP), knowledge networks, and distributed learning [24].

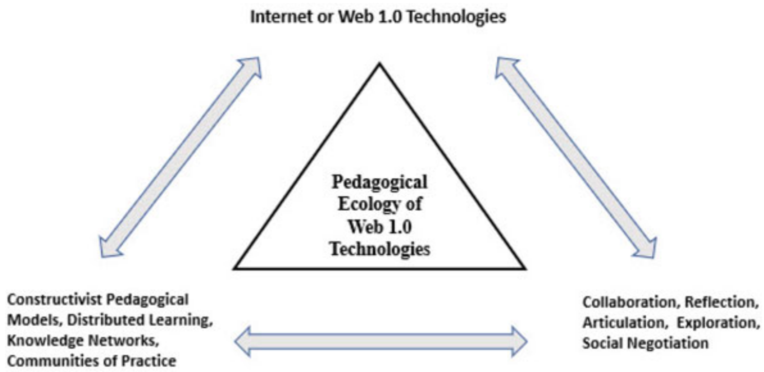

Fig. 4 Pedagogical ecology of Web 1.0 technologies

2.3 The Pedagogical Ecology of Web 2.0 Technologies

Technology evolved again in the twenty-first century leading to a new wave of ICT known as Web 2.0 technology. Web 2.0 technology possessed many of the inherent technological and pedagogical affordances of older computer-mediated communication tools but also represented a qualitative shift in how information is created, delivered, and accessed on the web [15]. Web 2.0 became a concept that embodied themes such as openness, personalization, customization, participation, social networking, social presence, user-generated content, the people's web, read/write web, and collective wisdom leading to its characterization as the "social web" [25–28]. In 2008, Mills Davis characterized Web 2.0 as the "The Social Web" and described it as the second stage of internet growth that is all about "connecting people" and "putting the "I" in user interface, and the "We" into Webs of social participation" [26]. The 2014 New Media Consortium (NMC) Horizon Report also emphasized the social side of Web 2.0, particularly as this relates to the ubiquitous use of social media technologies in the education sector and the way this use is changing how students and educators interact, present information, and judge the quality of content and contributions [29].

For example, blogging, microblogging (tweeting), podcasting, social bookmarking, social tagging, and social networking became the new affordances of Web 2.0 technologies, and as a result, new teaching approaches, theories, and constructs evolved such as connectivism [30], networked learning, MOOCs, mobile learning, and personal learning environments (PLEs). Figure 5 illustrates the pedagogical ecology of Web 2.0 or social media technologies, showing the relationship between the technology affordances of Web 2.0, the pedagogical practices (learning activities) (bottom right vertex), and the pedagogical models and constructs (bottom left vertex).

Unlike Web 1.0 technology where use was limited to only 14% of the adult population, most of which were programmers and tech-savvy individuals [31], Web 2.0 technology use grew to 90% of the US population and 65% worldwide because of its

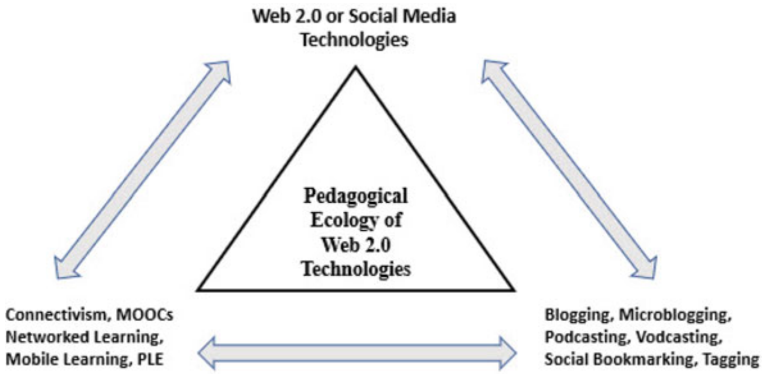

Fig. 5 Pedagogical ecology of Web 2.0 technologies

read/write affordances (the ability for users to create and post content) [32]. The new activities that grew out of Web 2.0 technologies (e.g., blogging, wikis, creating and posting videos) moved web-based learning activities away from having to be teacher centered to the possibility of being more learner centered. First, Web 2.0 technologies made it possible for learners to engage in high levels of dialogue, interaction, collaboration, and social negotiation through social networks and provided learners with the ability to generate and share knowledge across learning networks. Second, Web 2.0 technologies deflected control of learning away from a single instructor or expert by distributing learning among all participants in the learning community, promoting agency in the learning process and an appreciation of diversity, multiple perspectives, and epistemic issues. And third, Web 2.0 technologies enabled learners to personalize their learning environment by selecting the technologies they wish to use (e.g., apps on mobile devices), accessing and organizing information sources, customizing the user interface of a technology, and building personalized learning and professional networks [24].

2.4 The Pedagogical Ecology of Web 3.0 Technologies

Web 3.0 technology is the next iteration of the WWW and is sometimes referred to as the "semantic", "spatial", or "3D web" [33, 34]. As Evans describes, rather than seeking information by keyword, activities, or interests, users will be able to define their preferred means of information seeking. Enabled by blockchain technologies, the Web 3.0 movement has been characterized by embracing the principles of "open, decentralized, censorship-resistant, immutable, trustless, and permissionless" interactions [35]. These platforms cut out the middleman of the larger corporations so that the user can control their own data analytics, set their own rules, and obtain the full monetary gain from their efforts online. For example, a user getting a cut of profits from their offerings in Medium.com may be able to leverage Web 3.0 technologies to gain the full profit using blockchain technologies like Mirror.

Web 3.0 also promises interoperability so that end users do not need to create multiple accounts for multiple services. Web 3.0 also promises users voting rights that regulate the governance of overarching communities' roles as opposed to relying on the dictates of the bigger platforms like Twitter, Google, or Meta. Given the promised interoperability, Web 3.0 may enable personalization across platforms, yielding a cryptographically-backed digital identity to be represented across the web, and resources that better connect to the end users based on their interests and powered by machine learning [33]. These extended capabilities, however, are in their nascent stages and beg questions about privacy, security, bias, and censorship.

Immersive learning technologies such as AR, VR, and MR are also examples of Web 3.0 technologies that allow participants to be totally "immersed" in the context that the environment represents. They create virtual experiences that strive to look and feel like real settings. Immersive environments can be created as a "classic" immersive reality where the participant may wear goggles and interact via a headset and a joy-stick or other controller, and experience the environment through these devices. Immersive technologies also allow the participant to create an avatar to represent themselves. Simulations, educational games, and virtual reality environments are all examples of immersive environments. The immersive environment would include a three-dimensional (3D) visual experience, audio and potentially olfactory stimuli. Advances in artificial intelligence (AI), computational design, machine learning, and smart technologies like the Internet of Things (IoT) are automating the design of human-centered environments and human–machine partnerships, whether in real or virtual reality, transforming the future of work, entertainment, health care, education, business, and everyday life.

Figure 6 demonstrates the pedagogical ecology of Web 3.0 technologies suggesting that teaching and learning experiences are going to become more immersive, personalized, and AI supported. You will also note that sociomaterial entanglement theory (SET) will be a new pedagogical construct that aligns with the affordances of Web 3.0 technologies. As an approach that enacts contemporary ideas about how people learn, SET embodies the sociomaterial entanglement with which people learn and the technosocial reality we live in. SET can be considered as an extension of Gibson's theory of affordances because it addresses the prevailing tendency to limit conceptions of social interactions to between persons rather than between persons and things [36]. Moreover, SET is not an explanatory theory, rather an approach or framework with a broad spectrum of applications that are able to integrate some of the most naturalistic ideas about how people learn in the digital environment, the most relevant of which are: (a) learning anytime, anywhere, or what has come to be known as ubiquitous learning [37]; (b) adult learning, specifically as this relates to self-directed learning or what is known as heutagogy [38, 39]; (c) learning with others as conceptualized by social constructivism [40, 41]; and (d) learning in connection or connected learning as embraced by connectivism [30, 42] and networked learning [43–45].

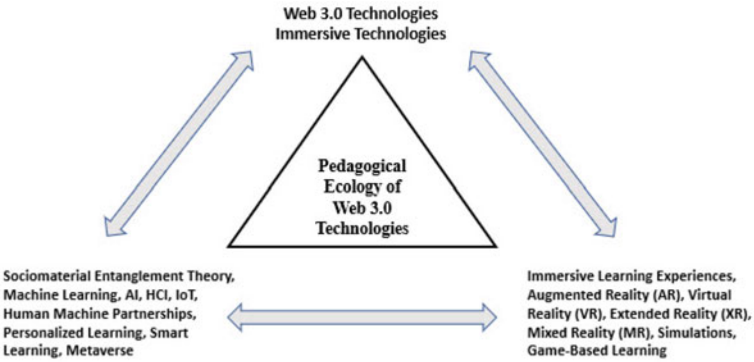

Fig. 6 Pedagogical ecology of Web 3.0 technologies

Figures 3–6 demonstrate that the pedagogical ecology of learning technologies is recursive and transformative in nature as a result of the reciprocal interplay between the affordances of technology and pedagogy. Anderson and Dron describe this interplay as a dance where technology sets the beat and creates the music while pedagogy defines the moves [46]. Anderson and Dron posit that pedagogical models "have evolved in tandem with the technologies that enable them" [46]. The co-evolution of technology and pedagogy suggests that technology can no longer be perceived as a neutral tool that may or may not be used for teaching and learning. Rather, technology is an enabler of virtually every teaching model or strategy and an empowering agent for its users. Patterns of technology use across the decades have shaped our teaching and learning practices, and consequently, our learning theories and pedagogical models. Henry Beston eloquently stated this when he said:

> There exists a mutuality between our tools and our intentions—while our tools are the product of our intentions, they also shape our intentions in turn [47].

More specifically, pedagogical ecology demonstrates that there is a recursive and transformative interaction between three components of a learning environment that work collectively to shape our learning spaces, perspectives, and interactions. These components are: (1) learning technologies (the top vertex in Figs. 3–6), (2) instructional practices and activities (the bottom right vertex), and (3) learning theories and pedagogical models or constructs (bottom left vertex). The arrows in Figs. 3–6 depict a reciprocal, cyclical, and iterative relationship between these three components in which patterns of technology use shape our instructional practices and learning interactions, which in turn shape our learning theories and pedagogical models leading to the emergence of new learning technologies with new pedagogical affordances. This three-component model (explained in more detail later in this chapter) embodies the non-neutrality of the learning space and emphasizes the pedagogical affordances of learning technologies.

Väljataga, Pata, and Tammets argue that Gibson's theory of affordances has been misconstrued in educational technology settings or interpreted to take into consideration *only* the "objective properties of the tools or functionalities provided by the developers of the tools" [48]. However, instructional designers and faculty need to be aware of the concrete or intended affordances of these tools in order to harness their pedagogical potential and design appropriate learning activities. So, the question for teachers, faculty, and instructional designers becomes "What is it about this technology that makes users [students] want to interact with it in this way?" and "What perceiving abilities does it provide or enable?" and "How can we leverage or harness this technology in educational contexts?".

Technology and internet connectivity have disrupted industries and transformed the lives of billions of people. Twenty-five years ago, less than 3% of the world's population had a mobile phone, and less than 1% had access to the internet. Today, 69% of the world's population (over 4.9 billion people) have access to the internet [49], and the United Nations International Telecommunication Union estimated that around 73% of the world's population over ten years of age own a cellphone [50]. Additionally, over 59.3% of the total global population (around 4.74 billion) use social media on average 146 min per day [49, 51]. Among the popular social media platforms, six platforms claim one billion or more monthly active users per month and 17 platforms have at least 300 million active users as of October 2022 [51]. As a result of this increased access to networked devices and platforms, online education, in its numerous pedagogical and delivery models, is becoming a major phenomenon around the world and has had its own pedagogical ecology due to advances in technology.

In the final sections of this chapter, we describe the pedagogical ecology of online learning and present a framework that can serve as a starting point for educational reform in the Arab world by moving the needle from "schooling to learning" in order to "serve the needs of pluralistic societies and foster the development of active, responsible citizens who are empowered to deal with complexity and advance constructive change" [52]. As technologies evolve, we have more and more opportunities to reimagine and reinvent e-learning and online education programs in higher education contexts locally and globally, moving away from models that ask learners to memorize information and take recall tests to an ecosystem in which technology enables the design of learning experiences that are relevant, meaningful, and useful to learners.

3 Online Learning Models and Frameworks

As discussed earlier in this chapter, distance education started with correspondence courses back in the late 1800s where individual learning triumphed, and evolved to audiovisual instruction using broadcast technologies in the early 1900s, then to asynchronous and synchronous forms of online learning in the late 1990s and early 2000s with the onset of the internet (Web 1.0 technologies), and eventually to fully online and hybrid courses, MOOCs, e-learning, microlearning, and other forms of blended learning (e.g., hyflex learning, bichronous learning, mobile learning) and immersive learning with the onset of Web 2.0 and Web 3.0 technologies.

In its simplest form, online learning might be described as any learning that takes place using the internet as a delivery system [24]. However, terminologies such as online learning, e-learning, blended learning, or hybrid learning are often used interchangeably, and definitions of online learning continue to be debated and reconstructed. Generally, it is safe to say that online learning can range from learning environments where individuals work primarily independently, experiencing little or no interaction with an instructor or other learners (e.g., e-learning), to instructional interventions where students are highly engaged in interactions with the instructor and peers (e.g., synchronous and asynchronous online courses).

In this chapter, online learning is defined from a pedagogical perspective as follows:

> An open and distributed learning environment that utilizes pedagogical tools enabled by internet- and web-based technologies to facilitate learning and knowledge building through meaningful action and interaction.

This definition emphasizes the link or interaction between perception and action as it pertains to the affordances that learning technologies present in a learning situation and the abilities a learner has to harness these affordances and engage in meaningful activity. To maximize the potential of this interaction when designing online learning environments, a three-component model, based on the construct of pedagogical ecology discussed earlier in this chapter, is presented (Fig. 7). The three components of this model are: (1) learning technologies (top vertex), (2) learning activities or interactions (bottom right vertex), and (3) pedagogical models or constructs (bottom left vertex).

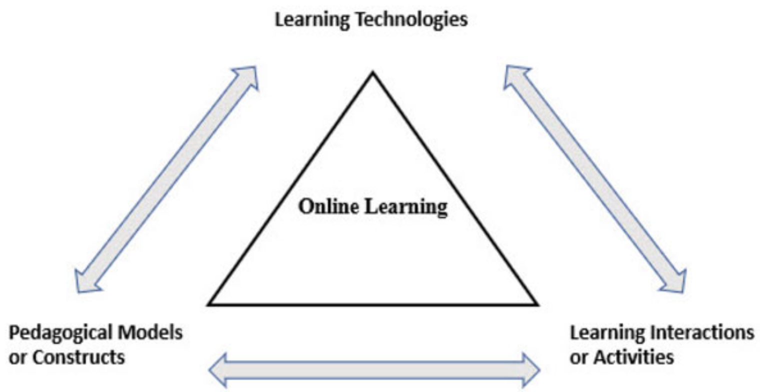

Fig. 7 Three-component model for online learning

3.1 The Three-Component Model for Online Learning

The three-component model for online learning is different from other learning design models in that it allows the instructional designer, developer, or online teacher/instructor the flexibility to begin thinking about designing an online course or course events with any of the three components of the model, and proceed clockwise or anti-clockwise to integrate the other two components in the design process. The decision regarding which component to start with is largely based on the instructional context and the expertise of the instructional designer, developer, or online instructor. For example, if a learning technology such as LMS has already been selected as a course delivery platform at an institution, the instructional designer or course developer should start by exploring the features of the LMS to understand its pedagogical potential in supporting online learning interactions and then proceed to design learning activities that maximize the pedagogical affordances of the LMS features to ensure overall instructional effectiveness and compatibility of the learning design.

Alternatively, a college professor who may be more experienced in pedagogical approaches can choose to begin with a familiar pedagogical model (e.g., experiential learning, personalized learning, game-based learning) and proceed to explore learning technologies and learning activities that support this pedagogical model to create an integrated learning design. Another unique feature of the three-component model is its emphasis on various media (learning technologies) as key components in the overall design process. Rather than treating these media as delivery vehicles or transmissive educational technologies, they are placed on an equal footing with the other two components to ensure that the affordances they bring forth to a learning situation are given appropriate consideration.

3.2 Meaningful Online Learning

The aforementioned definition of online learning also implies that learning should be *meaningful* and that learners should engage in *meaningful action and interaction.* Meaningful learning is grounded in a constructivist perspective, which grew in part from the work of Dewey and Piaget, and can be described as learning that has value, purpose, and significance. Constructivist learning theories posit that we (humans) learn by acting upon our environment, observing the results of our actions, and bringing our prior experience to the task at hand. Through reflection and retrospection, we either integrate what we have learned into our existing schema or we restructure our schema in order to reconcile the new knowledge with what we previously believed to be true [24].

So why is meaningful learning important in the online environment? If we (faculty/designers) make the mistake of thinking that an online course can be easily created by uploading lecture notes, creating online tests, and including some PowerPoint files and web links, we will be deeply amiss in terms of our knowledge of designing effective online learning environments. More importantly, we will be doing our students an injustice. While online courses can easily be developed by uploading recorded lectures, content materials, and resources online, this approach results in passive learning where students are receiving information to remember and restate without any real thinking, and where the instructor decides what is to be learned and students have no incentive to engage deeply with the concepts. Students would likely be disengaged from each other, forfeiting opportunities for learning with and from one another. More specifically, this approach to online instruction would be similar to the pedagogical ecology of broadcast technologies (pre-internet technologies) discussed earlier in this chapter and would not be taking advantage of the affordances of networked learning using Web 1.0, Web 2.0, or Web 3.0 technologies. Passive learning contrasts sharply with meaningful learning, which is described as learning that involves students "doing things" (learning by doing) and "thinking about the things they are doing" [53]. It is well documented in the research literature that designing learning activities that involve active teaching and learning have a positive impact on cognitive outcomes [54–56].

The most applied and impactful definition of *meaningful learning* comes from Howland, Jonassen, and Marra [57]. Howland et al. state that *meaningful learning is when we design learning tasks that are active, constructive, intentional, authentic, and cooperative.* This definition includes five characteristics, principles, or attributes, defined as follows:

- **Active learning** is when the learner is actively or intimately engaged in learning, manipulating the artifacts, objects, and materials of the learning environment, observing the effects of these actions, and reflecting on the consequences of these actions. Through our manipulations or interactions with things in our environment, we build meaningful knowledge and gain applied skills. Active learning is manipulative and observant.
- **Constructive learning** is when the learner is able to construct their own simple mental models that explain (articulate) their understanding of new knowledge. With experience and support in the online learning environment, learners will engage in reflective thinking that enables them to construct more complex mental models to represent their understanding of new concepts and processes. The active and constructive principles of the meaning making process are symbiotic. They work hand in hand for meaning making to occur.
- **Intentional learning** is when we ensure that learning is goal oriented and personally relevant. When learners are actively and deliberately working toward achieving a cognitive goal, such as getting a degree or developing a new career skill, they think and learn more because they are fulfilling a personal intention. This principle of meaningful learning aligns with the self-directed learning principle of adult learning. Self-directed learning requires the learner to engage in metacognitive self-regulatory strategies that include organizing, time-management, and self-discipline, which are critical in online learning and should be nurtured and supported in order to prevent attrition, a common problem of learning online.

- **Authentic learning** is learning that is complex and contextual. Research has shown that learning tasks that are situated in a meaningful real-world task or simulated using a case-based or problem-based pedagogical approach are not only better understood and remembered, but are also more consistently transferred to new situations. Relating learning concepts to something that is concrete and real, rather than abstract, allows learners to apply their knowledge in future conditions in which that knowledge may be applicable.
- **Cooperative learning** is learning that is collaborative and conversational or dialogical. Humans naturally engage in social activity, working together in communities and taking advantage of each other's skills and knowledge to support their goals and actions. Social learning can lead to the co-construction of knowledge among individuals. While one person may have good ideas, working together with others can collectively build greater knowledge. To work collaboratively, learners must communicate with each other by sharing ideas, listening to each other's perspectives, and working together to accomplish the task at hand. This requires specific design approaches in online learning leveraging the affordances of social media and information communication technologies.

As illustrated in Fig. 8, the characteristics of meaningful learning are interrelated, interactive, synergistic, and interdependent. That is, learning and instructional activities should be designed to include combinations of active, constructive, intentional, authentic, and cooperative learning rather than designing for each individual characteristic in isolation because that is how your online learning designs will result in meaningful learning [24].

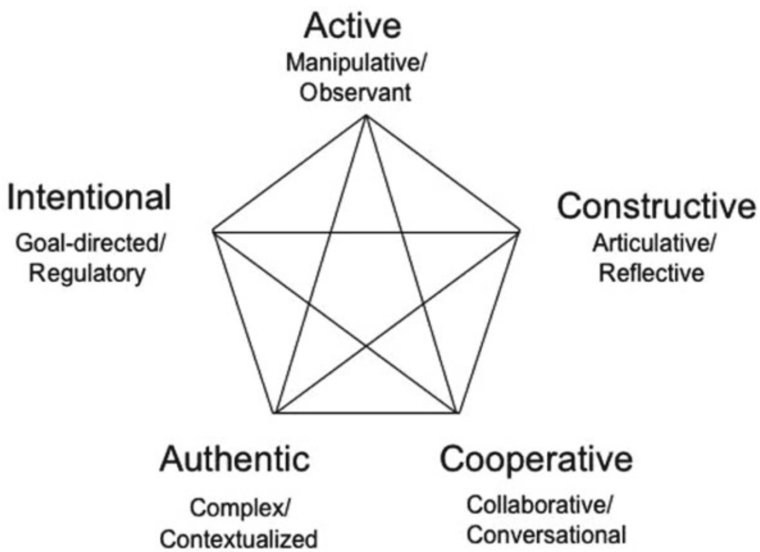

Fig. 8 Characteristics of meaningful learning

Designing meaningful learning activities using *The Three-Component Model for Online Learning* ensures that we are leveraging the pedagogical affordances of learning technologies for effective learning designs. Leveraging the pedagogical affordances of learning technologies results in providing opportunities for online learners to engage in meaningful learning activities that are active, constructive, intentional, authentic, and cooperative. Additionally, when interactions with technologies in the online environment are learner initiated and learner controlled, learners are empowered to take charge of their own learning and to use technologies as dynamic learning tools rather than information delivery tools. Figure 9 provides a classification of learning technologies based on their pedagogical affordances.

Figure 9 shows six classes of learning technologies that can be used to design and develop meaningful online learning environments:

1. Technologies for content creation and delivery
2. Technologies for collaboration and communication
3. Technologies for information search and resource management
4. Technologies for knowledge representation
5. Technologies for assessment and analytics
6. Technologies for immersive learning

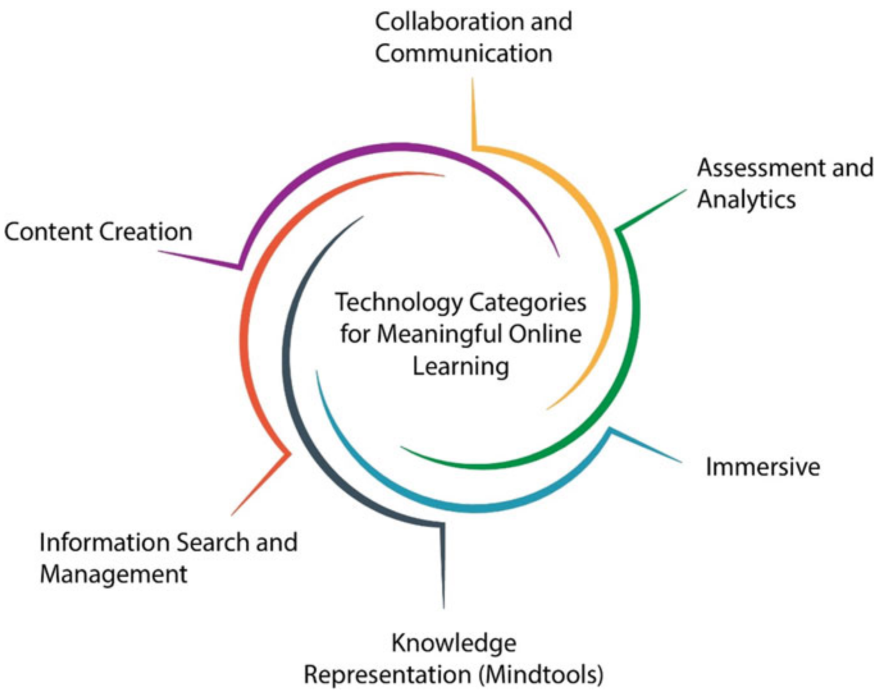

Fig. 9 Technology categories for meaningful online learning

Briefly, ***content creation and delivery technologies*** are primarily used by instructional designers or instructors (faculty/teachers) to create and manage digital content, but they can also be used by learners to create and contribute content such as assignments, journals, and resources. Examples of content creation technologies include tools embedded in learning management systems (LMS) (e.g., Moodle, Canvas, Blackboard, Google Classroom) such as course templates for setting up the course syllabus and content modules; a repository for content sharing, tagging, and reuse (e.g., a digital portfolio, wiki spaces); and instructional design tools for creating flexible learning sequences and designs as in e-learning (e.g., Articulate Storyline, Articulate Rise) among others. Web publishing tools such as Canva, Wix, Weebly, and Screencast-o-matic also belong in this technology category. ***Collaboration and communication technologies*** are technologies that help facilitate communication and collaboration between the learner and the instructor, the learner and other learners, and between and within learner groups. Collaboration and communication technologies can help reduce the isolation that can go along with being an online student as well as personalize the learning experience. Examples of collaboration and communication technologies include asynchronous communication technologies such as e-mail, discussion forums (features of LMS), blogs, wikis, social media technologies, and document storage spaces (e.g., Dropbox), as well as synchronous communication technologies such as chat, video-based synchronous sessions (e.g., Zoom, Skype), screen sharing technologies, and group synchronous workspaces (e.g., Google Drive and OneDrive).

Information-search and resource-management technologies are a class of technologies used to search for resources on the internet or in specific knowledge repositories (e.g., databases at a library) and technologies that help us manage these resources that are at the heart of many online learning activities. When learners need resources, they almost immediately turn to an internet search engine to find what they are looking for. This illustrates how important search tools are to today's online learners. Examples of information search and resource management technologies include knowledge bases (e.g., dissertation abstracts, EBSCO, Library of Congress, e-resources); internet search engine tools (e.g., Google, Bing); and content collection, aggregation, and annotation tools (e.g., Zotero). ***Knowledge representation technologies*** are primarily used by learners to help them represent their understanding using audiovisual technologies. A simple example that shows how knowledge representation tools can be used is for an exploratory activity such as generating a concept map to represent the relationships between key components that the student is learning. Learners are actively constructing their external knowledge structures when using knowledge representation technologies. Other examples include learner-created databases, expert systems, videos, and spreadsheets, as well as interactive web publishing tools such video-creation tools.

Technologies for assessment and analytics are used to assess student learning in online learning environments as well as the overall effectiveness of the course or instructional intervention. This category of technologies includes rubric generation tools and rubric banks (e.g., iRubric, Rubistar); analytic tools (e.g., Google Analytics, LMS-specific analytics reports, xAPI powered interfaces); test and quizzing tools (e.g., Kahoot, QuizStar, Articulate Quizmaker); digital portfolio systems (e.g., Weebly, Wix, WordPress); and learner response systems (e.g., Mentimeter, PollyEverywhere). ***Immersive learning technologies*** are technologies that enable the creation of virtual experiences or digital spaces that strive to look and feel like a real-world setting, allowing participants to be "in" or "immersed in" the experience to the extent possible [58]. Examples of immersive learning technologies include simulations, VR games for learning (e.g., Minecraft or FutuClass), 3D immersive learning environments (e.g., Second Life by Linden Lab), and augmented reality (AR), mixed reality (MR), and extended reality (XR) technologies.

For an in-depth look at how these technology categories can be used to design meaningful online learning activities and experiences based on their pedagogical affordances and to view specific examples and applications, you can consult Dabbagh, Marra, and Howland's 2019 book titled *Meaningful Online Learning: Integrating Strategies, Activities, and Learning Technologies for Effective Designs* [24].

3.3 Putting It All Together—The Meaningful Online Learning Design Framework

Figure 10 presents the Meaningful Online Learning Design (MOLD) Framework, which illustrates the relationship between the three-component model for online learning (Fig. 7) and the five characteristics of meaningful learning (Fig. 8). The five characteristics of meaningful learning shown in the outer circle of the MOLD framework in Fig. 10 should be considered as overarching pedagogical principles for designing meaningful online learning experiences and used to guide the designer as they select learning technologies, learning activities, and pedagogical models or constructs.

The MOLD framework suggests that in order to create active, engaging, and authentic online learning environments designers must consider the meaningful learning characteristics in their choices of each of the components of the three-component model for online learning while retaining the reciprocal and transformative interaction among these components.

3.3.1 Online Learning Example Using the MOLD Framework

To end this chapter, we provide an example of how the MOLD framework can be used to design online learning experiences for adult populations. The example was designed and developed by a student enrolled in a graduate class of the ***Learning Design and Technology (LDT)*** graduate program at a higher education institution in the United States. Students in this class are required to submit a proposal for an online learning environment that includes the following elements: (1) instructional

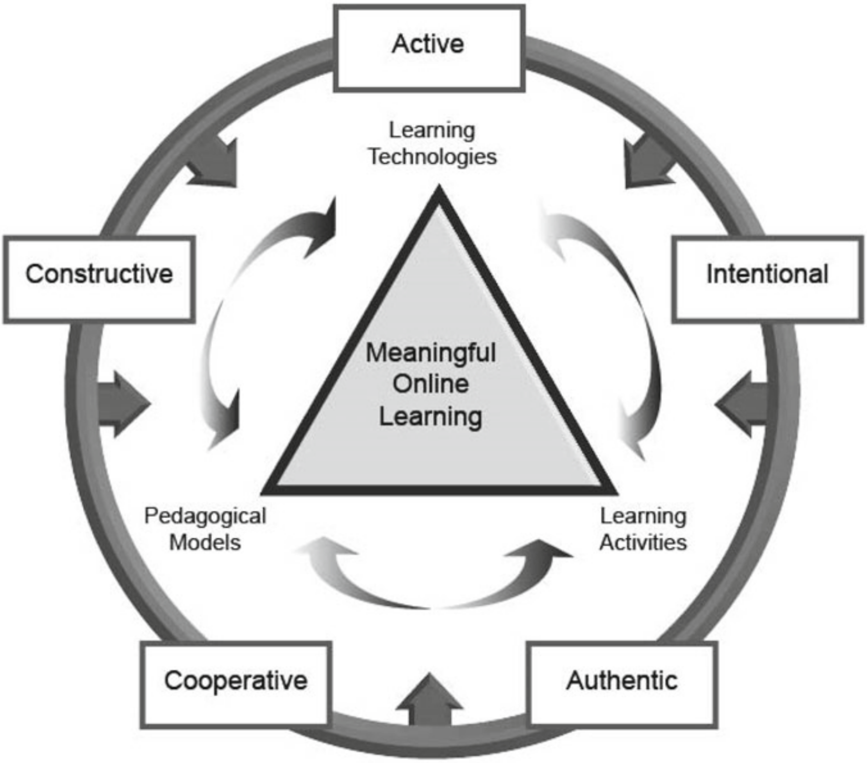

Fig. 10 Meaningful Online Learning Design (MOLD) framework

problem, (2) target audience, (3) general knowledge domain, (4) learning outcomes, (5) pedagogical model, (6) learning problem that will engage the target audience, (7) learning activities and learning technologies, and (8) assessment. The title of the student's proposal used in this example is: ***Math Education Challenge: K-12***.

3.3.2 Use Case Example of Applying MOLD—Math Education Challenge: K-12

(1) ***Instructional Problem***

Mathematics is one of the core subjects in K-12 education in the public school system in the United States. In the earlier school years, at the elementary level, teachers share similar issues in teaching English, math, or science. Most students can read and write by the middle elementary school years yet math can be intimidating for many students as they progress from basic math calculations like addition or subtraction to advanced concepts like algebra and geometry. Math educators face multiple challenges in their classrooms.

A math curriculum is built on concepts learned in previous school years. If a student does not have the prerequisite knowledge, then a math teacher can either do some remediation or forge ahead and cover concepts that the student might not understand. Often, students are not able to find a connection between important concepts in math and real life. For example, students do not find real applications of trigonometry, geometry, or algebra in their daily life. Mathematics teachers often have classes with students of varying ability levels within the same classroom. This might result from gaps in prerequisite knowledge or students' individual feelings in relation to their ability to learn math. Immediate feedback from the teachers can allow the students to understand their mistakes, work to correct the errors, and use the information effectively. Another important issue is the lack of practice and review by classroom students to achieve the mastery of concepts.

The problem, which needs to be addressed from a variety of angles, has been how to effectively teach mathematical concepts to a class of students with varying intellectual abilities. Suitable instructional opportunities specific to the mathematical concept are needed to engage classroom students to develop their mathematical thinking by creating connections to the concepts in the real world, listening and responding to students' thinking, supporting them to consolidate their understanding, and fostering regular math practice.

Various in-person workshops have been conducted at schools and there have been partial improvements in the mathematical abilities of students at the county level; however, with the reduction in the number of such workshops and teachers' hectic schedules, additional interventions are needed to address this instructional problem.

(2) ***Target Audience***

The target audience for this learning environment are the math educators in K-12 education (i.e., teachers). The learners can be novice trained teachers, teachers with some experience but lack the conceptual fluency in the subject, or experienced teachers but with limited experience in the use of technology in teaching mathematics. Some of these teachers are undergraduates or graduates majoring in math, while others are majoring in English or humanities. Learners without strong mathematical knowledge may be struggling with the content fluency and must get comfortable with using technology on a variety of devices.

(3) ***General Knowledge Domain***

The knowledge domain consists of the understanding of student learning and effective math teaching strategies in a classroom setting, i.e., understanding math in ways that help students develop their own mathematical thinking, seeing mathematical connections, being able to determine appropriate instructional representations for mathematical ideas, and recognizing what questions to ask next, in order to further students' thinking.

(4) ***Learning Outcomes***

The learning outcomes for these teachers are as follows:

- Assess the topic to engage students in mathematical activity like investigation, conjecturing, proving, collecting data, describing, solving, calculating, etc.
- Develop the skills of creating meaningful mathematical tasks.
- Develop the skills of listening to student's thinking and responding to the student thinking.
- Recognize and connect student thinking to meaningful mathematical ideas.
- Develop the skills to help students consolidate their understanding of mathematical concepts.
- Analyze the concepts to determine the connections with the real-world applications.
- Develop the skills to engage students in discussion about mathematical ideas to enhance their justification and argumentation skills that lead to proving the concept.
- Apply lessons learned from analyzing and assessing an example scenario to interpret their own scenario in the classrooms.

(5) ***Pedagogical Model***

The pedagogical model that will be suitable for this learning environment is the MOLD framework. The five characteristics of meaningful learning are active, constructive, cooperative, authentic, and intentional. The learners will be engaged in active learning as they examine the scenario example, research information, and analyze data to produce instructional strategies best suited for the situation. As the learners work through the problem, they will reflect on their experiences and observations to represent their understanding in multiple ways. They will be working in authentic learning settings in which the learning tasks are situated in meaningful real-world contexts that promote deeper understanding and transfer of skills to newer or different situations. Through authentic learning activities, learners will develop collaboration and critical thinking skills. The learning environment will enable the learners to work collaboratively, communicating with each other, sharing their ideas and knowledge, and building a collective knowledge base.

(6) ***Learning Problem***

The learners are presented with an example scenario that actively engages them in experiential learning to analyze and assess the situation for designing appropriate instructional opportunities specific to the mathematical concept for their students in the real classroom settings. The learning problem allows the learners to develop their students' mathematical thinking, creating connections, listening and responding to their student's thinking, and guiding them to consolidate their students' understanding of the mathematical concept.

(7) ***Learning Activities and Learning Technologies***

The learning activities and the learning technologies used will be based on real-world math teaching in K-12 classrooms. The learner adopts the role of a math teacher in a classroom setting. The learners are presented with a scenario to teach a mathematical concept. The learner will be provided with various curated resources to read articles and watch videos on the topic.

Scaffolding and Coaching: The learner will be presented with an example scenario. Each learner will be assigned a mentor or a coach. They can collaborate with the mentor or peers as they work on the scenario to build their instructional opportunities for their classroom students.

Collaboration and Social Negotiation: There will be a discussion forum where the learners will participate. Learners will be encouraged to share their strategies to solve the scenario. These discussions will foster collaboration and social negotiation and help the learners to learn newer perspectives or approaches to the problem.

Reflection: Learners will be encouraged to develop a journal that will help them reflect on the progress of their work. This will enable the learners to think deeper and explore the different ways to understand their students' thinking and connect them to mathematical ideas.

Articulation: The learners will articulate their knowledge by sharing multiple perspectives of the given scenario with their peers in order to generalize their understanding and knowledge.

The Math Education Challenge will be available to the learners as an online portal. The portal will provide access to all the relevant articles, videos, and other course content. The course activities will be structured and will follow a timeline for completion of the course. The portal will act as a learning community where learners will have access to the resources and will be able to communicate and collaborate in the future to share their experiences with others and learn from each other to construct a rich knowledge base.

(8) ***Assessment Strategy***

The learning environment will provide multiple forms of assessment to assess the learners on their use of suitable methods for teaching a mathematical concept to an individual student with different ability levels. This will include self-assessment strategies, peer-assessment strategies, mentor or coach assessment strategies, as well as the use of rubrics and feedback analytics.

- Self-assessment that allows the learner to compare and contrast their instructional strategies with that of the expert, coach, or mentor.
- A peer-assessment using a scoring rubric on the selection of the instructional strategies for the classroom teaching scenario.
- An assessment of the individual report summarizing the methods and tools used to address the situation. Expert math teachers will assess the report.

Table 1 shows a snapshot of how the components of this online learning environment align across learning outcomes, instructional strategies, learning activities, learning technologies, and assessment. This alignment is demonstrated for the first three learning outcomes.

Table 1 Pedagogical alignment across components of MOLD

Learning outcome	Instructional strategies	Learning activities	Learning technologies	Assessment
Assess the topic to engage classroom students in mathematical activity such as investigation, conjecturing, proving, collecting data, describing, solving, and calculating	Exploration Collaboration and Social Negotiation	Learners will research the mathematical activities applicable to the project topic (scenario example) Learners will work in pairs to design an instructional plan to identify the set of activities for the project topic	The learning environment with all the resources will be available for math educators online using an LMS or similar platform Google docs for collaborative work and Zoom for synchronous discussions	A rubric tool will be used by the instructor (expert, coach, mentor) to assess the appropriateness of the learning activity
Develop the skills of creating meaningful mathematical tasks	Exploration Collaboration and Social Negotiation	Learners will develop mathematical activities and steps to engage their students Learners will work in the same pair to design engaging mathematical tasks for their project Learners will create a presentation of the activities they have designed to explain their strategies to their peers and instructor	They work collaboratively using Google slides and Zoom meetings for discussions A video presentation of their slides using screencasting or zoom recording	Peer assessment based on a rubric tool will be used by every learner to assess two of their peers' instructional interventions or activities
Develop the skills to listen to students' thinking and responding to students' thinking	Scaffolding	Learners will view a video where a math educator listens to the thinking of their learner and responds accordingly	A video resource embedded in the learning environment demonstrating the skills	A rubric tool is used by the instructor to grade the video

(continued)

4 Conclusion

This chapter focused on the pedagogical ecology of learning technologies and described how technology evolved from the pre-internet era to the Web 1.0, Web 2.0, and Web 3.0 eras, and how the affordances of these technologies changed our teaching and learning practices as they evolved. An important argument was made regarding the non-neutrality of the learning space and the reciprocal interaction

Table 1 (continued)

Learning outcome	Instructional strategies	Learning activities	Learning technologies	Assessment
Apply lessons learned from analyzing and assessing an example scenario to interpret their own scenario in the classroom	Articulation Reflection	Learners will analyze and assess the example scenario Learners will participate in a discussion board to explain why the example scenario will work well or why it may not work for their classroom context The discussion board will have peer responses. At the end of the discussion, the instructor consolidates the learners' understanding related to the scenario and presents this to the learners for further reflection	A discussion board on analyzing and assessing the scenario, with at least two peer reviews Google Forms is used for the online quiz	Rubric tool will be used by the instructor to grade the discussion posts based on appropriate categories of the scenario Self-assessment in the form of a quiz that allows the learner to compare and contrast their instructional activities with those of the instructor or expert

between technology and pedagogy and how this interaction is recursive and transformative, yielding more innovative learning designs as technology advances. Transcending the pedagogy–technology dichotomy was emphasized by focusing on the concepts of entangled pedagogy and sociomaterial entanglement that place all the factors of a learning environment on an equal footing, particularly when technology is at stake, as technology is not just a delivery tool; rather, technology impacts our pedagogical and socio-cultural practices.

A three-component model for online learning was shared in which learning technologies, learning activities, and pedagogical models or constructs are placed on an equal footing, demonstrating the reciprocal interaction between these three elements and the importance of recognizing these interactions when designing online learning. This model was embedded in the principles of meaningful online learning resulting in a framework called MOLD. A use case example was provided to illustrate how MOLD can be used to develop online learning activities. Additionally, a classification of learning technologies based on their pedagogical affordances was provided.

As technologies evolve, we have more and more opportunities to reimagine and reinvent e-learning and distance education programs in higher education contexts locally and globally, moving away from models that ask learners to memorize information and take recall tests, to a world in which technology enables the design of learning experiences that are relevant, meaningful, and useful to learners, enabling them to develop a twenty-first-century skillset that is critical for modern-day workers.

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