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Future Trends in the Design Strategies and Technological Affordances of E-Learning

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Abstract

E-learning has become an increasingly important learning and teaching mode in recent decades and has been recognized as an efficient and effective learning method. The rapidly rising number of Internet users with smartphones and tablets around the world has supported the spread of e-learning, not only in higher education and vocational training but also in primary and secondary schools.

E-learning and traditional distance education approaches share the emphasis on "any time, any place" learning and the assumption that students are at a distance from the instructor. The design of the initial e-learning courses tended to replicate existing distance education practice based on content delivery. However, long textual lectures were clearly not suitable for the online environment. These early insights guided the development of e-learning (technical and pedagogical) and emphasized the need for communication and interaction.

E-learning describes learning delivered fully online where technology mediates the learning process, teaching is delivered entirely via Internet, and students and instructors are not required to be available at the same time and place.

E-learning practices are evolving with the mutual influence of technological e-learning platforms and pedagogical models. Today, the broad penetration and consolidation of e-learning needs to advance and open up to support new possibilities. Future e-learning should encompass the use of Internet technologies for both formal and informal learning by leveraging different services and applications.

The purpose of this chapter is to provide a general analysis of the evolution and future trends in e-learning. The authors intend to summarize findings from contemporary research into e-learning in order to understand its current state and to identify the main challenges in the technological and pedagogical affordances of e-learning.

Keywords

E-learning development • E-learning technology • E-learning models • Learning digital ecosystems

Introduction

Advances in educational technology and an increasing interest in the development of asynchronous spaces influenced the rise of the term e-learning in the mid-1990s as a way to describe learning delivered entirely online where technology mediates the learning process. The pedagogical design and technology behind e-learning have gradually evolved to provide support and facilitate learning.

E-learning has become an increasingly important learning and teaching mode, not only in open and distance learning institutes but also in conventional universities, continuing education institutions and corporate training, and it has recently spread to primary and secondary schools. Moreover, greater access to technological resources is providing e-learning not only in formal education but also in informal learning.

The evolution of e-learning has evolved from instructor-centered (traditional classroom) to student-centered approaches, where students have more responsibility for their learning. This evolution has been made possible due to the technological platforms that support e-learning. Learning management systems (LMS) provide the framework to handle all aspects of the e-learning process. An LMS is the infrastructure that delivers and manages instructional content, identifies and assesses individual and organizational learning or training goals, tracks progress toward meeting those goals, and collects and presents data to support the learning process.

It is also important to stress the influence of social media on users' daily habits, as this has led to increased demand for learning personalization, social resources to interact with peers, and unlimited access to resources and information (Siemens, 2014). Moreover, e-learning is also being called on to offer flexibility in the way and place people learn and permit a natural and necessary coexistence of both formal and

informal learning flows. Thus, the "traditional" e-learning platforms, despite their extensive penetration and consolidation, need to evolve and open themselves up to supporting these new affordances to become another component within a complex digital ecosystem. This, in turn, will become much more than a sum of its independent technological components due to the interoperability and evolution properties orientated to learning and knowledge management, both at institutional and personal levels.

The continued growth and interest in e-learning have raised many questions related to learning design and technology to support asynchronous learning: What are the best instructional models in online settings? How have the roles of instructors and learners evolved? What are the most appropriate forms of interaction and communication? How can formal and informal learning be combined? What is the most appropriate technology to support e-learning? The main goal of this chapter is to describe the evolution of e-learning and to analyze the current situation and future trends in the design strategies and technological affordances of e-learning.

The chapter is divided into four sections. Firstly, we describe the meaning of the term e-learning and its evolution from the early 1990s until today. In the second part, we focus on the evolution of pedagogical approaches in e-learning. The third part analyzes learning technologies with particular emphasis on the development of the learning ecosystem as a technological platform that can provide better services than traditional LMS. Finally, in the fourth part, based on the resulting analysis, the authors offer some general remarks about the future of e-learning.

The Concept of E-Learning

In this section we analyze the meaning of the term e-learning in relation to other similar terminologies (distance education, online learning, virtual learning, etc.) and the evolution of e-learning generations from the early 1990s until today.

Evolution of the Concept

A major confusion in the discourse on e-learning is its blurring with distance education: e-learning and distance education are not synonymous. Distance education can be traced back to ancient times, whereas e-learning is a relatively new phenomenon associated with the development of the Internet in the 1990s. However, it is undeniable that the origins of e-learning lie in distance education and share the idea that the use of media can support massive learning without face-to-face interaction.

The first documented example of training by correspondence (as distance education was known for many years) dates back to 1828, when Professor C. Phillips published an advertisement in the Boston Gazette offering teaching materials and tutorials by correspondence. In 1843, the Phonographic Correspondence Society was founded, which could be considered the first official distance education

institution as it would receive, correct, and return shorthand exercises completed by students following a correspondence course.

The idea that technology such as radio and television could be used to bring education to a wide audience began to surface as long ago as the 1920s, but it was not until the early 1960s that the idea gained momentum, with the landmark creation of the Open University in the UK, with a manifesto commitment in 1966 that became a reality in 1971 when this university started to accept its first students.

The e-learning concept has evolved alongside the evolution of its supporting technology, from the early concept linked to the introduction of personal computers up to today's distributed systems, which have favored learning networks and the roots of connectivism (Siemens, 2005). However, the most outstanding and important event in the history of e-learning is the emergence of the Web, after which the evolution of the e-learning model has been inextricably linked to the evolution of the Web (García-Peñalvo & Seoane-Pardo, 2015).

When a time approach is used to classify e-learning models according to their technological evolution, the most suitable metaphors are generations (Downes, 2012; García-Peñalvo & Seoane-Pardo, 2015; Garrison & Anderson, 2003; Gros et al., 2009) or timelines (Conole, 2013), as opposed to other taxonomies that use variables such as centrality (Anderson, 2008) or the pedagogical model (Anderson & Dron, 2011).

Garrison and Anderson (2003) refer to five stages, or generations, of e-learning, each with its own theoretical model. The first is based on a behaviorist approach; the second appears as a result of the influence of new technologies and an increasing acceptance of the cognitive theory, including strategies focused on independent study; the third generation is based on constructivist theories and centers on the advantages of synchronous and asynchronous human interaction; the fourth and fifth generations have no theoretical background, and the authors considered that their main characteristics were not yet present in training programs, but they would be based on a huge volume of content and distributed computer processing to achieve a more flexible and intelligent learning model.

Gros et al. (2009) present three generations, each with a different e-learning model. The first generation is associated with a model focused on materials, including physical materials enriched with digital formats and clearly influenced by the book metaphor. The second generation is based on learning management systems (LMS) inspired by the classroom metaphor, in which huge amounts of online resources are produced to complement other educational resources available on the Internet known as learning objects (Morales, García-Peñalvo, & Barrón, 2007; Wiley, 2002). In this generation the interaction dynamics start through messaging systems and discussion forums. The third generation is characterized by a model centered on flexibility and participation; the online content is more specialized and combines materials created both by the institution and the students. Reflection-orientated tools, such as e-portfolios and blogs (Tan & Loughlin, 2014), and more interactive activities, such as games (Minović, García-Peñalvo, & Kearney, 2016; Sánchez i Peris, 2015), are also introduced to enrich the learning experience with a special orientation toward the learning communities model (Wenger, 1998). In

addition, web-based solutions are expanded to other devices which leads to the development of mobile learning training activities (Sánchez Prieto, Olmos Migueláñez, & García-Peñalvo, 2014).

Stephen Downes (2012) starts with a generation zero based on the concept of publishing multimedia online resources with the idea that computers can present content and activities in a sequence determined by the students' choices and by the results of online interactions, such as tests and quizzes. This foundational basis is the point of departure for all subsequent developments in the field of online learning. Generation one is based on the idea of the network itself, with tools such as websites, e-mail, or gopher to allow connection and virtual communication through specialized software and hardware. Generation two takes place in the early 1990s and is essentially the application of computer games to online learning. Generation three places LMS at the center of e-learning, connecting the contents of generation zero with the generation one platform, the Web. Generation four is promoted by the Web 2.0 concept, which in online education is known as e-learning 2.0 (Downes, 2005). One of the most significant characteristics of e-learning 2.0 is the social interaction among learners, changing the nature of the underlying network where the nodes are now people instead of computers. This social orientation also causes a real proliferation of mobile access and the exploitation of more ubiquitous approaches in education and training (Casany, Alier, Mayol, Conde, & García-Peñalvo, 2013). Generation five is the cloud-computing generation (Subashini & Kavitha, 2011) and the open-content generation (García-Peñalvo, García de Figuerola, & Merlo-Vega, 2010; McGreal, Kinuthia, & Marshall, 2013; Ramírez Montoya, 2015). Finally, generation six is fully centered on Massive Open Online Courses (MOOC) (Daniel, Vázquez Cano, & Gisbert, 2015; SCOPEO, 2013).

Gráinne Conole (2013) presents a timeline to introduce the key technological developments in online education over the last 30 years (see Fig. 1).

E-Learning Generations

Based on the generation metaphor presented above, García-Peñalvo and Seoane-Pardo (García-Peñalvo & Seoane-Pardo, 2015) reviewed the e-learning conceptualization and definition according to three different generations or stages that are consistent with the broad proposals of the different authors and particularly with Stephens Downes' idea that generations are not replaced but coexist, and the maturity of the first brings the evolution of the following and the emergence of new generations (Downes, 2012). In fact, the term "e-learning" have been used as a teaching and learning method but also as a learning and teaching approach.

The first generation is characterized by the emergence of online learning platforms or LMS as the evolution of a more generic concept of the virtual learning environments that were set up after the Web appeared, with the broad (and poor) idea that e-learning is a kind of teaching that uses computers (Mayer, 2003). These learning environments are too centered on content and overlook interaction. The technological context is more important than the pedagogical issues. The classic

Fig. 1 The e-learning timeline adapted from Conole, 2013

definitions of e-learning are generally associated with this e-learning generation. For example, Betty Collis (1996) defines tele-learning as "making connections among persons and resources through communication technologies for learning-related purposes." Marc Rosenberg (2001) confines e-learning to the Internet as the use of Internet technologies to deliver a broad array of solutions that enhance knowledge and performance. He bases his idea on three fundamental criteria: (1) networked, (2) delivered to the end user via a computer using standard Internet technology, and (3) focused on the broadest view of learning. García-Peñalvo (2005) defines e-learning with a perspective focused on interaction, a characteristic of the next generation, "non-presential teaching through technology platforms that provides flexible access any time to the teaching and learning process, adapting to each student's skills, needs and availability; it also ensures collaborative learning environments by using synchronous and asynchronous communication tools, enhancing in sum the competency-based management process."

The second generation underlines the human factor. Interaction between peers and communication among teachers and students is the essential elements for high-quality e-learning that seeks to go beyond a simple content publication process. Web 2.0, mobile technologies, and open knowledge movement are significant factors that help this e-learning generation to grow. Based on this, LMS evolved to support socialization, mobility, and data interoperability facilities (Conde et al., 2014). Examples of e-learning definitions that are congruent with these second generation principles include: "training delivered on a digital device such as a smart phone or a laptop computer that is designed to support individual learning or organisational performance goals" (R. C. Clark & Mayer, 2011) or "teaching-to-learning process aimed at obtaining a set of skills and competences from students, trying to ensure the

highest quality in the whole process, thanks to: predominant use of web-based technologies; a set of sequenced and structured contents based on pre-defined but flexible strategies; interaction with the group of students and tutors; appropriate evaluation procedures, both of learning results and the whole learning process; a collaborative working environment with space-and-time deferred presence; and finally a sum of value-added technological services in order to achieve maximum interaction" (García-Peñalvo, 2008).

The third and last generation of e-learning is characterized by two symbiotic aspects. The first is technological: the LMS concept as a unique and monolithic component for online education functionality is broken (Conde-González, García-Peñalvo, Rodríguez-Conde, Alier, & García-Holgado, 2014). Since the emergence of Web 2.0 and social tools, the e-learning platform has become another component in a technological ecosystem orientated toward the learning process (García-Holgado & García-Peñalvo, 2013), transcending the mere accumulation of trending technology. This learning ecosystem should facilitate interaction and offer greater flexibility for any educational teaching.

The second aspect implies a loss of verticality in the e-learning concept to become a broader and more transverse element that is at the service of education in its wider sense. Both from an intentional (formal and informal) and unintentional (informal) view, learning ecosystems are at the service of people involved in teaching and learning processes or in self-learning. Thus, e-learning is integrated into educational designs or learning activities in a transparent way. It reveals the penetration of technology into people's everyday lives, making it easier to break down the barriers between formal and informal learning (Griffiths & García-Peñalvo, 2016).

Technological learning ecosystems facilitate this globalization of the e-learning notion, either to support an institutional context (García-Holgado & García-Peñalvo, 2014; García-Peñalvo, Johnson, Ribeiro Alves, Minovic, & Conde-González, 2014; Hirsch & Ng, 2011) or a personal one through the concept, more metaphorical than technological, of the personal learning environment (PLE) (Wilson et al., 2007).

Nevertheless, technological learning ecosystems are supporting other approaches to using technology in the classrooms, such as flipped teaching (Baker, 2000; Lage, Platt, & Treglia, 2000). Flipped teaching methodology is based on two key actions: moving activities that are usually done in the classroom (such as master lectures) to the home and moving those that are usually done at home (e.g., homework) into the classroom (García-Peñalvo, Fidalgo-Blanco, Sein-Echaluce Lacleta, & Conde-González, 2016). The Observatory of Education Innovation at the *Tecnológico de Monterrey* (2014) has also detected a tendency to integrate inverted learning with other approaches, for example, combining peer instruction (Fulton, 2014), self-paced learning according to objectives, adaptive learning (Lerís López, Vea Muniesa, & Velamazán Gimeno, 2015), and the use of leisure to learn. Thus, the flipped teaching model is based on the idea of increasing interaction among students and developing their responsibility for their own learning (Bergmann & Sams, 2012) using virtual learning environments as supported tools. These virtual environments allow students to access learning resources, ask questions, and share material in

forums, as it is mandatory for students to have help available while studying at home (Yoshida, 2016).

In this last stage, the MOOC concept has broken out strongly, perhaps with no new e-learning approach, but with sufficient impact to make institutions reflect on their e-learning processes and conceptions.

The term MOOC appeared for the first time in 2008 to describe the connectivism and connected knowledge course by George Siemens and others (http://cckno8.wordpress.com). This course gave rise to cMOOCs, where "c" means that the course is based on the connectivist approach (Siemens, 2005). A second type of MOOC appeared in 2011 under the name xMOOC, which is based on digital content and individualized learning as opposed to cMOOCs, which are more related to collaborative learning. There is currently a great deal of interest in MOOCs among the e-learning community. Other proposals for improving MOOCs have introduced the use of associated learning communities (Alario-Hoyos et al., 2013), adaptive capabilities (Fidalgo-Blanco, García-Peñalvo, & Sein-Echaluce Lacleta, 2013; Sein-Echaluce Lacleta, Fidalgo-Blanco, García-Peñalvo, & Conde-González, 2016; Sonwalkar, 2013), and gamification capabilities (Borrás Gené, Martínez-Nuñez, & Fidalgo-Blanco, 2016).

However, the existing dichotomy between cMOOCs and xMOOCs is questioned by different authors due to its limitations. Thus, Lina Lane (2012) proposes the sMOOC (skill MOOC) as a third kind of MOOC based on tasks; Stephen Downes (2013) suggests four criteria to describe an MOOC's nature, autonomy, diversity, openness, and interactivity; Donald Clark (2013) defines a taxonomy with eight types of MOOC, transferMOOC, madeMOOC, synchMOOC, asynchMOOC, adaptiveMOOC, groupMOOC, connectivistMOOC, and miniMOOC; and finally Conole (2013) provides 12 dimensions to classify MOOCs, openness, massivity, multimedia usage, communication density, collaboration degree, learning path, quality assurance, reflection degree, accreditation, formality, autonomy, and diversity.

With regard to the core elements that define this third generation, García-Peñalvo and Seoane-Pardo (2015, 5) propose a new definition of e-learning as "an educational process, with an intentional or unintentional nature, aimed at acquiring a range of skills and abilities in a social context, which takes place in a technological ecosystem where different profiles of users interact sharing contents, activities and experiences; besides in formal learning situations it must be tutored by teachers whose activity contributes to ensuring the quality of all involved factors."

Pedagogical Approaches in E-Learning

In the previous section, we described the evolution of e-learning and noted the existence of different educational approaches over time. In this section, we focus on the evolution of e-learning, taking into account the pedagogical approach.

Pedagogical approaches are derived from learning theories that provide general principles for designing specific instructional and learning strategies. They are the

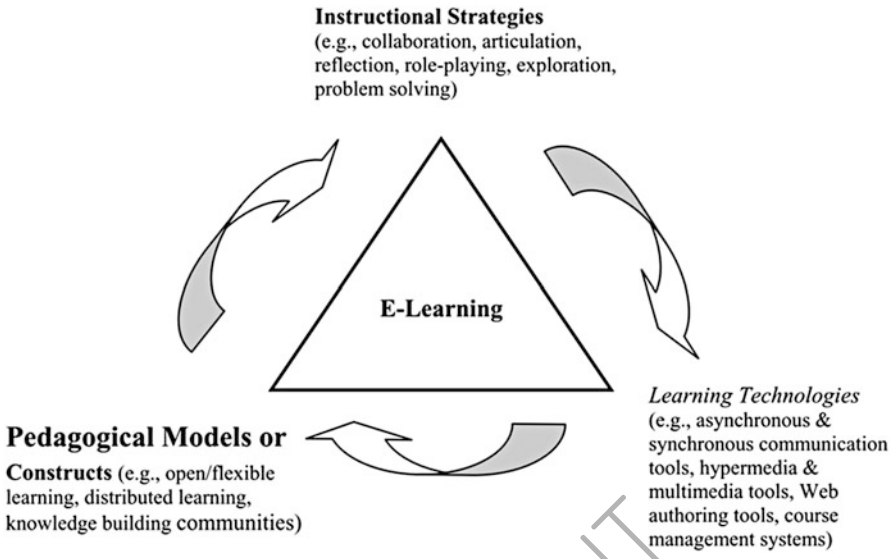

Fig. 2 A theory-based design framework for e-learning (Source: Dabbagh (2005, p. 32))

mechanism to link theory with practice. Instructional strategies are what instructors or instructional designers create to facilitate student learning. According to Dabbagh (2005, p. 32), "there are three key components working collectively to foster meaningful learning and interaction: (1) pedagogical models; (2) instructional and learning strategies and, (3) pedagogical tools or online learning technologies (i.e., Internet and Web-based technologies). These three components form an iterative relationship in which pedagogical models inform the design of e-learning by leading to the specification of instructional and learning strategies that are subsequently enabled or enacted through the use of learning technologies" (see Fig. 2). Due to the fact that learning technologies have become ubiquitous and new technologies continue to emerge bringing new affordances, pedagogical practices are continuously evolving and changing. This does not mean that some designs and pedagogical practices have disappeared. As we have mentioned, generations of e-learning coexist. For example, some instructive models based on the transmission of knowledge are still used but, sometimes, they incorporate new strategies such as gamification.

Conole (2014) divided pedagogies of e-learning into four categories:

1. Associative – a traditional form of education delivery. Emphasis is on the transmission of theoretical units of information learning as an activity through structured tasks, where the focus is on the individual, with learning through association and reinforcement.
2. Cognitive/constructivist – knowledge is seen as more dynamic and expanding rather than objective and static. The main tasks here are processing and understanding information, making sense of the surrounding world. Learning is often task orientated.

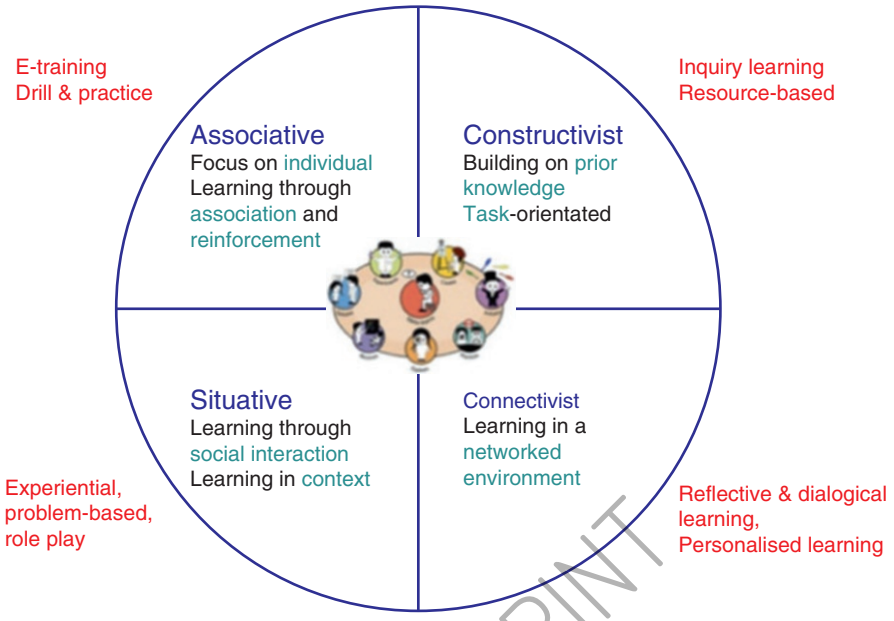

Fig. 3 The pedagogies of e-learning. *Source*: teachertrainingmatters.com/blog-1/2015/12/19/learning-theories-in-practice

3. Situative – learning is viewed as social practice and learning through social interaction in context. The learner has a clear responsibility for his/her own learning. This approach is therefore "learner centered."
4. Connectivist – learning through a networked environment. The connectivist theory advocates a learning organization in which there is not a body of knowledge to be transferred from educator to learner and where learning does not take place in a single environment; instead, it is distributed across the Web and people's engagement with it constitutes learning.

Each of these theories has a number of approaches associated with it which emphasize different types of learning (Fig. 3). For example, the associative category includes behaviorism and didactic approaches, the cognitive/constructivist category includes constructivism (building on prior knowledge) and constructionism (learning by doing), etc.

The development of the first e-learning platforms supported an instructional design based on the associative/behaviorist approach. The design process follows a sequential and linear structure driven by predetermined goals, and the learning output is also predefined by the learning designer. The designers organize the content and tasks and break them down from simple to complex. Information is then delivered to the learner from the simplest to the most complex depending on the learner's knowledge.

This type of approach has major limitations because it is not really suited to the needs of the learner. The evolution of technology allows the development of approaches that accommodate constructivist and connectivist perspectives that engage learners and give them more control over the learning experience.

Choosing the pedagogical approach is obviously related to what we want to achieve. However, it is important to establish a clear difference between designing face to face or e-learning. Many of the studies into the effectiveness of e-learning (Noesgaard & Ørngreen, 2015) have employed a comparative methodology. This means that the effectiveness of e-learning is based on the comparison between traditional face-to-face teaching and online learning. Along these lines, Noesgaard and Ørngreen (2015, p 280) ask "should different modalities have the same measures of performance, or should we consider e-learning to be a unique learning process and thus use different definitions of effectiveness?" This question is important because the effectiveness of e-learning can be analyzed in different ways. For instance, we can design e-learning to improve learning retention, work performance, or social collaboration. The measure to assess effectiveness will be different in each case. However, what is clear is that there are still some research gaps regarding the impact of e-learning on educational and training environments, as well as insufficient studies on cost-effectiveness and long-term impact.

Research on e-learning design points out that one of the most significant requirements for further adoption of e-learning is the development of well-designed courses with interactive and engaging content, structured collaboration between peers, and flexible deadlines to allow students to pace their work (Siemens, 2014). Certainly, every aspect of such a design can be interpreted in different ways. Nevertheless, research shows that structured asynchronous online discussions are the most prominent approach for supporting collaboration between students and to support learning. Darabi et al. (2013) consider that the greatest impact on student performance is gained through "pedagogically rich strategies" that include instructor participation, interaction with students, and facilitation of student collaboration as well as continuous monitoring and moderating discussions. A promising approach to developing self-regulatory skills using externally facilitated scaffolds is presented in Gašević, Adescope, Joksimović, and Kovanović's (2015) study. Their research shows that meaningful student-student interaction could be organized without the instructor's direct involvement in discussions. There is a significant effect of instructional design that provides students with qualitative guidelines on how to discuss, rather than setting quantitative expectations only (e.g., number of messages posted) (Gašević et al., 2015). The provision of formative and individualized feedback has also been identified as an important challenge in e-learning (Noesgaard & Ørngreen, 2015).

In addition to support from the theories of learning, we can also find e-learning models that provide specific support for designing effective learning experiences for students participating in online courses. Bozkurt et al. (2015) provide a content analysis of online learning journals from 2009 to 2013. In their study, they found that the Community of Inquiry model has been particularly relevant to the successful implementation of e-learning.

In the Community of Inquiry model (Garrison, Anderson & Archer, 2003), learning is seen as both an individual and a social process, and dialogue and debate are considered essential for establishing and supporting e-learning. The Community of Inquiry model defines a good e-learning environment through three major components:

1. Cognitive presence: the learners' ability to construct knowledge through communication with their peers
2. Social presence: the learners' ability to project their personal characteristics and identities in an e-learning environment
3. Teaching presence: defined as the design, facilitation, and direction of cognitive and social processes for the purpose of realizing personally meaningful and educationally worthwhile learning outcomes

Teaching presence provides the necessary structures for a community's formation, social presence fosters a community's development by introducing students and instructor to each other, and cognitive presence ensures the community's continuing usefulness to its participants.

After undertaking an extensive review of the literature on online interactions and communities, Conole (2014) developed a new Community Indicators Framework (CIF) for evaluating online interactions and communities. Four community indicators appear to be common: participation, cohesion, identity, and creative capability. Participation and patterns of participation relate to the fact that communities develop through social and work activity over time. Different roles are evident, such as leadership, facilitation, support, and passive involvement. Cohesion relates to the way in which members of a community support each other through social interaction and reciprocity. Identity relates to the group's developing self-awareness and in particular the notion of belonging and connection. Creative capability relates to how far the community is motivated and able to engage in participatory activity.

The Community Indicators Framework (CIF) provides a structure to support the design and evaluation of community building and facilitation in social and participatory media. Research shows that structured asynchronous online discussions are the most prominent approach for supporting collaboration between students and to support learning.

The approaches described are based on a conception of the use of e-learning in formal learning contexts. However, the broad penetration of e-learning prompts the need to develop designs that allow formal and informal settings to be linked. In this sense, we maintain that an ecological approach can be useful to support the systemic perspective needed to integrate formal and informal processes.

Brown (2000) uses the term ecology as a metaphor to describe an environment for learning. "An ecology is basically an open, complex adaptive system comprising elements that are dynamic and interdependent. One of the things that makes an ecology so powerful and adaptable to new contexts is its diversity." Brown further describes a learning ecology as "a collection of overlapping communities of interest (virtual), cross-pollinating with each other, constantly evolving, and largely

self-organizing." The ecology concept requires the creation and delivery of a learning environment that presents a diversity of learning options to the student. This environment should ideally offer students opportunities to receive learning through methods and models that best support their needs, interests, and personal situations.

The instructional design and content elements that form a learning ecology need to be dynamic and interdependent. The learning environment should enable instructional elements designed as small, highly relevant content objects to be dynamically reorganized into a variety of pedagogical models. This dynamic reorganization of content into different pedagogical models creates a learning system that adapts to varying student needs.

Barron (2006) defines personal learning ecologies as "the set of contexts found in physical or virtual spaces that provide opportunities for learning. Each context is comprised of a unique configuration of activities, material resources, relationships and the interactions that emerge from them" (Barron, 2006, p. 195).

From this perspective, learning and knowledge construction are located in the connections and interactions between learners, teachers, and resources and seen as emerging from critical dialogues and enquiries. Knowledge emerges from the bottom-up connection of personal knowledge networks. Along these lines, Chatti, Jarke, and Specht (2010, p. 78) refer to the learning as a network (LaaN) perspective. "Each of us is at the centre of our very own personal knowledge network (PKN). A PKN spans across institutional boundaries and enables us to connect beyond the constraints of formal educational and organisational environments. Unlike communities, which have a start-nourish-die life cycle, PKNs develop over time."

Knowledge ecologies lie at the heart of the LaaN perspective as a complex, knowledge-intensive landscape that emerges from the bottom-up connection of personal knowledge networks.

The value of the ecological perspective is that it provides a holistic view of learning. In particular, it enables us to appreciate the ways in which learners engage in different contexts and develop relationships and resources. The emphasis is on self-organized and self-managed learning. The learner is viewed as the designer and implementer of their own life experience.

The important question here is whether we are using the appropriate technology in e-learning to support an ecological approach. In the next section, we analyze the use of learning management systems (LMS) and propose new technological innovations and solutions to improve e-learning.

Learning Ecosystems

There are very few technological innovations that reach a sufficient level of maturity to be considered as consolidated technologies in the productive sector. It is also true that some of these technologies arrive on the scene surrounded by a halo of fascination that leads to the creation of different ad hoc practices, often resulting in

unfulfilled expectations and eventually the complete disappearance of said technology.

In e-learning, LMS are a paradigmatic case. They are a fully consolidated educational technology, although the educational processes in which they are involved could improve substantially. E-learning platforms are well established in the higher education area and enjoy very significant adoption in other educational levels and the corporate sector.

Although LMS are very complete and useful as course management tools, they are too rigid in terms of communication flow, limiting participants' interaction capabilities too much. For this reason, teachers and students tend to complement e-learning platforms with other tools, thereby creating personal learning networks (Couros, 2010).

It would seem that LMS have lost their appeal as a trending or research topic due to their known limitations, while different approaches and technologies are appearing in the education sector to claim the apparently empty throne. Various reports on educational technology trends underline topics such as MOOCs (SCOPEO, 2013), gamification (Lee & Hammer, 2011), learning analytics (Gómez-Aguilar et al. 2014), adaptive learning (Berlanga & García-Peñalvo, 2005), etc., but none of these proposed technologies, by themselves, have achieved the disruptive effect that allows them to substantially improve or change teaching and learning processes.

Consequently, LMS can no longer be regarded as the only component of technological/educational innovation and corporate knowledge management strategy (García-Peñalvo & Alier, 2014). Nevertheless, these platforms should be a very important component of a new learning ecosystem in conjunction with all the existing and future technological tools and services that may be useful for educational purposes (Conde-González et al., 2014).

Technological ecosystems are the direct evolution of the traditional information systems orientated toward supporting information and knowledge management in heterogeneous contexts (García-Peñalvo et al., 2015).

Recently, there has been a fundamental change of approach in debates on innovation in academic and political systems toward the use of ecologies and ecosystems (Adkins, Foth, Summerville, & Higgs, 2007; Aubusson, 2002; Crouzier, 2015). The European Commission has adopted these two concepts as regional innovation policy tools according to the Lisbon Declaration, considering that a technological ecosystem has an open software component-based architecture that is combined to allow the gradual evolution of the system through the contribution of new ideas and components by the community (European Commission, 2006).

In fact, the technological ecosystem metaphor comes from the field of biology and has been transferred to the social area to better capture the evolutionary nature of people's relationships, their innovation activities, and their contexts (Papaioannou, Wield, & Chataway, 2009). It has also been applied in the services area as a more generic conceptualization of economic and social actors that create value in complex systems (Frow et al., 2014) and in the technological area, defining Software

Ecosystems (SECO) (Yu & Deng, 2011) inspired by the ideas of business and biological ecosystems (Iansiti & Levien, 2004).

These software ecosystems may refer to all businesses and their interrelations with respect to a common product software or services market (Jansen, Finkelstein, & Brinkkemper, 2009). Also, from a more architecture-orientated point of view, a technological ecosystem may be studied as the structure or structures in terms of elements, the properties of these elements, and the relationships between them, that is, systems, system components, and actors (Manikas & Hansen, 2013).

Dhungana et al. (2010) state that a technological ecosystem may be compared to a biological ecosystem from resource management and biodiversity perspectives, with particular emphasis on the importance of diversity and social interaction support. This relationship between natural and technological is also presented by other authors who use the natural ecosystem concept to support their own definition of technological ecosystems (Chang & West, 2006; Chen & Chang, 2007). Although there are various definitions of natural or biological ecosystems, there are three elements that are always present in all of them: the organisms, the physical environment in which they carry out their basic functions, and the set of relationships between organisms and the environment. Thus, the technological ecosystem may be defined as a set of software components that are related through information flows in a physical medium that provides support for these flows (García-Holgado & García-Peñalvo, 2013).

The ecosystem metaphor is suitable for describing the technological background of educational processes because the ecosystem may recognize the complex network of independent interrelationships among the components of its architecture. At the same time, it offers an analytic framework for understanding specific patterns in the evolution of its technological infrastructure, taking into account that its components may adapt to the changes that the ecosystem undergoes and not collapse if they cannot assume the new conditions (Pickett & Cadenasso, 2002). On the other hand, the users of a technological ecosystem are also components of the ecosystem because they are repositories and generators of new knowledge, influencing the complexity of the ecosystem as artefacts (Metcalfe & Ramlogan, 2008).

From the learning technologies perspective, the past has been characterized by the automation that spawned the development of e-learning platforms. The present is dominated by integration and interoperability. The future challenge is to connect and relate the different tools and services that will be available to manage knowledge and learning processes. This requires defining and designing more internally complex technological ecosystems, based on the semantic interoperability of their components, in order to offer more functionality and simplicity to users in a transparent way. Analyses of the behavior of technological innovations and advances in cognitive and education sciences indicate that the (near) future use of information technology in learning and knowledge management will be characterized by customization and adaptability (Llorens, 2014).

The learning ecosystem as a technological platform should be organized into a container, the architectural framework of the ecosystem, and its functional components (García-Holgado & García-Peñalvo, 2016).

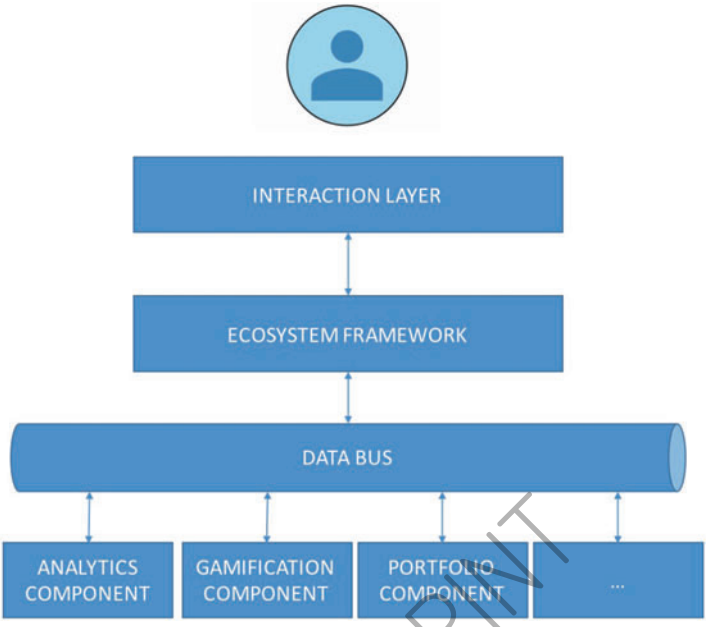

Fig. 4 Ecosystem architecture

The framework should involve the integration, interoperability, and evolution of the ecosystem components and a correct definition of the architecture that supports it (Bo, Qinghua, Jie, Haifei, & Mu, 2009). The current status and technical and technological evolution of technological ecosystems show very pronounced parallelism with all the technology developing around the Internet and cloud services. More specifically, the evolution in data collection, analysis procedures, and decision-making drink from the same fountain as certain types of emerging technologies such as the Internet of things, the processes that extract concepts from business intelligence, or data mining processes applied to knowledge management.

Figure 4 presents the essential architecture of a learning ecosystem, distinguishing the framework and a set of basic components for analytics, adaptive knowledge management, gamification, and evidence-based portfolios.

The interconnection of platforms, tools, and services requires communication protocols, interfaces, and data and resource description standards that enable data to be entered and transmitted with minimal quality requirements that allow its meaning and context to be preserved. Interconnection protocols and data collection rely on platform interoperability, on the possibility of using sensors and other ways of gathering evidence of learning, on open data with standard semantic content, and even on descriptors and evidence linked to knowledge acquisition processes (Retalis, Papasalouros, Psaromiligkos, Siscos, & Kargidis, 2006). The current state of development of e-learning ecosystems and their extension to different learning methodologies and paradigms pinpoints the relevance of this research area for the process,

because data is the raw material (U.S. Department of Education - Office of Educational Technology, 2012) for designing the learning cycle (data-driven design), assessing learning tasks and activities (learning analytics), and even as a means of providing real-time feedback (data-driven feedback) and tailoring the learning environment to the learner's needs.

The most outstanding characteristic of these learning ecosystems is that they are a technological approach but they are not an end in themselves. Instead, they serve the pedagogical processes that teachers want to organize in the technological contexts they provide, masking the internal difficulty of the technology itself.

Concluding Remarks

In the 1990s, student profiles in e-learning were similar to those of classic distance education: most learners were adults with occupational, social, and family commitments (Hanson et al., 1997). However, the current online learner profile is beginning to include younger students. For this reason, the concept of the independent adult, who is a self-motivated and goal-orientated learner, is now being challenged by e-learning activities that emphasize social interaction and collaboration. Today's online learners are expected to be ready to share their work, interact within small and large groups in virtual settings, and collaborate in online projects. According to Dabbagh (2007, p. 224), "the emerging online learner can be described as someone who has a strong academic self-concept; is competent in the use of online learning technologies, particularly communication and collaborative technologies; understands, values, and engages in social interaction and collaborative learning; possesses strong interpersonal and communication skills; and is self-directed." Stöter, Bullen, Zawacki-Richter, and von Prummer (2014) identify a similar list to Dabbagh and also include learners' personality traits and disposition for learning, their self-directedness, the level of motivation, time (availability, flexibility, space) and the level of interaction with their teachers, the learning tools they have at their disposal, and the level of digital competency, among many other characteristics.

The research into learner characteristics identifies behaviors and practices that may lead to successful online learning experiences for learners. However, it is important to emphasize that due to today's greater diversity of profiles, there are many influences on students' individual goals and success factors that are not easy to identify. As Andrews and Tynan (2012) pointed out, part-time online learners are a very heterogeneous group. Due to this diversity of e-learners, it is not appropriate to privilege a particular pedagogical model, instead it is very important to design learning environments that take learners' needs and the context into account.

Providing formative, timely, and individualized feedback has also been identified as an important challenge in the online learning environment. Likewise, more recent studies have also highlighted the importance of timely, formative, effective, and individualized feedback in order to efficiently support learning.

As Siemens (2014) argues, there is also a great opportunity for further research to examine how (and whether) institutions are redesigning online courses based on the

lessons learned from MOOCs. Moreover, another potential line of research might be investigating how universities position online learning with respect to on-campus learning. Finally, current research also shows that higher education has been primarily focused on content design and curriculum development. However, in order to develop personalization, adaptive learning is crucial.

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